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A PROPOSED FRAMEWORK TO SUPPORT ADAPTIVITY IN ONLINE LEARNING ENVIRONNMENT: USE CASE IN LMS

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ABSTRACT

Online Learning Environments (OLE) such as LMS, MOOC and ALS are becoming increasingly popular in many educational institutes like universities. However, LMSs and MOOCs provide the same content for all learners in a given course. Educational theory suggests that learners possess different proprieties such as background, preference, cognitive level and style of learning. This paper investigates an experiment of implanting the adaptation in these environments. The goal is to propose a model of adaptation taking into account several dimensions of adaptation. We will so examine these dimensions in the context of hybrid systems consisting of LMSs, MOOCs and ALSs.

Keywords: *Adaptation, Adaptive Learning Systems, Learning Management System, Massive Open Online Cours, Learning Content, Adaptation Engine, Online Learning Environnement, AeLF*

1. INTRODUCTION

Over the last decade, the awareness of adaptive learning is absolutely shared. If we had to prove it, a simple review of current search engines can attest to the large number of accomplished publications, articles and books.

The concept of adaptation is probably a requirement in modern education generally based on Online Learning Environments (OLE). Many study shows that in all of the used technology in online learning (LMSs or MOOCs), a dropout rate of a large number of learners is found [16, 26, 38]. This is due, in our view to the fact that these systems do not necessarily take into account some fundamentals of adaptation such as *prerequisites*, *preferences of learners* and their own *learning styles* and *rhythms*. It's also owing to the isolation of learners, difficulties to engage a sufficient number of tutors within the MOOCs, because of their massive dimension.

Thus, the learner emerges in a vast space of resources, activities and interactions with various stakeholders (teachers, tutors, peers, etc.), which is far to be relevant for learners and to meet their specific needs [17].

We suggest showing through this paper the interest and importance of this adaptation in the context of OLE, with all of its dimensions, namely the individual dimensions, the fun, the social and the massive one.

To argue our proposals, we will use some studies among the most relevant ones in the field of adaptive learning. Thus, we will base our paper on the ideas of Brusilovsky [10], through Adaptive Learning Systems (ALS) such as ELM-ART in one hand.

The following of this paper will be carried out in five main parts. The first part presents, in summary, some definitions of the concept of adaptation as well as the existing mechanisms depending on the considered learning system. The second part will deal with a presentation of the

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evaluation of the adaptation in the context of OLE, by combining them. The third part will be devoted to discuss an adaptation model that integrates LMS and MOOC platforms. Some results of the implementation of our model will be explored in the fourth section. An example of use case will be discussed in the fifth section. Finally the conclusion and the planned future work are presented in the last section.

2. ADAPTATION IN ONLINE LEARNING ENVIRONMENTS

In this section, we present some definitions and the underlying mechanisms of adaptation in the context of OLE.

2.1 The concept of Adaptation

In literature, several terms are used to refer to the concept of adaptation [33, 6]. However, these terms do not necessarily mean the same concept and trying to distinguish all of them is beyond the scope of this paper. We will choose two of the most used terms. Thus we find the Anglo-Saxon terms *Adaptability* and *Adaptivity.*

- **Adaptability** is a static process, carried out during system initialization. This approach is based primarily on the knowledge acquired by the system about prior user interactions. This may come directly from a questionnaire on the learner profile. We note that this knowledge remain unchanged during the learning process.
- **Adaptivity** is a dynamic process that can change the resources and activities using different parameters and predefined rules of adaptation. The knowledge used in this process comes from the evolutionary model of the learner in the user/system interactions.

In this paper, we use the term "adaptation" to mean the adaptivity concept.

2.2 Adaptation in Adaptive Learning Systems (ALSs)

Adaptive Learning Systems (or ALS) support learning by providing individualized access to educational content. They dynamically select a number of resources or learning objects (LO) based on the knowledge they have on the learner. This usually concerns their prerequisites, preferences, learning styles and other factors. Research in this context differs depending on the selected criteria for adaptation, its methods and techniques. These techniques can be classified into three dimensions: the adaptation of the **presentation**, **navigation** and **content**. For these dimensions, we can report a dozen techniques proposed in [8, 9, 27], such as for example the *rearrangement of layouts*, *direct guidance*, *showing or hiding links and annotations links*.

In this perspective, several learning systems have been developed. Among them we can mention: ELM-ART [8], KBS-Hyperbook [23], AHA! [7, 13] and Interbook [10]. For example, the **ELM-ART** system (**E**pisodic **L**earner **M**odel, the **A**daptive **R**emote **T**utor) is a learning system for the Lisp programming language. ELM-ART has not only traced the way for further developments but also became a standard for adaptive link annotations through a traffic light metaphor. By using green, red, grey and yellow colors the ELM-ART can indicate the recommendation of links to content pages. Many later systems, including AeLF have inherited this metaphor.

2.3 Adaptation in Learning Management Systems (LMSs)

The situation in the **L**earning **M**anagement **S**ystems (**LMS**) is quite different. In fact, LMS (such as Moodle[1] , Blackboard[2] , Sakai[3], etc.) are an integrated system which supports the learning process and administration. It presents an important package of services and features enhancing e-Learning. An LMS supports teachers in developing e-learning courses that students can enroll in. In addition, it allows the use of external learning materials (resources/activities) and the reuse of already developed learning materials. An LMS can support creating and serving tests, grading assignments, publishing course material. It can also allow a synchronous and /or an asynchronous communication between users (teachers, students or administrators) through chat rooms, discussion forums, etc.

Nevertheless, this category of systems doesn't support the adaptation and personalization of courses; typically they present exactly the same course for every learner without consideration of the learner's individual characteristics, situation, and needs [20]. Such a **one-size-fits-all** approach

[1] http://www.moodle.org/
[2] http://www.blackboard.com/
[3] https://www.sakaiproject.org/

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often leads to frustration, difficulties in learning, and a high dropout rate [26, 38]

In this case, to overcame this issue, we'll set out the various works allowing integrating the adaptation concepts in the LMSs. We classified this works in four different approaches depending on the philosophy followed [31] :

- **LMS Extensibility**. It's based by using a plugin that can provide features of adaptivity based on the profile of each learner. We can mention the work of the author Sabine Graf [33], Gert Sauerstein [35] and Andre Scherl [3];
- **Modifying LMS Source Code**. This approach is mainly concerns the Open Source LMS. This important feature of this category allows developers to access the source code, read it, understand it and modify it according to the objectives. We can mention the work of the author Jantke [24] which he integrated a PHP script to the source code Moodle in order to add some adaptive features;
- **E-Learning Standards**. Standards such as: IMS-LD[4] , IMS QTI[5], SCORM[6], xAPI[7] can be used in two different case. The first one is to use *the standards as a means for creating adaptive learning scenarios*. These can be imported and run in the LMS to deliver learners with individualized learning experiences. This vision is supported by Santos [34]. While the second case is to use *the standards as a means of information on the experiences and state of learning of each learner*. This vision is supported by the author Moisa [29];
- **A Framework Communicating with LMS**. It concerns the use of a framework as an adaptivity services producer communicating with the LMS. This approaches was supported by several authors namely Conlan with the framework APeLS [12] and Paul De Bra with the framework GRAPPLE [14];
- **LMS Customization**. This approach consists essentially of two steps: (i) *categorization of learners according to homogeneous groups* with respect to different criteria such as: learning style, cognitive level ... etc; (ii) *the development of educational resources tailored to each group*. Among the authors who have adopted this approach, we quote the author Despotovic-Zrakic [15] and the author Surjono [22].

For more details about these approaches, we refer the reader to another paper [31].

3 ADAPTATION IN MASSIVE OPEN ONLINE COURS (MOOCS)

The current phenomenon of Massive Open Online Cours (MOOCs), like: Coursera, Udacity, edX, and Khan Academy; aims at unlimited participation (massive) and open access via the Internet. MOOCs are distinguished from LMSs and ALSs by different characteristics such as the massiveness, openness, accessibility, certification, the nature and programming of content, assessment modalities, etc.

However, same as the LMSs, the MOOCs are also based on the **one-size-fits-all** approach which raises particular issues related to the drop-out problem. A promising solution lies in supporting **the motivation and engagement of learners** [5].

Based on a literature review, we can distinguish four different approaches to minimize the dropout rate [4]:

- **Pedagogical Strategies Approach**. It is a number of theoretical strategies validated by empirical studies. Among the pedagogical strategies discussed in the literature, we highlight the work of Williams [39] of adding motivational messages to students when they solve mathematics problems.
- **Personalization and/or Adaptivity Approach.** Several researches focus on the importance of personalization to avoid dropout. In this context, we can mention PERSUA2MOOC project [18]. This project provides a system for personalization of learning outcomes in MOOCs. PERSUA2MOOC is a project that aims to "adapt" the learning activities considering the individualities and teachers educational activities.
- **Gamification Approach.** Integrating games into the learning process is a solution to capture a

[4] http://www.imsglobal.org/learningdesign/
[5] http://www.imsglobal.org/question/
[6] http://scorm.com/
[7] http://adlnet.gov/adl-research/performance-tracking-analysis/experience-api/

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larger audience. Indeed, the coupling of learning, virtual reality and video games allow to consider the integration of serious games in the online learning process. We can mention the work of [32, 19].

- **Technological Approach**. Finally, we note that in addition to video, MOOCs also follow technological ascent implementing other tools web 2.0, namely, social networks, wikis, forums, etc.

3. COMBINING ADAPTIVE METHODS IN OLE

As we have said before, adaptation aims to create and present content based on the needs, preferences, goals and knowledge of a learner and/or a group of learners. This adaptation has been extended in recent years with the arrival of LMSs and MOOCs incorporating new dimensions such as: **the individual dimension**, **the fun dimension**, **the social dimension** and **the massive dimension**.

Figure1 shows our own compilation of dimensions we present in the following of this paper.

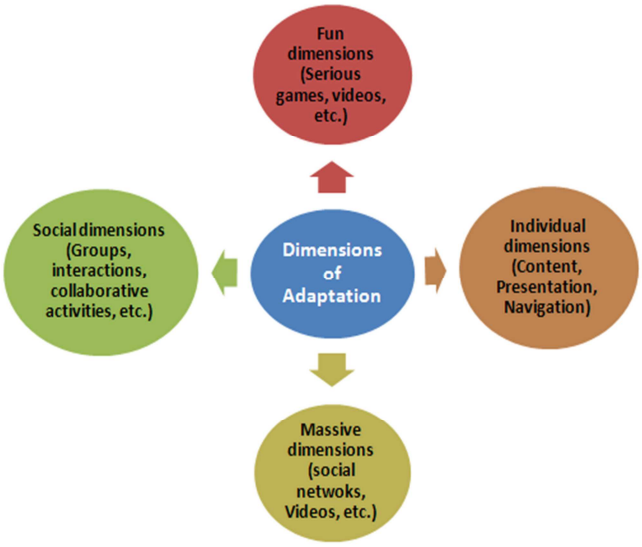

Figure 1. Dimensions of Adaptation in OLE

3.1 Individual dimension

The individual dimension of adaptation according to [10, 30], can be carried out in three sub-dimensions:

- **Adaptation of content**: select the different suited resources (images, texts, animations, videos, etc.;) depending on the learner model,
- **Adaptation of presentation:** provides the learner with layouts of various communication interfaces,
- **Adaptation of navigation:** support the navigation by preventing the learners from following ways of navigation without any relationship with their tasks or their purposes.

The adaptation in this dimension can be done using different technique which has been widely cited in the literature. Among them, we cite, for example, the annotation link for the adaptation of navigation and the variants pages for the adaptation of content.

3.2 Social dimension

The social dimension plays a more important role to support Learning. In reality, students nowadays are always **looking for peers** who share the same characteristics, preferences or common learning experiences [11].

So, several studies and research have focused on this issue and have given various methods for **forming a small community or a group among the learners**. The exploitation of these techniques could **improve learner motivation and engagement.**

3.3 Fun dimension

Any teacher know that learning through playing is important and an alternative solution able of capturing attention of learners. The goal is to combine **teaching aspects** of learning, training, communication and information, with **playful springs** and/or **video game** technologies.

In fact, the coupling of learning, virtual reality and video games today allow to consider the integration of serious games in the learning process online either in use or design. For design, some work like [28] are interested in the social creation of serious games. Thus, participants go through all the stages of developing an educational game by choosing the idea, linking the objectives of the development and testing the prototype, in an environment that does not necessarily require programming skills. The curriculum will enable participants to understand the process of making software. At the same time, participants will benefit from practical experience, working in

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intercultural teams, interdisciplinary and distributed

3.4 Massive dimension

As discussed above, a detailed review of the literature identifies three distinct kinds of papers on the massive scale: (**1**) those concerned with the need or motivation for personalization in MOOCs, (**2**) outlines of gold plans proposals for implementing personalization in MOOCS and (**3**) accounts and evaluations of the implementation of personalization services in MOOC.

These various studies have proposed adaptation strategies by **personalizing content**, **learning pathways**, and **providing good recommendations** as mentioned in [37].

This customization involves the **generation of feedback** [36], **planning time of learners** [21], **the use of ITS technologies**,...etc. Other work has suggested to **diagnose** learners and **assigning** them to a community of learners [25].

In the following, we are interested in the proposal of an adaptive model that can be used by different types of OLE.

4. THE PROPOSED ADAPTIVE MODEL

Generally, an adaptive model is defined as a 3-tuple <**DM**, **UM**, **AE**> where **DM** is a domain model, **UM** is a user model, and **AE** is an adaptive engine.

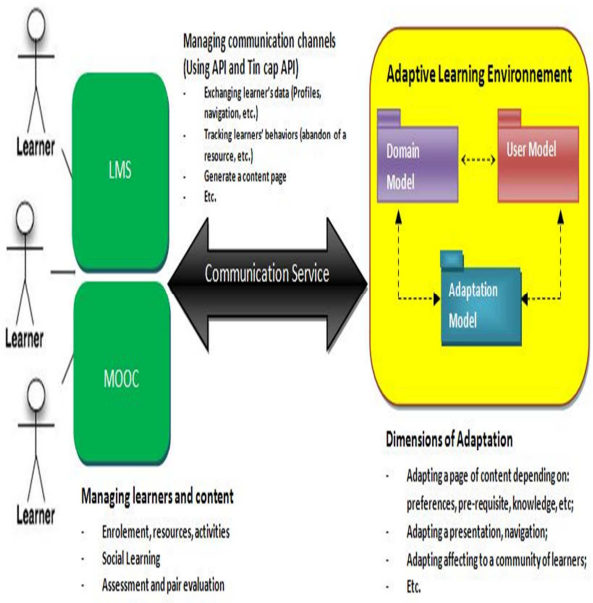

Figure 2. Integrating the Adaptive Learning Environment with LMSs and MOOCs

Figure 2 shows these different components as an integrating architecture which shows the possibility of interaction and hybridization with the online learning environments.

The ALE component is responsible in adapting content on the basis of all dimensions of adaptation earlier presented (see section 3). The LMSs and MOOCs have the functionalities of management learners and content like enrolment, uploading resources, creating activities and assessments. For this end, it needs information about learner or group of learners that can be provided by an LMS or a MOOC to update the learner model. Other information can be used to search resources and activities tailored to the learner according to the representation of the DM. From a technological point of view, all of this information can be transferred using the API for LMS and Tin Cap API for MOOCs (Figure 2). In summary, this solution involves a distributed system with possibly many LMSs, MOOCs, ALE and many users.

We propose in the following to return to some elements of the adjustment model <**DM**, **UM**, **AE**>, which achieve the required adaptivity.

4.1 Domain Model

The domain model (DM) is described by its faculty in the representation of concepts to learn, the resources available to learners and the structuring of several elements of the domain.

Two types of concepts components are distinguished: **Concepts** like *Variable*, *Instruction*, *IF-Else* in the programming language domain and **Concept relationships** like *IS-PREREQUISITES-OF IS-COMPOSED-OF*.

4.2 User Model

The user model aims to represent a real description of the learner. It's open for editing and viewing by both the system and the learners.

Three kind of information are considered in the UM: **Personal** (name, email address, phone, picture, etc.), **Preferences** (language preferences, favorite colors, the preferred type of educational con- tent, etc.), **Knowledge of learner** that is described in relation to each domain model.

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4.3 Adaptive Engine

The adaptive engine deals with the automatic production of adaptive content that will be presented to the learner through the LMS/MOOC interface. This component is based on a set of rules to achieve the adaptation: **Research of concepts**, **Collecting of information**, **Adaptation**, **Updating user model**.

We'll present some example of these rules in the next section 5.

5. IMPLEMENTATION

For the implementation of our model, we try to work in the first case on LMS by development a new framework called **AeLF** (**A**daptive **e**-**L**earning **F**ramework) as a solution for adaptive LMS. The AeLF brings the world of LMSs and ALSs together in order to offer a powerful life-long online learning solution. The AeLF is based on our experience with ALS-CP [2] developed in IRF-SIC Laboratory at the Faculty of science in Ibn Zohr University Agadir (Morocco). The macro-architecture of the proposed system consists of by four central components (see Figure 7).

In this figure 7 we see the different component of the ALS presented before like the **UM** which we separated in two parts: *static* and *dynamic*. The **DM** which store the content and the pedagogical relationships. The **communication bus** between LMS and AeLF which is based on the runtime communication API used in SCORM 2004 4th edition[1], and finally the **AE** which has three sub- components: (1) **Management User Model Engine** (**MUME**), (2) **Content Adaptation Engine** (**CAE**) and (3) **Navigation Adaptation Engine**(**NAE**). Every single contains a set of rules to enable the adaptation which we'll be explored next:

5.1 The Content Adaptation Engine (CAE)

This component is used to produce individualized content based on the UM of each learner. The Content Adaptation Engine is based on set of rules like:

RULE 1 : **IF** the concept chosen by the learner is a generic concept
THEN CAE adds to its selection of the different concepts that make up this concept.

RULE 2 : **IF** the concept chosen by the learner has prerequisites,
THEN CAE adds to its selection this concept and its prerequisites.

RULE 3 : **IF** the list of concepts acquired by the learner is empty and this is the first session,
THEN CAE added to the selection all the concepts without prerequisites.

RULE 4 : **IF** the concept is already acquired,
THEN CAE presents the learner a summary or synthesis on this concept.

RULE 5 : **IF** the prerequisites of the chosen concept are already acquired,
THEN CAE retains only the desired concept.

RULE 6 : **IF** the multimedia preferences of the learner are video and image,
THEN CAE focuses on all OP having the same type.

RULE 7 : **IF** the educational preferences of the learner are the kind exercise,
THEN CAE present more exercise to this learner.

5.2 The Navigation Adaptation Engine (NAE)

The Navigation Adaptation Engine component is used to adapt the presentation of the link anchors. This realizes the direct guidance, the link annotation, and it can also realize the link hiding. As we mentioned before this component use a set of rules like:

- **For the Link Annotation**

RULE 1 : **IF** the state of concept C is acquired,
THEN the link concept C is colored in gray.

RULE 2 : **IF** the state of concept C is not acquired, not visited and its prerequisites are acquired,
THEN link the concept C is colored in green.

RULE 3 : **IF** the state of concept C is not acquired, not visited and its prerequisites are not acquired,
THEN link the concept C is colored in red.

RULE 4 : The current concept is colored in yellow.

RULE 5 : **IF** the concept is generic and one his children are not acquired,
THEN the concept is colored orange.

- **For the Hiding link**

RULE 1 : **IF** the state of concept C is not acquired, not visited and its prerequisites are acquired,
THEN link the concept C is displayed.

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RULE 2 : **IF** the state of concept C is not acquired , not visited and its prerequisites are not acquired,
THEN link the concept C is hidden.

5.3 The Management User Model Engine (MUME)

The role of this component is to filter the experiences of the learner, to detect the types of favorite OP and the learning progress. Finally it permits to update the dynamic part of the AUM. Somme rules used in this component:

RULE 1 : **IF** all concepts son are acquired, **THEN** MUME marks the generic concept as granted

RULE 2 : **IF** more fragments are linked to a particular concept,
THEN the scores are accumulated in a variable related to the concept.

RULE 3 : **IF** the accumulated reaches a threshold (currently 60%),
THEN the concept is considered acquired.

RULE 4 : **IF** the % of the positioning test is between 0-49% or between 50% -75% or greater than 75%
THEN the system considers the learner's level respectively "beginner", "intermediate" and "advanced".

RULE 5 : **IF** the result of the evaluation of a concept is less than 50%,
THEN the system presents a revision of the concept.

The Figure 3 and the Figure 4 shows two screenshots of the AeLF in Moodle in which the content adaptation is done by presenting the same concept in two different form text (see Figure 4) and video (see Figure 3) according to the learning preferences storing in the UM.

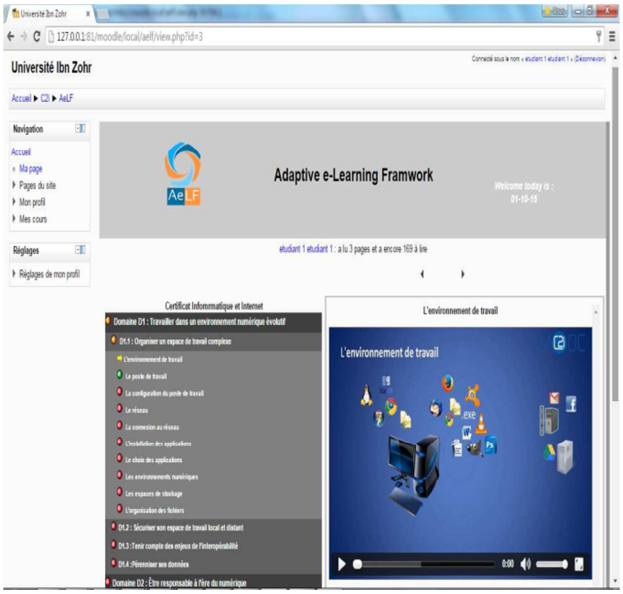

Figure 3 Screenshot Of Aelf In Moodle For A Learner Preferring Media Type Video.

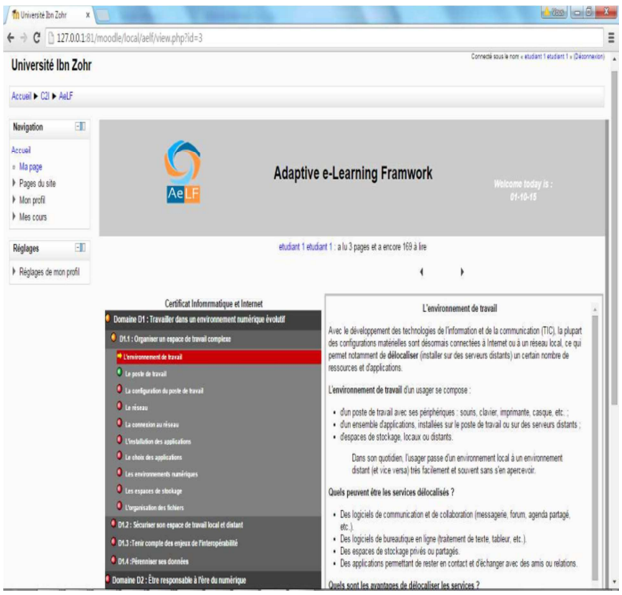

Figure 4 Screenshot Of Aelf In Moodle For A Learner Preferring Media Type Text.

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In the Figure 5 we see the navigation adaptation realized by the AeLF:

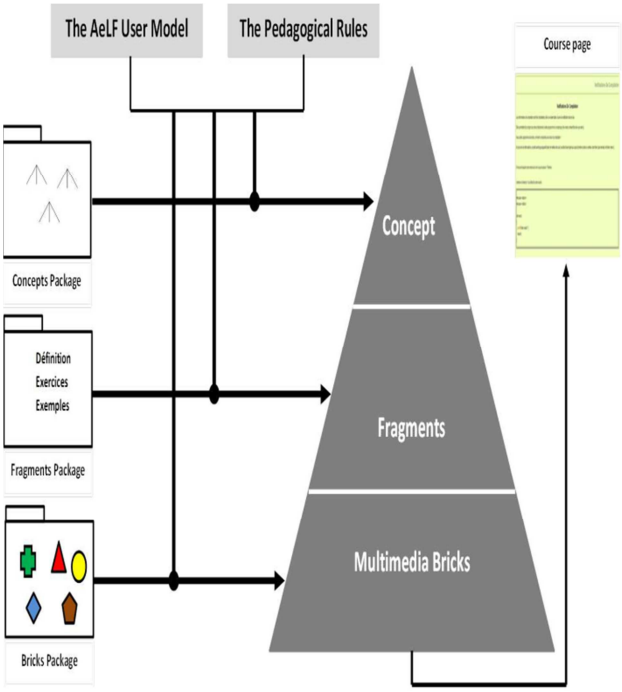
It's based by using the link annotation technique with 5 different colors; each one has a special signification:

- **Orange** : means that the concept is a generic concept and one of his children is not yet acquired,
- **Yellow**: means the current concept,
- **Green**: means the concept is not acquired, not visited and its prerequisites are acquired,
- **Red**: means the concept is not acquired, not visited and its prerequisites are not yet acquired,
- **Gray**: means the concept is acquired.

Figure 5 The AeLF link annotations

6. Example of use case within the AeLF

The first step of the adaptation process within the AeLF framework is to determine the objective of a session. This objective is composed of one or more concepts assembled



based on the process presented in the Figure 6.

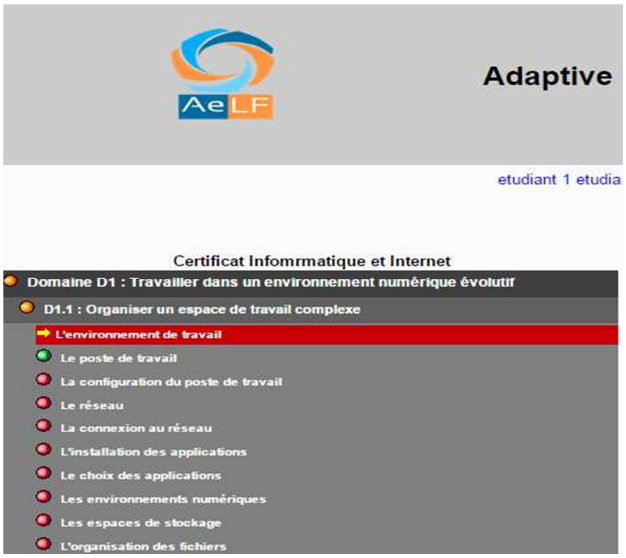


Figure 6. The Assembling Courses Process

When a learner interacts for the first time with the system, the list of concepts learned in the AUM is empty. The concepts stored in the ADM without preconditions and have not been acquired by the learner will initialize the list of active concepts. This allows deciding on the objective of the session. Some elements of the AUM can impact this decision. This impact comes from the ***background knowledge*** and ***skills of the learner*** represented in the AUM like ***use of information technology level*** (*beginner, intermediate, Expert*), or ***the background knowledge*** built from a set of concepts about the domain in study, such as the C2I[8] domain (file, folder, computer, text processing , spreadsheet , database, navigator, and mailbox, etc..). Each decision is controlled by the pedagogical rules already presented.

The selection of one or more concept(s) related with other information depends in particular on the representations of the learner, especially the sequence that will be derived after in fragments. If, for example, the AUM indicates that the learner prefers to study by examples, the sequence will contain more examples. For exercises, the difficulty level will rely on information extracted from the AUM corresponding to her/his level (Beginner, Intermediate, and Advanced). This sequence corresponds to a prototypical sequence of fragments to complete the selected learning

[8] C2I : Certificat Informatique et Internet (Computer and Internet Certificat)

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concept. Depending on the AUM, the system associates a multimedia brick with each fragment of this sequence. If the AUM indicates for example that the learner prefers pictures and videos, the system will promote anything that is multimedia. If she/he prefers reading on the screen, the text associated with fragments will be used to create a course page (see Figure 3 and Figure 4).

7. CONCLUSION AND FUTURE WORK

Following the various issues presented, and within the limits to be met by this paper, we hope to put a first draft of the current problems related to the issue of adaptation in Online Learning Environments. The synthesis of the literature highlights our viewpoint on the adaptation of four dimensions: the individual dimension, the fun dimension, the social dimension and the massive dimension. All of these dimensions are complementary and they are likely to allow robust and hybrid systems combining both characteristics of MOOCs, LMSs and ALS.

These attempted systems can both run in manual and automatic scheduling. In the case of large groups of learners, it's very difficult that tutors can follow all learners individually. The existing LMSs until today are better suited for small groups of learners. But their interest is essential particularly for collaborative work. For larger groups, it is better to use MOOCs and with possibilities to communicate with a framework adapting automatically courses and activities for each learner, leaving him the opportunity to communicate with peers and tutors, or any other technological tool. This framework is what we have called the AeLF (Figure 6). We remind that it is composed of three main entities: *AeLF User Model*, *AeLF Domain Model* and *AeLF Adaptation Engine* combining a set of pedagogical rules and processes.

It is clear that several issues remain to be addressed to arrive at the expected hybrid systems. Our work continues along these lines to try to finish a complete model of adaptation in OLE.

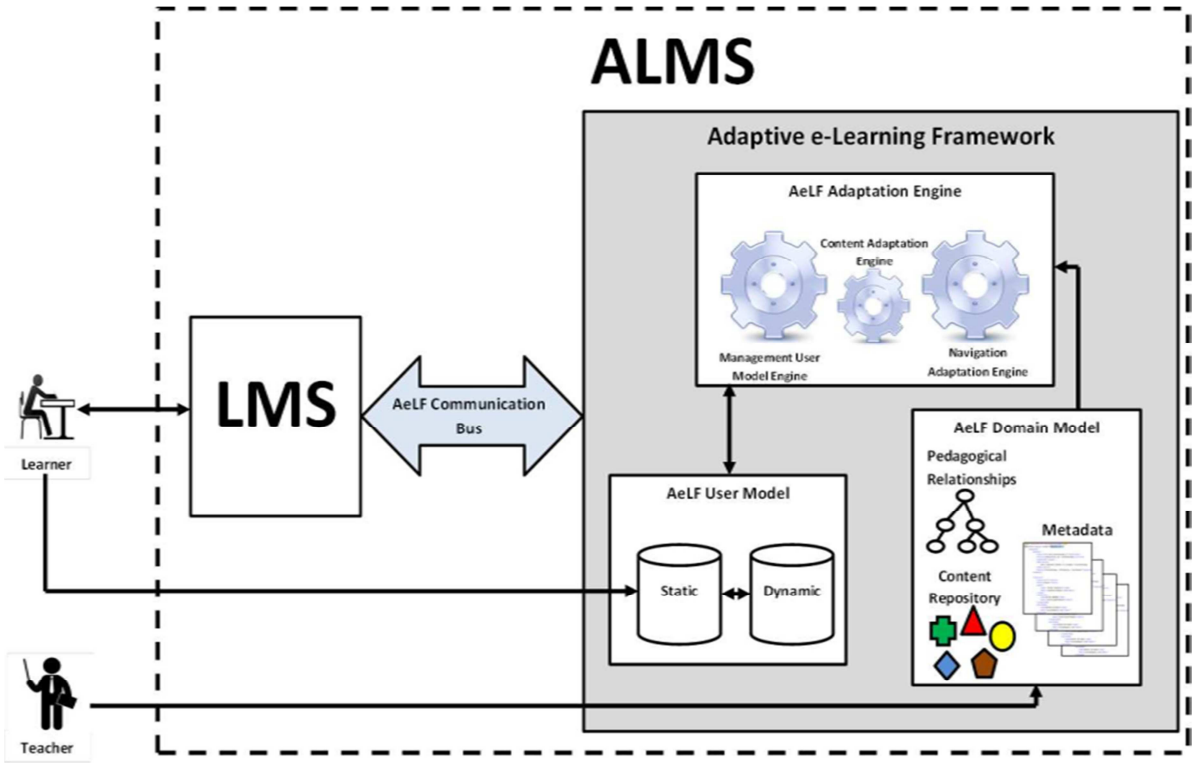

Figure 7. Macro-architecture of AeLF

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