Prototyping a Disciplinary Information Space for a New Smart Learning Management System Based on IMS-LD and NoSQL

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Abstract—This work is mainly based on the prototyping of a disciplinary information space for a new LMS. Our work is first to think about the conditions for creating a real LMS between learners and teachers. We have chosen to base ourselves on the hybridization between four learning theories as the basis for teaching this LMS, namely traditional pedagogy, behaviorism, cognitivism and social constructivism. These pedagogies have already proven themselves, mainly in classroom learning situations. The LMS consists of different activity spaces for teaching and learning activities. We limit ourselves in this work to the prototyping of disciplinary information space for a new LMS based on IMS-LD, NoSQL MongoDB database, and Symfony framework.

Keywords—LMS, IMS-LD, eLearning platform, designing an IMS-LD, NoSQL, Symfony Framework, disciplinary information space

1 Introduction

We present a simple disciplinary information model of our new LMS for creating and administering educational content online. This tool allows you to generate and edit website structures through a database rather than pedagogical models, with a variety of choices that ensure better adaptation to the course teaching and learning style.

To model the disciplinary information space, we based ourselves on the IMS-LD specification by focusing on four learning theories deemed most relevant for our modeling, namely traditional pedagogy, behaviorism, cognitivism and social constructivism. Then, some learning theories that have long inspired the design of computer applications are combined and put into perspective with several emerging educational features to build an original modeling of the disciplinary information space of our new LMS.

The IMS-LD specification or instructional design engineering uses pedagogical concepts, allowing to model learning units. IMS-LD takes into account a wide variety of teaching models it is there its flexibility. A course plan extract of a general or specific database can be modeled with IMS-LD, through the description of the different roles, activities, environments, methods, properties, conditions, and notifications. It is used to transform the course plans into formal learning units (UOL) that can be performed with an IMS-LD editor based on an engine such as Copper core [18]. These executable units can be designed from the beginning using an editor such as Reload [19].

Several models of LMSs have been developed previously [13, 14, 15, 16, 17], but they have been abandoned because the life cycle of these LMSs evolves rapidly. Therefore, we conducted an analytical study on free LMSs. This based on an approach to assess the quality of LMSs [1, 2, 3, 21]. Based on this research, which seemed to us incomplete, we proposed a design portrait of an IMS-LD model of the disciplinary information space for our new LMSs. The latter is anthropocentric and is based on a learning concept, which is at the intersection of the most used learning theories. In fact, the idea is to orient research towards optimal compatibility between the services offered by LMSs and the needs of learners, for better optimization of online learning.

This paper mainly includes several important sections:

- We start by general introduction of paper with the objectives of this work
- Then we will determine the LMS and the underlying activity spaces
- Thereafter, we specify the IMS-LD concept which constitute the cornerstone of this study
- We model the disciplinary information space of the LMS based on the IMS-LD, after generating the IMS-LD meta-model of the disciplinary information space
- Therefore, we design the disciplinary information model based on the MongoDB database
- Finally, we contribute our work by prototyping the disciplinary information model based on the Symfony framework.

2 LMS and the Activity Spaces

The LMS consists of different activity spaces for activities of teaching and learning [8, 9, 12]. Each model represents a space, in these spaces, both teachers and learners can have a:

- Disciplinary information space
- Communication space
- Collaboration space
- Sharing space
- Evaluation space
- Production space
- Self-management space
- Assistance space

3 Instructional Management Systems – Learning Design

IMS-LD was published in 2003 by the IMS/GL[1]. The source (EML[2]) of the proposed language was assessed by the European Committee for Standardization (CEN) in a comparative study of different SRMS [5, 7]. EML is defined by CEN / ISS as *"an information aggregation and semantic model describing the content and processes involved in a unit of learning from an educational perspective and to ensure the reusability and interoperability."* [23]. In this context, the North American IMS consortium undertook a study and provided a specification of such a language, giving birth in February 2003, the Learning Design specification V1.0 (IMS-LD). She adds that proposal, largely inspired EML developed by [6, 7] (OUNL) provides a conceptual framework for modeling a Learning Unit and claims to offer a good compromise between on the one hand to the generic implement a variety of instructional approaches and secondly, the power of expression that allows an accurate description of each learning unit.

4 Modeling a Disciplinary Information Based on IMS-LD

We carry out the design of our LMS model without using the transformation based on the rules of the ATL language, because we detected a semantic loss during the transformation of the model.

This led us to develop our model through the broad lines of the diagram in which we will eventually identify the characteristics of the constituent entities of our class diagram, in which we will specify the constituents of the different classes for the disciplinary information space.

4.1 Use case diagram

Use case diagrams identify the functionality provided by the use case; users interact with actors and interactions between them.Figure 1 describes the use case diagram of the disciplinary information space representing the external actors who will interact with the system.

4.2 Correspondence between the terminology of IMS-LD and that of the disciplinary information model

We try to adapt the IMS-LD model to our model. This adaptation will go through three stages, firstly, the development of the disciplinary information model. Second, the study of the correspondence between the developed model. Finally, the IMS-LD model and their transformation into an IMS-LD model based on the ATL language. However, we design our model without using the transformation based on the rules of the ATL language, because we detected the same problems as in this works [10, 20, 23, 11, 22,

[1] **IMS/GLC:** Instructional Management Systems Global Learning Consortium
[2] **EML:** Educational Modelling Language.

24, 25, 26, 4]. In IMS-LD, we do not have the possibility of building a course, which consists of several chapters; because, there is at this level a semantic loss.

The majority of the classes designed in our model correspond perfectly to the IMS-LD model, which allows their transformations. Model transformation is a technique that aims to put links between models to avoid unnecessary reproductions. In Table 1, we have tried to collect all the classes of the disciplinary information space and their equivalent to IMS-LD.

Table 1. Correspondence between the terminology of IMS-LD and that of the disciplinary information model

Disciplinary information model	IMS-LD model
Prerequisite	Prerequisite
Phase	Play
The role, and features	Role
Members	Person
Coordinator, tutor, and teacher	Staff
Learner	Learner
Objective	Learning Objective
Activity space	Environment
Course, chapter, section, and block	Learning Object
Disciplinary information space	Services

4.3 IMS-LD class diagram

We create a model based on the theoretical study of our current work and we try to recognize our model with the IMS-LD model. We will use the same IMS-LD terminology for all the classes of our proposed model. There is an equivalent class in the IMS-LD, for the different classes of our model (see table 1).

Table 2. Table function description

Actor	Function	Description
Learners	Consult the course	The learner can view the course, prerequisites, and its objectives at any time
	Browse calendar	The learner can browse the defined task calendar.
	View documents	Learners read the downloaded documents.
	Download documents	The learner can download the documents
	Upload documents	The learner can upload documents
	Download documents	The learner can download the documents
Tutor	Supervise the learners	The tutor adds, modifies or deletes his learners
	Manage groups	The tutor adds, modifies or deletes groups
	Assign students to groups	The tutor can assign learners to groups
	Set calendar	The teacher can set schedules for the tasks and phases
	Consult the intervention schedules	The tutor can consult the intervention schedules of the learners
Teacher	Create courses	The teacher can create courses
	Set prerequisites	The teacher can set prerequisites for course
	Set objectives	The teacher can set objectives for course, projects, activities, quizzes, and assessments
	Upload documents	The teacher can upload documents
	Download documents	Teachers can download the documents
	Planning of teaching resources	The teacher must be planning of teaching resources
Administrator	Set in place groups	The administrator can set in place the classes' groups
	Assignment of courses to tutors	The administrator can assignment of courses to tutors according to the specialty of each one
	Management of the courses	The administrator can management of the courses
	Manage access rights	The administrator can manage the access rights of teachers and learners.
Coordinator	Manage teachers	The coordinator adds, modifies, or deletes a teacher
	Set in place groups	The coordinator can set in place the classes' groups
	Assignment of courses to tutors	The coordinator can assignment of courses to tutors according to the specialty of each one
	Management of the courses	The coordinator can management of the courses

Fig. 1. Use Case Diagram of disciplinary information space

We propose the following class diagram (see Figure 2), as a model of disciplinary information space, which meets the needs of teachers and learners.

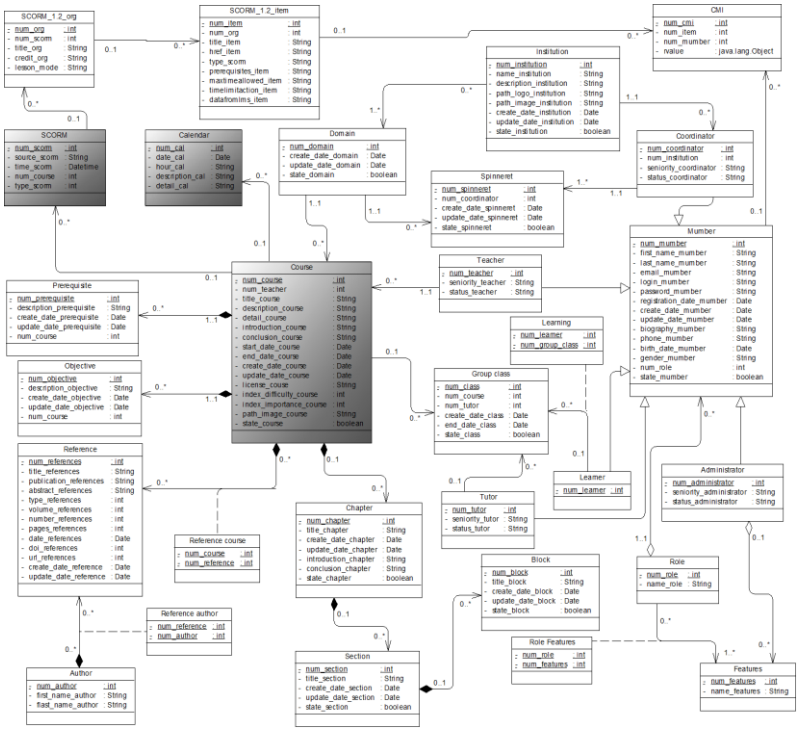

Fig. 2. Class Diagram of disciplinary information space for LMS

5 Designing a Disciplinary Information Space for LMS Based on MongoDB Database

MongoDB database is a free, open source document-oriented database program. Classified as a NoSQL database program. MongoDB uses JSON type documents with schemas. It supports field, range, and regular expression queries. Queries can return specific document fields and include user-defined JavaScript functions.

We have chosen to design our LMS via the NoSQL MongoDB database, for many functionalities:

- Flexibility. It is the ability to store different types of data in your document
- Speed. NoSQL databases takes less time to access data than SQL
- Continuous backups. Via NoSQL Mongo database, which includes a continuous backup solution with point and instant request
- In addition, comprehensive monitoring and customizable alerts.

Table 3 describes the course collections of the MongoDB database of the disciplinary information space representing only the external actors who will interact with the system.

Table 3. Course collections of MongoDB NoSQL database of the disciplinary information space

Course Collection

```
{
  "_id":"ID of the course",
  "title_course":"title of the course",
  "description_course":"description of the course",
  "detail_course":"detail of the course",
  "introduction_course":"introduction of the course",
  "conclusion_course":"conclusion of the course",
  "start_date_course":"start date of the course",
  "end_date_course":"end date of the course",
  "create_date_course":"create date of the course",
  "update_date_course":"update date of the course",
  "licence_course":"licence of the course",
  "index_difficulty_course":"difficulty index of the course",
  "index_importance_course":"importance index of the course",
  "path_picture_course":"path picture of the course",
  "state_course":"state of the course",
  "chapter_ids_cascade":[chp_number1...chp_numberN],
  "reference_ids":[ref_number1...ref_numberN],
  "objective_ids":[obj_number1...obj_numberN],
  "prerequisite_ids":[pre_number1...pre_numberN],
  "calendar_ids":[cal_number1...cal_numberN],
  "groupClass_ids":[grpC_number1...grpC_numberN],
  "scorm_ids":[sc_number1...sc_numberN],
  "tools_id":"tools ID of the course"
}
```

Reference Collection

```
{
  "_id":"ID of the reference",
  "title_reference":"title of the reference",
  "publication_reference":"publication of the reference",
  "abstract_reference":"abstract of the reference",
  "type_reference":"type of the reference",
  "volume_reference":"volume of the reference",
  "number_reference":"number of the reference",
  "pages_reference":"pages of the reference",
  "date_reference":"date of the reference",
  "doi_reference":"doi of the reference",
  "url_reference":"url of the reference",
  "create_date_reference":"create date of the reference",
  "update_date_reference":"update date of the reference",
  "course_ids":[course_number1...course_numberN],
  "author_ids"[author_number1...author_numberN]
}
```

Author Collection

```
{
  "_id":"ID of the author"
  "first_name_author":"first name of the author",
  "last_name_author":"last name of the author",
  "reference_ids"[reference_number1...reference numberN]
}
```

Chapter Collection

```
{
  "_id":"ID of the chapter",
  "title_chapter":"title of the chapter",
  "create_date_chapter":"create date of the chapter",
  "update_date_chapter":"update date of the chapter",
  "introduction_chapter":"introduction of the chapter",
  "conclusion_chapter":"conclusion of the chapter",
  "state_chapter":"state of the chapter",
  "course_id":"course ID of the chapter",
  "section_ids_cascade":[sec_number 1...sec_number N]
}
```

Section Collection

```
{
  "_id":"ID of the section",
  "title_section":"title of the section",
  "create_date_section":"create date of the section",
  "update_date_section":"update date of the section",
  "state_section":"state of the section",
  "chapter_id":"chapter ID of the section",
  "block_ids_cascade":[blc_number 1...block number N]
}
```

Block Collection

```
{
  "_id":"ID of the block",
  "title_block":"title of the block",
  "create_date_block":"create date of the block",
  "update_date_block":"update date of the block",
  "section_id":"section ID of the block"
}
```

Prerequisite Collection

```
{
  "_id":"ID of the prerequisite",
  "description_prerequisite":"description of the prerequisite",
  "create_date_prerequisite":"create date of the prerequisite",
  "update_date_prerequisite":"update date of the prerequisite",
  "course_id":"course ID of the prerequisite"
}
```

Objective Collection

```
{
  "_id":"ID of the objective",
  "description_objective":"description of the objective",
  "create_date_objective":"create date of the objective",
  "update_date_objective":"update date of the objective",
  "course_id":"course ID of the objective"
}
```

6 Prototyping a Disciplinary Information Space Based on Symfony Framework

6.1 Symfony framework

We have chosen to develop our LMS via the Symfony framework, for the following objectives:

- It aims to speed up the creation and maintenance of websites
- It has a low performance overload used with a bytecode cache
- It aims to create robust websites and aims to give developers full control over the configuration.

Table 3 describes the schema of the course and chapter collections of the NoSQL MongoDB database, of the disciplinary information space.

6.2 Prototyping a disciplinary information space

In this subsection, we limit ourselves to presenting the general information interface of the course in the disciplinary information space.

General information interface: In the latter (see Figure 3), the author/teacher has several privileges, which he needs for the creation of a course, which respects academic standards. For this, we have given the author/teacher the right to:

- Add a general title, an image, and a short description of a course, which are displayed when the course appears for the first time
- Add a short introduction, the details, and the conclusion of a course, which are displayed if the learner wants to see more details about the course
- Select the start and end date of a course, which indicates the duration of a course session, thus, they allow you to close the session if the course duration has elapsed
- Determine the license of a course, to respect copyright
- Add the difficulty index of a course, to recommend the courses adapted to the level of each learner
- Choose the language of a course, to recommend the course adapted to each learner
- Choose the course area, to simplify the search for a course by area.

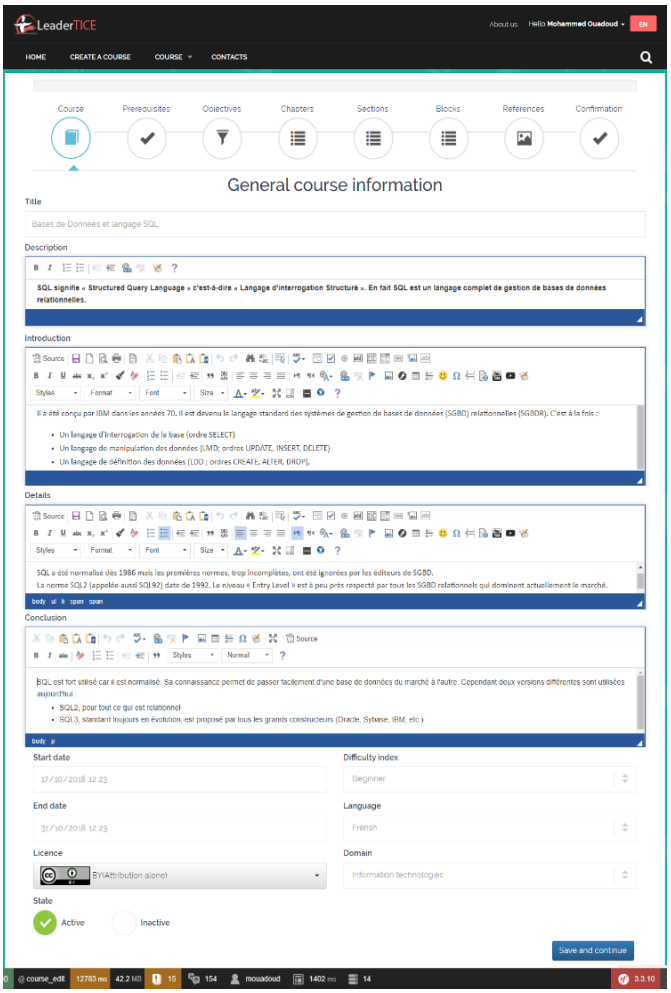

Fig. 3. General information interface of the course developed by the NoSQL MongoDB database and the Symfony framework

The prerequisite course interface: In the course prerequisite interface (see Figure 4); the author/teacher has several privileges, which he needs to create the objectives of a course that meet academic standards. For this, we have given the author/teacher the right to quote the prerequisites so that the learner can start the session of the course.

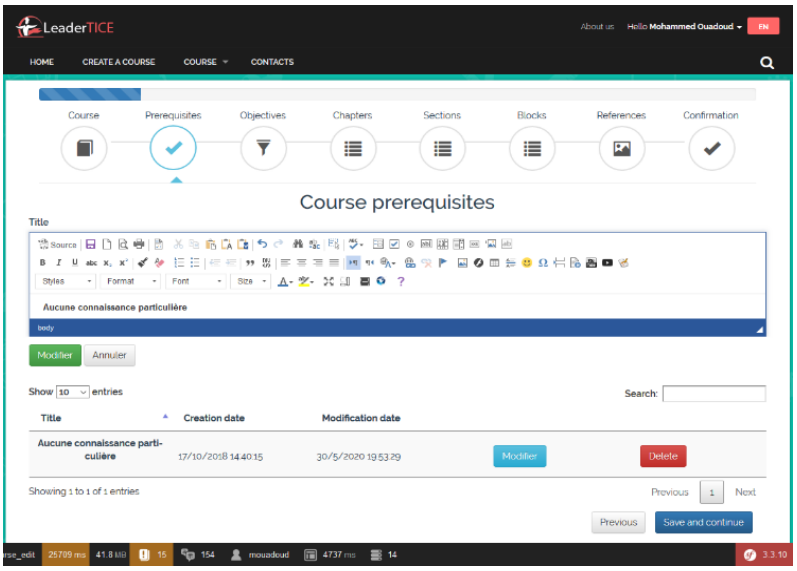

Fig. 4. Course prerequisite interface developed by the NoSQL MongoDB database and the Symfony framework

The course objectives interface: In the course objectives interface (see Figure 5), the author/teacher has several privileges, which he needs to create the objectives of a course that meet academic standards. For this, we have given the author/teacher the right to cite all the objectives of the course so that the learner can determine if the course meets his needs.

The course chapters interface: In the chapters interface of the course (see Figure 6, the author/teacher has several privileges, which he needs for the creation of the chapters of a course which respect the academic standards. For this, we have given the author/teacher the right to insert the title, introduction, and conclusion of all chapters of a course that the learner can determine if the course meets his needs.

To make the chapters of the course active, by clicking on the checkbox "active", if the chapters are well written, or leave it inactive, by clicking on the checkbox "inactive", if the chapters require certain modifications.

- Make the general course information active, by clicking on the “active” checkbox, if the general course information is well written, or leave it inactive, by clicking on the “inactive” checkbox, if the general information of the course requires certain modifications.

The sections interface of a chapter: In the section interface of a course chapter (see Figure 7), the author/teacher has several privileges, which he needs for the creation of chapter sections that comply with academic standards. For this, we have given the author/teacher the right to choose the chapter in which he wants to add sections. For each section of a selected chapter, the author/teacher can insert the title of the section and the type of media to use (text, audio, video, etc).

To make the section active, by clicking on the “active” checkbox, if the section information is well written or leave it inactive, by clicking on the “inactive” checkbox, if the section information requires some modifications.

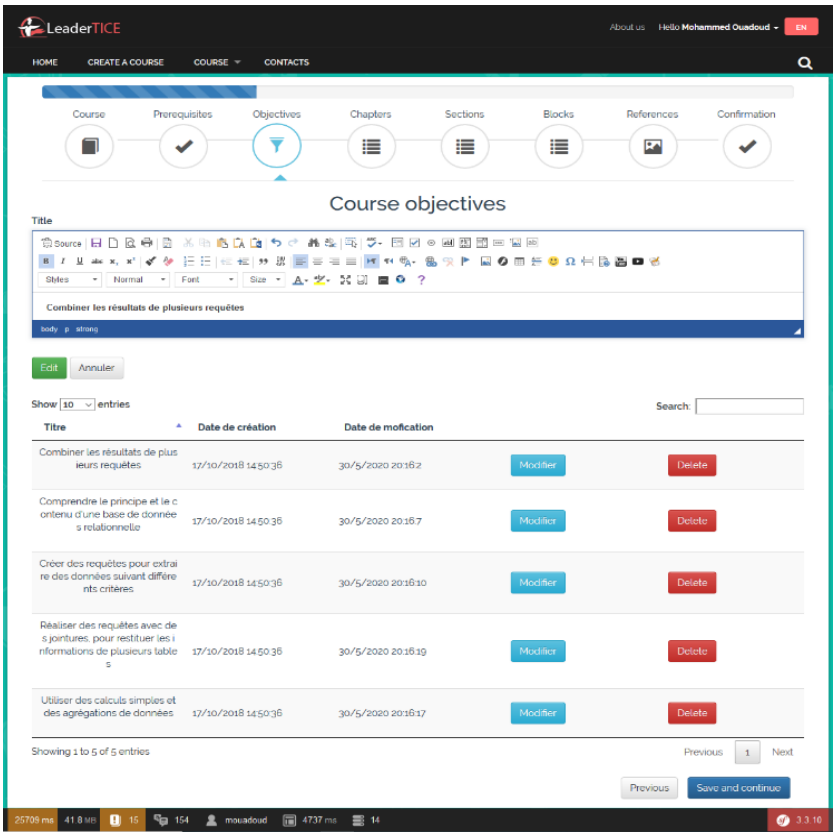

Fig. 5. Course objectives interface developed by the NoSQL MongoDB database and the Symfony framework

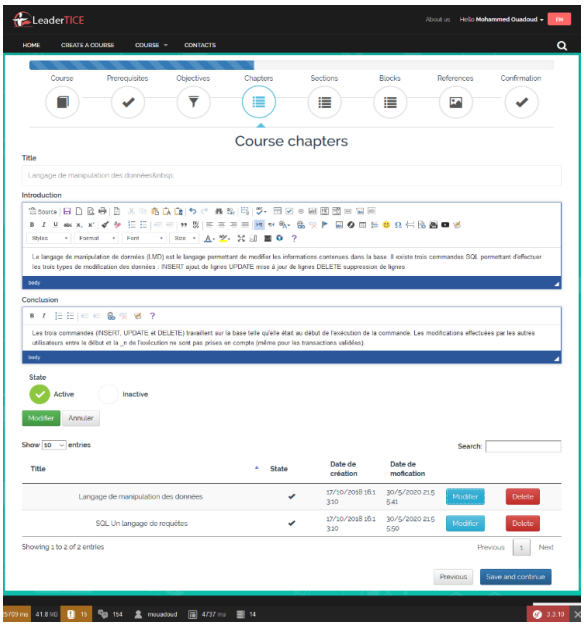

Fig. 6. Course chapters interface developed by the NoSQL MongoDB database and the Symfony framework

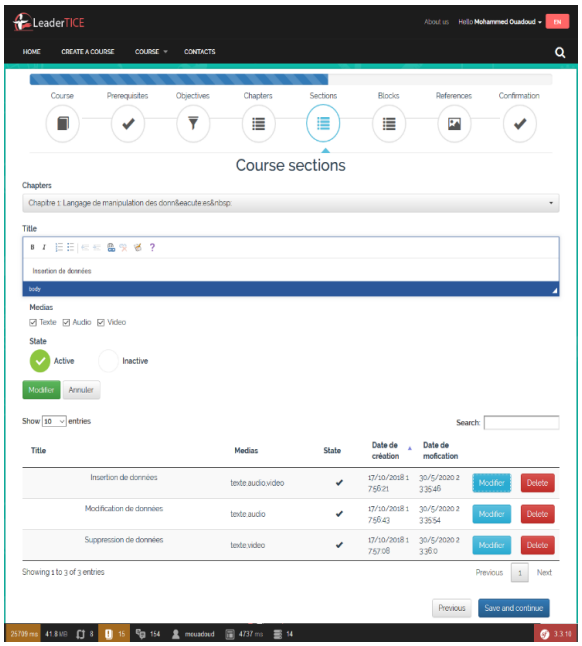

Fig. 7. Course sections interface developed by the NoSQL MongoDB database and the Symfony framework

The block interface of a section: In the block interface of a chapter section (see Figure 8), the author/teacher has several privileges, which he needs to create the blocks of a section that meet academic standards. For this, we have given the author/professor the right to choose the chapter and section in which he wishes to add blocks. For each section block of a selected chapter, the author/teacher can insert the title and the content of the block.

To make the block active, by clicking on the “active” checkbox, if the block information is well written, or to leave it inactive, by clicking on the “inactive” checkbox, if the block information requires some modifications.

The course references interface: In the course references interface (see Figure 9 – Appendix), the author/teacher has several privileges, which he needs for creating a course references that meet academic standards. For this, we have given the author/teacher the right to:

- Select the type of reference (article, chapter, book, thesis, manuscript, report, web page, etc.
- Add a title, publication date, and a summary of the reference
- Add the list of authors, to indicate the first, second ... until the last author for each reference
- Indicate the volume, issue, DOI, publication journal and numbers of the start and end page, to simplify the search for each reference.

Make the reference active, by clicking on the “active” checkbox, if the reference information is well written, or leave it inactive, by clicking on the “inactive” checkbox, if the reference information requires some modifications.

The general plan interface of a course: In the interface "general plan of a course" (see Figure 10 – Appendix), the learner has the right to see all the chapters, sub-chapters, and references of a course. He also has several means, which he needs to better understand a course that respects the learning style of each learner (visual, auditory, or audiovisual). For this, we gave the learner the right to choose the learning medium suited to his learning style, audio, video, image, text.

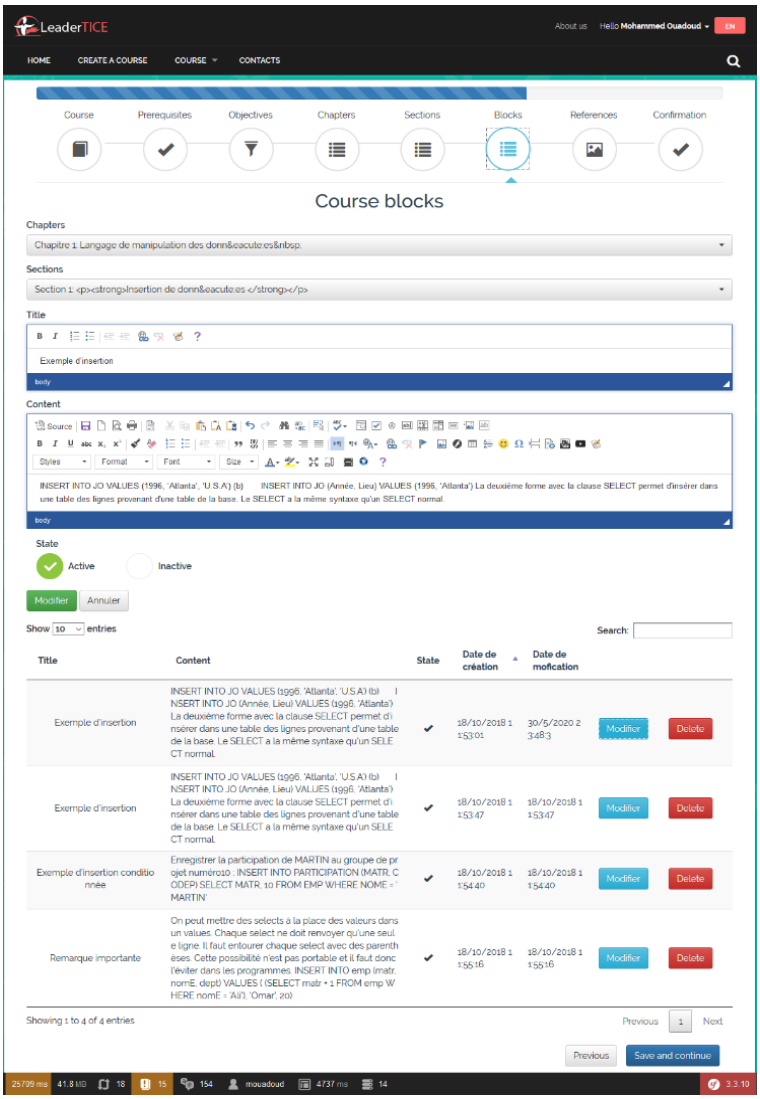

Fig. 8. Course blocs interface developed by the NoSQL MongoDB database and the Symfony framework

To make the section active, by clicking on the “active” checkbox, if the section information is well written or leave it inactive, by clicking on the “inactive” checkbox, if the section information requires some modifications.

The course details interface: In the “course details interface" (see Figure 11 – Appendix), the learner has several means, which he needs to better understand a course that respects each learner's learning style (visual, auditory, or audio-visual). The system after several choices of means of learning, few recommend the means of learning

adapted to the learning style of each learner. At the end of each chapter, the learner must click on the following symbol to go to the next chapter.

7 Conclusion and Perspectives

We are on our way to the design and modeling of a new LMS compatible with IMS-LD and NoSQL. This conception is based on active teachings centered on the learner, from which we opted for four learning theories as the teaching and learning base of this new LMS, namely traditional pedagogy, behaviorism, cognitivism, and social constructivism. This LMS allows us to achieve an educational object through the implementation of projects, activities and quizzes which are divided into tasks performed by the students, in collaboration or individually. To achieve our goal, we will develop the rest of our LMS via Symfony framework, which will facilitate the implementation phase.

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10 Appendix

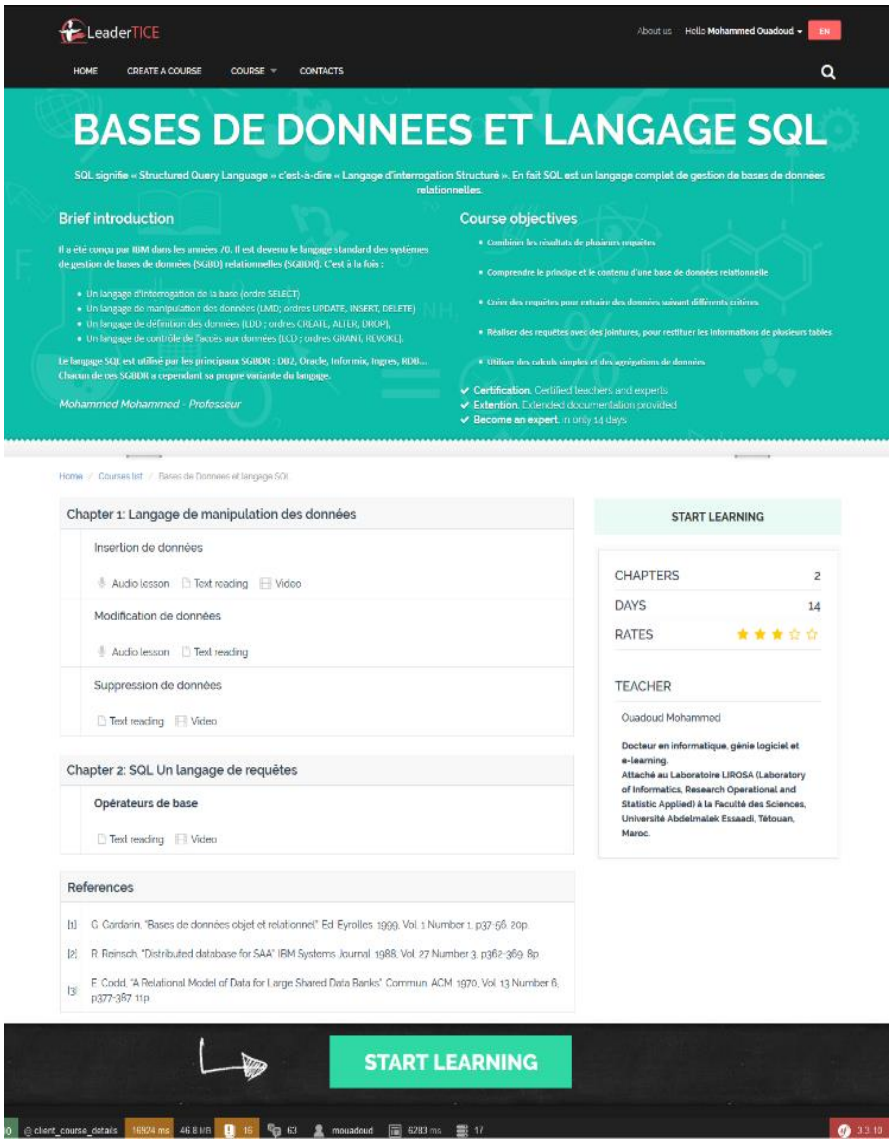

Fig. 9. General plan of a course developed via Sumfony Framework

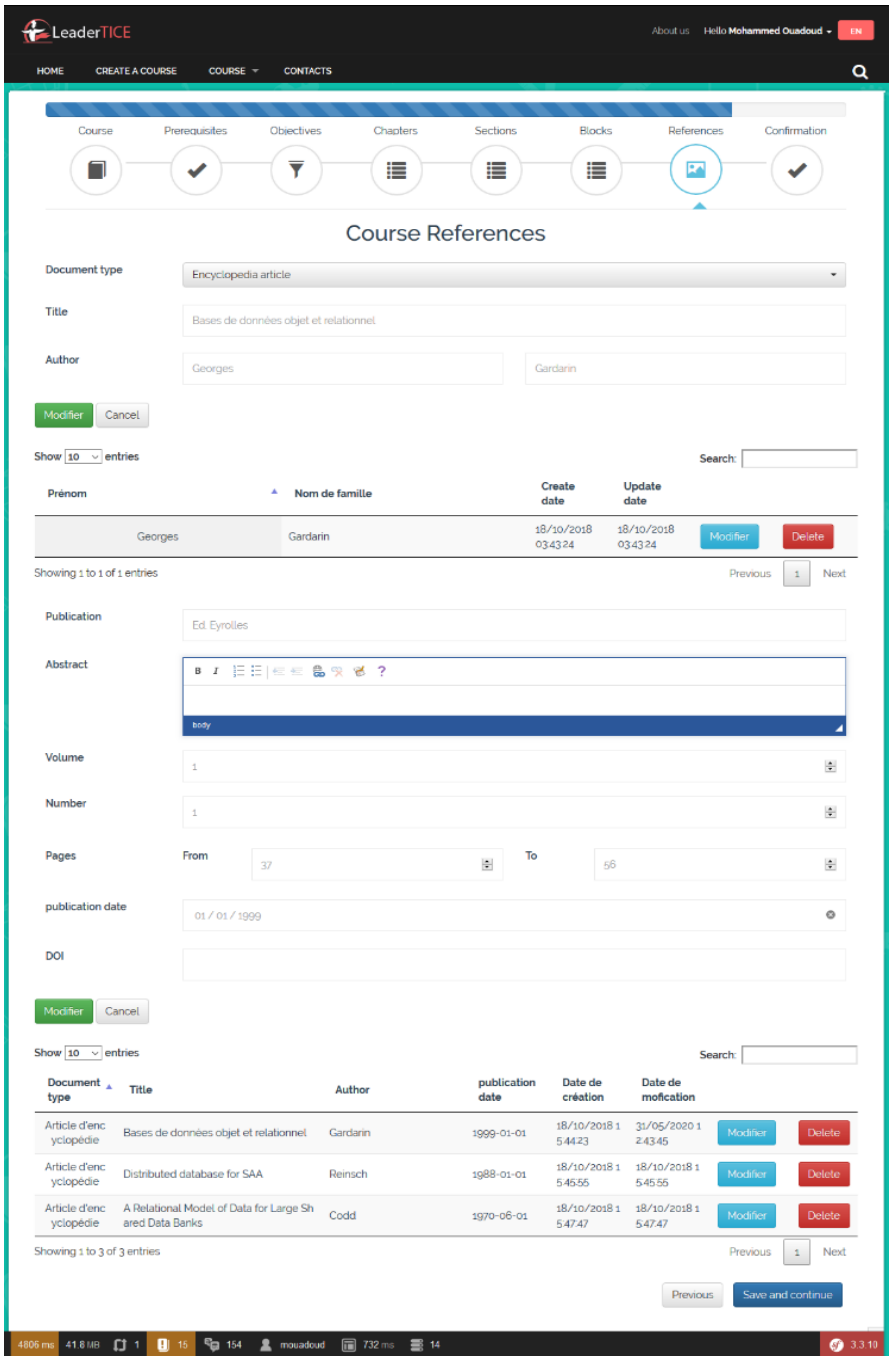

Fig. 10. Course references interface developed by the NoSQL MongoDB database and the Symfony framework

Fig. 11. Details of a course developed via Symfony Framework