Educational Content Development Process in "CleverUniversity": Our Dynamic Adaptive Hypermedia Environment

https://doi.org/10.3991/ijet.v11i12.5868

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Abstract—**The implementation of a simple and flexible dynamic adaptive hypermedia environment meets several needs of teachers. Using a fitting system, teachers will be able to share their knowledge in chunks of content in order to create quality teaching resources.**

In this paper, we propose a development approach through our simple system dedicated to teachers and learners alike taking into account the different work done on the subject. Moreover, our approach is based on the various elements of our system such as the learner's model, the domain model, the pedagogical model, the courses generator and the multimedia database.

Our focus in this paper will be on the domain model given its importance in the development and adaptation of educational content as needed, and which consists of finding educational content related to a given field of knowledge to be adapted for a particular learner.

Index Terms—**Domain model, dynamic adaptive hypermedia, evaluation model, student model, Workflow.**

I. INTRODUCTION

The integration of ICTs in a given educational system is marked by the use of digital learning resources that have to be created in accordance with the standards allowing their use in teaching methods.

However, building a quality educational resource requires the use of a simple environment that will suit the teachers and allow them to convey their teaching strategy in a content meeting the needs of learners in terms of adaptability, portability and monitoring.

In order to achieve this objective, a number of questions are raised: how to develop educational content for them to be reused? Does a granular representation improve adaptability?

To provide answers to these questions, we discuss in this paper a process of creating educational contents through our Dynamic Adaptive Hypermedia System (DAHS) simple and online called "CleverUniversity".

To ensure better adaptability of educational content in the context of dynamic adaptive hypermedia systems, we examined the use of a fine-grained approach to learning contents. The approach entails content remodeling.

This article is structured in three main parts. The first part briefly presents the architecture of our "CleverUniversity" environment. The second part focuses on the process and the creative process of educational content, through which it examines the concept of granularity, reusability and adaptability, and the relationship between these three concepts. The realization and implementation of our system "CleverUniversity" is the subject of the third part before drawing conclusions and exposing the prospects of our study.

II. OUR DAHS'S DESIGN

The system "Clever University" that we propose is a dynamic adaptive hypermedia, simple and user-friendly, tailored to the needs expressed by people involved, namely, the author is the producer of the learning objects, the teacher plays the role of a tutor and assessor and the learner who is the end user of content.

The dynamic aspect of our system results in the generation, customization and composition of learning content according to the characteristics of learners taking into account their learning style and cognitive state.

Figure 2 below illustrates the architecture of our "CleverUniversity" environment which generally approximates the standard architecture of dynamic adaptive hypermedia. It is based on five main pillars:

1. **Domain Model**: which provides information on the concepts that will be taught. It aims at identifying the relevant concepts and relationships and provides an overall structure of the learning area. This model focuses on designing an authoring environment for authors to produce educational content dedicated for learners.
2. **The learner's model**: The intelligence of a Dynamic Adaptive Hypermedia System (DAHS) is mainly attributed to its ability to adapt to a specific learner during the learning process. This can only be achieved by knowledge of the learner's model, which is a crucial component of a DAHS. This component presents the core of any custom, dynamic learning and gives the learner an active role in learning and build knowledge.

In addition, all information in the learner's model will help maintain a deep knowledge of each learner and to define the relevant characteristics that can better describe or measure their performance, motivation, identify their level of knowledge, define their goals, interests, learning style, strategies and psychological problems, track their progress and provide adapted administrative and cognitive tutoring.

The creation of the learner's model and the concept of adaptation of educational content are closely related. Indeed, the information represented in the learner's model has a great influence on the type and nature of adaptation that the system has to offer [1], [2] including: content, navigation and presentation. The purpose of the modeling is to provide complete and accurate description of all aspects of behavior of the learner and the system used. This modeling allows an adaptation that will improve the operation and usability of the system; it can present the most interesting information and help learners in their learning.

The creation of this model is done in different ways. For this model, we have chosen the method of recovery (Overlay), where the state of knowledge of the learner is represented as a subset of the domain knowledge model [3] and we chose the Felder-Silverman model to learn about their learning style.

Each individual has a unique reading and learning style. A way that is unique to organize concepts and information. This is known in pedagogy and psychology as learning styles [4]. This justifies a teaching situation cannot be perceived in the same way by all learners.

In this part, we are interested in the study of learners' profiling process using the measure of learning style. This measure is based on the index of learning styles (ILS) established by Felder and Silverman. The Felder-Silverman questionnaire contains 44 questions. For each question, the learner must choose an answer between 'a' and 'b'. The 44 questions are divided into four groups of 11 questions for each.

Each group of questions defines a dimension of the learner's cognitive model which is composed of four dimensions:

- **Dimension 1**:It represents the size of thinking and information processing of the learner. It ranges from reasoning to active learning. Active learners do better by engaging in an activity (group or individual) or by discussion of the concept provided. Reasoning learners prefer learning by introspection (Observe, Listen ...).
- **Dimension 2**: It represents the reasoning. It ranges from deductive to inductive. Deductive learners prefer to move from principles to deduce the consequences or applications. By contrast, Inductive learners prefer to move from facts and examples to identify principles.
- **Dimension 3**: This is the sensory dimension. It ranges from what is visual to what is verbal. A visual learner prefers learning using images, charts, graphs and animations. By contrast, a verbal learner prefers learning using texts, words, readings and discussions.
- **Dimension 4**: Defines how the learner prefers to progress in learning a lesson. It varies between global and sequential. A sequential learner prefers progress in stages. By contrast, a global learner prefers to freely choose their path to big jumps in context.

After the questionnaire was uploaded online, it was addressed to students of the National School of Commerce and Management of Fez (ENCGF), the results were transferred to the data base of our system.

The primary objective of this study is to measure the learning style of each student and then reveal the most popular style, which will be assigned to all newly registered students on our system that have not taken the questionnaire. After analyzing our results, we found that the target group consisted of multiple and different learning styles.

According to the questionnaire, the learner must answer the 44 questions, in which each dimension has 11 questions and in each dimension there are two different values. We can deduce that **16 (4^2)** possible Learning styles in our study, so we have retained the following table:

TABLE I.
DIFFERENT LEARNING STYLES IDENTIFIED

Style	Dimension 1	Dimension 2	Dimension 3	Dimension 4
Style 1	Active	Inductive	Verbal	Sequential
Style 2	Active	Inductive	Verbal	Global
Style 3	Active	Inductive	Visual	Sequential
Style 4	Active	Inductive	Visual	Global
Style 5	Active	Deductive	Verbal	Sequential
Style 6	Active	Deductive	Verbal	Global
Style 7	Active	Deductive	Visual	Sequential
Style 8	Active	Deductive	Visual	Global
Style 9	Reasoning	Inductive	Verbal	Sequential
Style 10	Reasoning	Inductive	Verbal	Global
Style 11	Reasoning	Inductive	Visual	Sequential
Style 12	Reasoning	Inductive	Visual	Global
Style 13	Reasoning	Deductive	Verbal	Sequential
Style 14	Reasoning	Deductive	Verbal	Global
Style 15	Reasoning	Deductive	Visual	Sequential
Style 16	Reasoning	Deductive	Visual	Global

The study we conducted separately in each dimension does not really reflect the learners' profiles. Then, the results obtained so far, remain insufficient. For the style of a learner, a value must be assigned to them for each dimension; that is to say, a profile is represented by a combination of four different values.

For this purpose, we focused on the four dimensions for each learner. The results illustrated in the following figure represent the number of learners in each learning style.

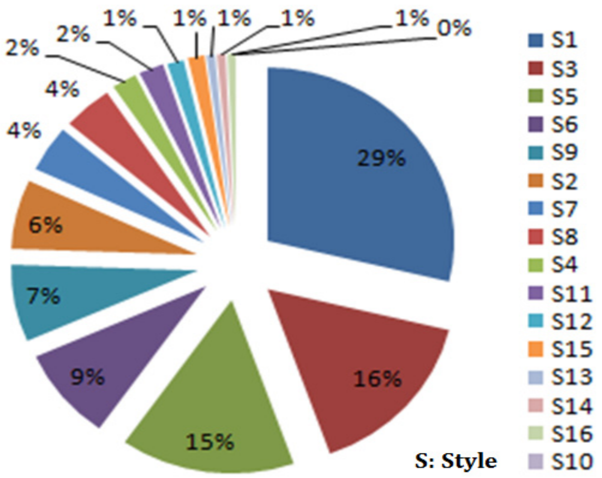

Figure 1. Distribution of learners in each learning style

We notice from the figure above that style 1 is the most popular one among learners, then style 3 then style 5 ,... etc. This result reflects the focus of our study, as we have mentioned above; this style will be assigned by default to new learners who do not wish to take the Felder-Silverman questionnaire. Style 1 is composed of four dimensions:

- Sensory dimension: Verbal
- Progression dimension: Sequential
- Thinking dimension: Active
- Reasoning dimension: Inductive

We can deduce that learners who belong to style 1 prefer text and sound educational resources, navigate and advance step by step in a learning sequence. They also prefer practical activities, individual or group and start their sequences with examples, facts; then, practices and theories.

3. **The pedagogical model**: the main objective of DAHS is to provide the learner with adequate assistance. In this regard, the proposed educational model should be able to provide choices to make learning successful learning.

The pedagogical model is the set of specifications regarding the content to be presented by the system as well as how and when they should be presented. This model mimics the behavior of a teacher in an educational situation. It allows to choose the mediums to assist the learner in the learning process by considering educational, pedagogical and psychological principles and also allows us to offer educational assistance adapted to the learner's profile.

In principle, the pedagogical model of a DAHS allows the handling of educational interventions of the system. It uses the learner's model of information to organize and identify aspects of the model domain to be introduced to the learner appropriately. Therefore, this model must be able to model the interactions between the teacher and the learner, design the content to be presented adaptively, select the problems that the student must solve, through guiding him towards the solution, by providing adequate assistance, conducting educational activities such as providing explanations, examples and advice and giving tests in order to minimize the differences between the domain expert and the learner.

The flexibility of adaptive educational systems is always growing especially when adding a prediction unit that can anticipate future actions of the learner based on a history of previously viewed teaching concepts as well as the current one of studies, and it aims at orienting and giving appropriate help at the right time during the learning activity.

Up to this stage, the Forward algorithm is used to choose the probabilistic distribution of each pedagogical concept [5], [6].

4. **The basis of multimedia resources**: represents a container that includes all multimedia resources that the "CleverUniversity" system uses. These resources are the building blocks associated with a concept of domain model and contents differed pending on the tasks that are in progress, as they are resources available locally or on the Web.

Multimedia resources are all characterized by a set of attributes; one in four types, namely: the cognitive type, the cognitive level and the physical type and the educational objective [7]

5. **The courses generator**: is considered one of the most important parts in our system, as it connects the different above mentioned models of the latter. It includes the steps to follow for the update of the "learner's model" according to the learner's behavior and rules which define the arrangements for adapting:

- Adaptation of content: is based on the generation of content based on the learner's profile.
- Adaptation of the browsing: enables adaptation of the scheduling of educational concepts that will be presented to the learner.
- Adaptation of the presentation: deals with the layout and the visual appearance. This form of adaptation uses certain preferences of the learner.

This component offers tools for the generation of a dynamic adaptive hypermedia for research, selection and organization of educational resources through two mechanisms:

- Adaptation mechanism depending on the learning style of the learner.
- Adaptation mechanism depending on the cognitive state of the learner.

III. ELABORATION OF EDUCATIONAL CONTENTS

Like any source, an educational source has a cyclic process that extends from its structure to its dissemination. In fact, an educational source should be structured, scripted, publicized, indexed, validated and disseminated.

In the designing system, the author provides a structured and hierarchical representation of educational content through the structuring module.

Domain experts, instructional designers, writers and teachers\authors aim at defining the hierarchical structure and the specific characteristics of educational content through the structuring module.

The learning object then enters the scripting step that provides the author with an interface for planning the possible scenarios, how will chain the different parties and the conduct of the learner's actions through a sequence graph which interprets the pre-conditions and post-conditions of each action.

So, the learning object passes through the media stage. This is for the mediator to choose the appropriate media, which is previously stored in the database of multimedia resources. The media module is responsible for the association of actions with media objects.

Then, the learning object joins the indexing system which allows for the description of learning resources and facilitates the management and location of educational resources.

During the validation phase, the learning object is subject to the opinion of the validation committee to judge the quality of the resource. Once the learning object is validated, it moves to the diffusion step. This diffusion can be achieved through different devices allowing its use by learners and tutors.

The overview of the architecture of our domain model that represents the life cycle of the learning object is shown in Figure 3 next.

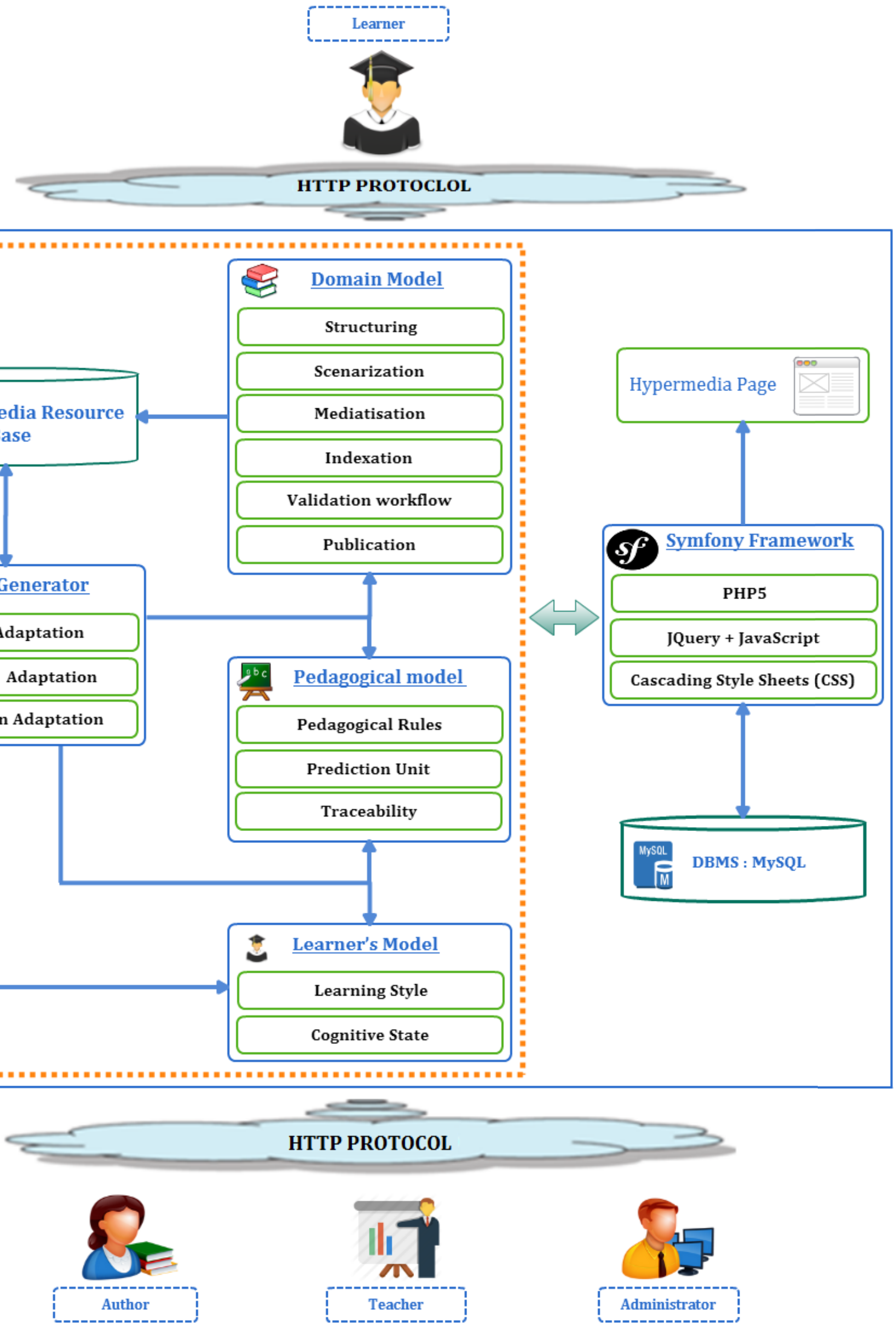

Figure 2. Design of our DAH system « CleverUniversity »

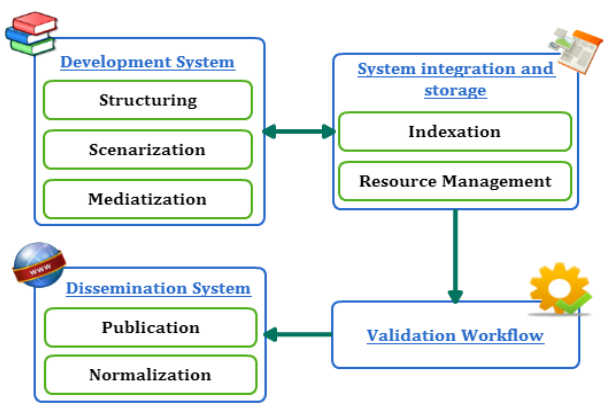

Figure 3. The life cycle of the learning object

In what follows, we will tackle the life cycle of our learning object and explain in detail its various modules.

A. Structuring

The first stage in the development of educational content is the structuring which consists of fragmenting knowledge in elementary units of fine-grained with basic educational goals [8], [9]. These units can then be combined in several ways to build various different learning paths and adaptive to the cognitive status, learning style, needs and preferences of learners and allow them to progress at their own pace.

This granularisation will allow to, fully, prioritize educational content, to reuse in an easier way the teaching grains in a learning situation and to pool resources between teachers.

To facilitate understanding of the information, it must be synthesized and structured consistently. This approach helps clarify the content and better align educational goals. When the whole content is structured, completed and autonomous semantic units can be created in order to facilitate the dynamic information processing and updating of these units.

Our study has also dealt with the standardization objects such as EduML, EML, SCORM and the existing authoring systems such as thyme-author and Toolbook.

Therefore, this study has led us to retain several points, most notably:

- Structuring of content in logical units and decomposition of elementary knowledge in hierarchical units.
- Establishment of the relational structure between the units and the dynamic nature of relations between the educational content of grains.
- Validation of consistency of the links and structure.
- The importance of the reuse of these building blocks to develop new educational content.

To understand this hierarchy, the interactive diagram below illustrates the correspondence between the various units of our educational content.

So, our learning object consists of a set of elements that can be defined as follows:

- Educational Module: It corresponds to the upper granularity of educational content structure which can be associated with metadata for describing content. The metadata facilitates courses management and optimizes the search. It must have a title indicating the course content.
- Division: it is the most inclusive content. It may contain activities like learning, evaluation as well as other divisions. A division must contain at least one grain to be opened by default.
- Grain's content: the grain is a group of paragraphs forming a semantic unity. If the grain is long, it might be subdivided into recursive parts.
  - Part: it is a group of pedagogic blocks having a common pedagogic goal. The use of parts is appropriate to the hierarchized content on more than two levels.
  - Pedagogic blocks: if the grain is short, it will be directly composed of pedagogic blocks. Each block will be materialized in media (Information's type paragraph, remark's or advice's type paragraph: attention, method, reminding and definition, images, tableau or resources)
- Pedagogical activities: it is a group of activities in which the learner interacts with the pedagogic content for a determined period. It could be either a learning or assessment activity.
  - Learning activity: it is the didactic unit proposed by default in a module. It may not contain other learning activities. Its structure includes one or various synthesis questions or general reference.
  - Assessment activities: it contains only quiz's type activities. Its structure includes modular feedback according to the score got out of the overall exercises. The aim behind the assessment activity is to get, on the part of learners, a trace which they have developed.

B. Scenarization

The structuring step, previously cited, divides the content into pedagogical units. Each of which will be scenarized. This scenarization is the second step of the pedagogical process implementation, diffused online. Scenarization gives meaning to the hierarchized pedagogical content through the determination of the concepts that the learner has to start with during the learning process. It aims at planning in time and space all the pedagogical activities, such as learning or assessment activity for a population, taking into account the educational background and competences of potential learners. It enables also the establishment of a link between the different parts and elements of the content, taking into account the hindrances of adaptability and re-usage. The order of these elements might be expressed by assigning each unit pedagogical rules that are pre-defined by the teacher in pedagogical module. The links between concepts could be of different types. In our conception, we have chosen to use three relations which seem the most important and are as follow:

- **Pre-requisite link**: the passage to the following notion necessitates the acquisition of the notion in, for example: if the concept A is a pre-requisite of the concept B, the acquisition of the concept B implies the acquisition of the concept A.
- **Conditional link**: in addition to the pre-requisite condition, the teacher-scenarist may determine other conditions, such as the time passed and the score they got. The access to a concept is conditioned by the acquisition of the concept's pre-requisite. To pass from one concept to another, the mark of the first test's concept must exceed the average which the teacher has fixed. If the mark is inferior to the average, the learner cannot have access to the following concept.
- **The link by default**: the first notion must be seen to move to the notion in. This link determines a certain order between notions without imposing some conditions on the passage.

In still another, and for a better adaptation, the system determines a scenario more adaptable to the cognitive state of the learner, following some rules which specify the enchainment of concepts by attributing to each instruction pre-conditions and post-conditions.

- **Pre-conditions**: it is a threshold of entrance associated with each act, so the learner cannot accede only to concepts of which the average is got. In this sense, the system proposes a pre-test of general knowledge which the learner could take during his enrollment in a course.
- **Post-condition**: it is an average given to a learner once he finishes a notion. This may determine the following notion to learn, so the learner, and the end of each concept, must sit for a post-test of evaluative type. The following schema presents the necessary and the different elements to better scenarize the pedagogical content.

C. Mediatization.

This module associates actions and the chosen mediatic objects. At this level, there is an implementation of the pedagogical content as well as its representation by the mediatic resources to pedagogical concepts of the scenario. By contrast, the mediatization of the pedagogical content implies a new structuring of more sequenced pedagogical elements as well as a reflection on the role of media to be integrated(sound, image, animation and flash) with regard to the pursuit goals. The process of mediatization is part and parcel of the pedagogical engineering because it takes into account the pedagogical choices, context and learning purposes.

The following figure illustrates the process of content mediatization.

D. Indexation.

It is of paramount importance to index pedagogical resources by associating them to meta-data in order to facilitate their manipulation, re-usage, partaking and diffusing as well as optimizing research [10]. The main aim of indexation is a better access to resources. Thus, the more correctly announced meta-data are, the more identifiable resources will be. In order to be useful or rather used in an optimal way, resources must be the most possibly visible. Thus, the ideal is to granulize the maximum and index each pedagogical grain to have an added pedagogical value in order the teachers could re-use these grains in other pedagogical resources. In order to better partake and therefore valorize the pedagogical resources, there must be a certain respect of the format indexation's specification. Some norms were proposed, such as Dublin core, LOM, LOMFR and SUPLOMFR. Contrary to DUBLIN CORE, LOM is a specification which enables the correctly detailing the pedagogical part of a pedagogical resource. In our system, we have used some categories of LOM standards to which we have added some semantic fields. Figure 6 shows the field that we have used for the indexation of our granular pedagogical objects.

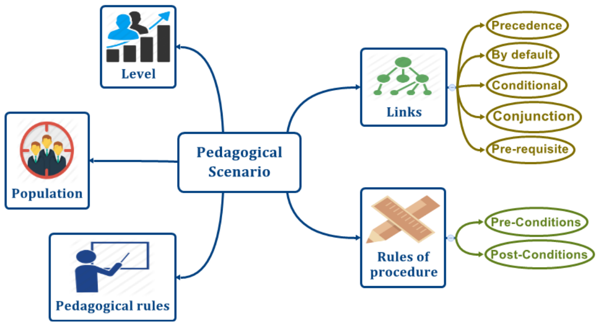

Figure 4. The scenarization of our pedagogical content

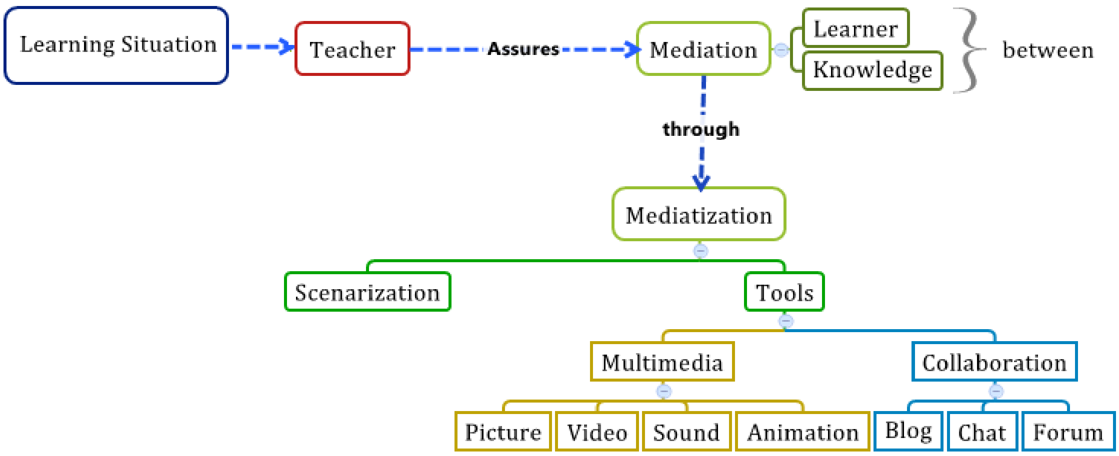

Figure 5. The process of content mediatization

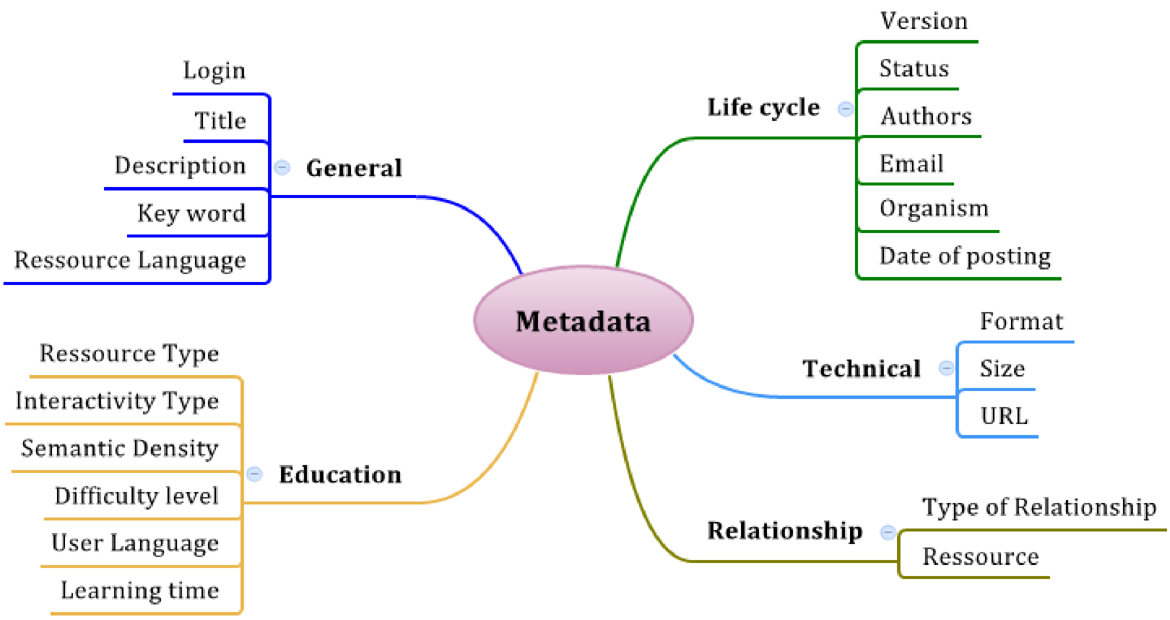

Figure 6. The indexation of our granular pedagogical grain

E. The validation workflow

The workflow mechanism enables the validation of workflow of pedagogical content to be handed to learners even before publication. Therefore, regardless of the means used to integrate the system within the pedagogical content, it has to go through validation workflow to get to the final version approved by the validation committee. This workflow takes into account the access rights and the profiles of other concerned actors.

When a pedagogical content submitted by the elaborator to the person in charge of validation, this latter should be emailed via a message containing the link of the pedagogical content to be treated. We have two possibilities:

- **Refusal of pedagogical content**: the author is to be informed by email and has therefore to work on the content for a new submission.
- **The acceptance of pedagogical content**: the pedagogical content may be published and the author is to be emailed.

F. Publications.

Our system makes it possible for the author to publish the pedagogical content anytime in several publication formats: Web format (html, scorm)and PDF format.

Our domain's model is used is certainly used as a tool to help creating pedagogical contents and create all the necessary files to comply with the world norm SCORM and therefore export these courses to the systems of learning's management.

IV. IMPLEMENTING OUR DYNAMIC ADAPTIVE HYPERMEDIA

After presenting the architecture of our domain model and expressed different policy features and design, we will introduce the computer realization of its components.

To validate our model, we have developed an educational environment on the web called "CleverUniversity" allowing authors to produce their own structured content, scripted, mediated and indexed to facilitate the adaptability of education to learners according to their learning style and cognitive status. It provides important tools for the organization of learning to key players such as the author, the teacher and the learner.

From the login page, stakeholders can then identify access their own space, according to the rights associated with their profiles.

To illustrate the use of the system, we will define some interfaces to the tasks envisaged by the actors in the system.

A. Development of content.

This space for the development of educational content contains a set of tools for structuring, scripting, indexing and publishing courses. The production will be done using an interface. Thereby lead to logically structured content while respecting the separation of the sub-grade to be presented and where we allow every moment to choose the right concept for each learner to choose the appropriate content pages that will be presented separately from the structure way. So, this space allows the author:

- Prepare and organize the content into reusable elements.
- Embed multimedia resources such as animation, sound, image, video, simulation.
- Manage references: bibliography, glossary, keyword index.
- Manage exercises or evaluations and publish content in multiple formats: PDF, HTML and SCORM.

Figure 8 illustrates the elements that the author may define in an educational module.

B. Learning Space.

Once the learner is registered, he connects to CleverUniversity. The categories and classes of subcategories will appear to him as well as the number of courses that contain all of them.

When a student chooses a category, a second list will be displayed containing, this time, all courses in that category. The student then chooses the desired course and the system takes care of the assembly of content, according to the learning style of the learner, his level of knowledge calculated using pre-test to know and availability of the fragments in the database.

This space also allows the learner to perform its work, to view its detailed results for each module or summaries via the dashboard. When the learner selects one module of their course, a page consists of three parts appears:

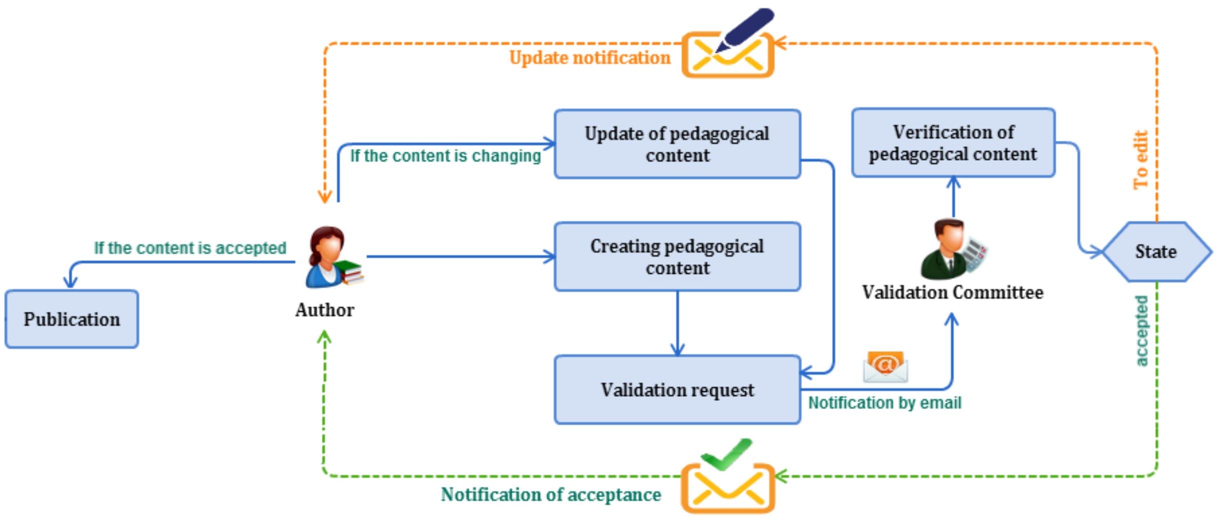

Figure 7. Workflow of pedagogical content validation

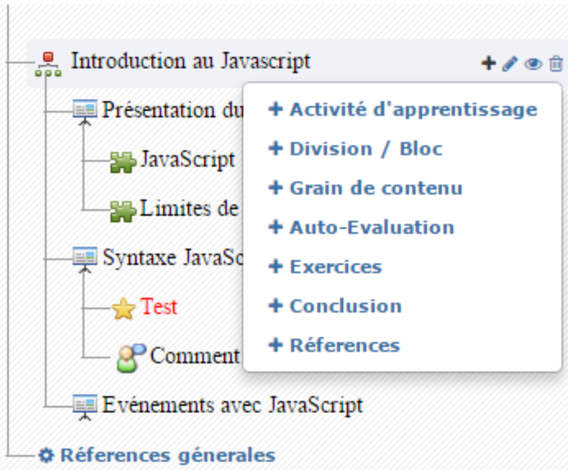

Figure 8. Area development of educational content

- The left side of the window contains the module plan. This is truly the corresponding activity to the profile of this learner. Indeed, as soon as the student chooses.
- A module, the system accesses its sub-model attitude and knowledge and domain model to search the contents of the structure corresponding to the level of the learner and his learning style.
- Part of the center of this interface is the page where the learning object associated with the activity chosen by the learner will be displayed him.

Figure 9 below shows the interface of a learner for a learning session and illustrate the points mentioned above.

V. CONCLUSION

In this paper we presented the architecture of our Adaptive Hypermedia Dynamic system called "CleverUniversity" by focusing on the domain model that specifies the process to be followed by the designer or author, to succeed to the best of its production and define its own structure of educational content, a modular, reusable structure, to generate lessons adapted to the learning style and cognitive status of learners.

We finished with the presentation of some interfaces and scenarios respecting the defined model.

Our research perspectives are part of an experiment in a real learning situation deeper looking for the impacts of the use of our environment.

We plan to expand and extend our system with other features such as the simplification of authoring tools to facilitate the use by none-IT teachers.

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Figure 9. Interface for a learning session

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Submitted 22 May 2016. Published as resubmitted by the authors 23 September 2016.