Asynchronous Learning Management System - The Case of

Federal University of Technology (UTFPR)

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Abstract—Mobile Learning has been emerging as a new research branch of learning, in which mobile devices are explored during the learning process. The development of these applications, however, is a non trivial task since it requires skills and knowledge of various domains (computational, pedagogical, etc.), along with technologies to support the process. This paper describes a case study at UTFPR, with the objective of integrate mobility, not only in terms of learning through mobile devices, but also in terms of mobile participants and mobile administration. The case study focuses on a generic and asynchronous computer architecture (PEDRO), based on a the Moodle-based adaptation. Our proposal allows the Learning Management System and mobile devices to work together in order to provide a complete set of instructional materials to students.

Keywords–Moodle; Learning Management Systems; Mobile Devices.

I. INTRODUCTION

In spite of common beliefs, learning is not confined and the inclusion of remote experiments on mobile devices is a reality. In fact, students are always learning, no matter the place they are. However, there are learning environments and learning management systems [1] where this skill is maximized, being the most common: the schools. Traditional schools have some disadvantages [2], namely student's attention is not well focused and teachers and students must all meet in a common place, so that knowledge can be transmitted.

The popularization of Mobile Devices (MDs), such as "tablets" and "smartphones", for example, enabled an alternative learning method for students. MD has been used as tool access to information and execution of activities. Examples include teaching of science [3] and mathematics [4], among others.

Text editors, spreadsheets, production of videos and photos or playing electronic games can be accessed from any place and time, and can be easily integrated with a learning environment. Nevertheless, participants can also function as mobile learners in the sense that they may use the application any time and anywhere, in informal settings, in the course of their everyday activities.

The potential use of these devices has been promoting a new set of research possibilities and challenges for the community of Computing in Education [5], and their final use in a Virtual Learning Environment (VLE). The possibility of a student using a MD to access classes instigates alternatives

of how to explore traditional environments. One of the great challenges for developing for MD applications [6] is their limited capacity when compared to personal computers. Another challenge appears when we consider that not necessarily all MDs have 24 hour access to Internet.

This paper addresses these issues in a case study at UTFPR, with the objective of integrate mobility. The case study focused on a generic and asynchronous computer architecture (PEDRO - portuguese acronym for "Programa de Ensino e Desenvolvimento Remoto Off-line" - Offline Learning and Remote Development Tool), based on a Moodle [7] adaptation. The novelty resides on a flexible architecture which explores (i) mobility not only in terms learning through MDs, but also in terms of mobile participants, and mobile administration; and (ii) the background infrastructure (software, hardware), considering network traffic and different locations.

A. A Motivating Example

For instance, consider the infrastructure for the Federal University of Technology - Paraná (Brazil), with 12 different campus (Utfpr Pato Branco 'A' , Utfpr Medianeira 'B' , Utfpr Campo Mourão 'C' , Utfpr Cornélio Procópio 'D' , Utfpr Curitiba 'E' , Utfpr Dois Vizinhos 'F' , Utfpr Francisco Beltrão 'G' , Utfpr Guarapuava 'H' , Utfpr Londrina 'I' , Utfpr Apucarana 'J' , Utfpr Ponta Grossa 'K' , Utfpr Toledo 'L'), as shown in Figure 1.

The university aims to integrate mobility, not only in terms learning through MDs, but also in terms of mobile participants and mobile administration. In this case, the participants are mobile learners in the sense the same course (in a VLE) can be available to several locations, and participants can remotely interact with MDs. In the same way, the system administration should be flexible in order to have structural and data updates from different locations, maintaining an architecture which can be easily adaptable in order to receive new requirements.

The background infrastructure (software, hardware) should also have an easy integration with the new proposed architecture. Since the institution has several locations (far apart from each other), with their respective users, the network traffic is another parameter which can result in a bottleneck (consider for example, that a specific course might be composed by several videos, which are transfered to one central campus to others).
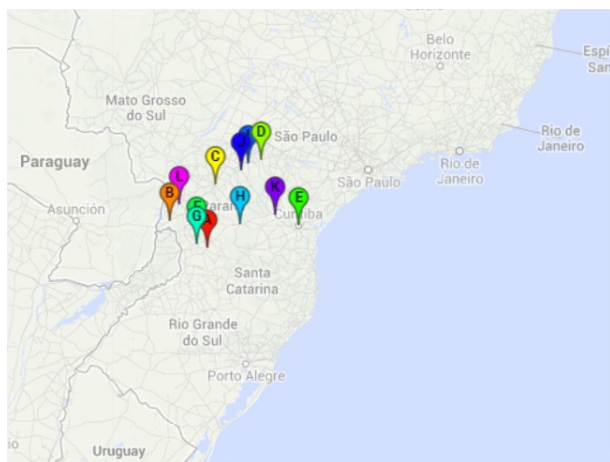
Figure 1: The 12 UTFPR campus location provided by Google Search Engine.

Briefly, the interdisciplinary efforts may vary in several domains: (i) from the database perspective, the challenge is how to explore available learning systems within the institution with the minimal set of tables in order to have efficiency (and to enable any future integration with other systems); (ii) from the network perspective, the challenge is how to exchange a great amount of information within several campus and do not have a bottleneck; (iii) from the hardware perspective, the challenge is how to store a set of courses within the minimal amount of memory and space available within the MD; (iv) from the MD lifetime perspective, the challenge is how to decide which information should be deleted/compressed, due to limited space; (v) from the pedagogycal perspective, the challenge is how to explore all this structures and have a motivated student which is responsable for his main learning; (vi) from the design perspective, the challenge is how to adapt an interface which explores the MD interface; among others.

In this paper, we explore the term of mobility, along with the mentioned interdisciplinary efforts, through a case study PEDRO, a generic architecture proposed for mobile learning and administration. The novelty resides on the idea that not only students may interact with a remote and offline learning system, but also administrators and professors.

B. Organization

The remainder of this paper is organized as follows. Section 2 contains a description of related work. An overview of our solution is described in Section 3. Finally, we offer our conclusions and future work in Section 4.

II.   RELATED WORK

Mobile learning involves the use of mobile technology, either alone or in combination with other information and communication technology, to enable learning anytime and anywhere [8]. Learning can be explored in a variety of ways: people can use mobile devices to access educational resources, answer assignments, connect with others, or create content.

Multiple initiatives have explored ways to integrate or use MDs in learning situations [9]–[13]. If we consider room

classes [14], for example, solutions with good results with MDs have already been presented. At this work, students are questioned by teacher during the class and answers should be provided by MDs. A central computer system summarizes these answers, processes them, and the teacher instantly presents a summary of choices of students, by means of graphs and tables.

Other initiatives focused on distance education and MDs (allowing students to interact in discussion forums [15]) or generic frameworks delimited by Pedagogical and Technological domain [5].

Some other research initiatives have been developed with the purpose of allowing customization of MD contents. For example, da Silva et al. [16] presents a recommendation system for learning objects based on Sharable Content Object Reference Model [17], using agents and ontologies.

In their system, agents located on the server monitor the activities of the student. The selection of Learning Objects (LO) is made by comparing the choices of students. The LOs which were more accepted by students of similar behavior were recommended to a new student added to an activity.

Another example of a system which allows the customization of learning objects sent to the MD is presented by Orlandi and Isotani [18]. In this system, a tool for initial diagnosis identifies which objects should be available to students. The architecture defined within this paper also provides lists of exercises with automatic correction. The main difference resides with the "feedback" messages which can be sent to students.

All the systems presented above centralize a data server or applications. But, there are also other initiatives which do not require a centralized element (such in [19]). In this architecture, three heterogeneous agents (Social, Interface, and Collector) are scattered within different mobile devices to interact. Similar to [16], it explores the concept of Context Environment, storing geographic information to recommend suggestions for student interaction.

Among the more than 200 VLEs available on the market [20], Moodle [7], along with several extensions [21] has been highlighted by the number of users and servers installed around the world, mainly by its low cost, it is free software, and for different features depending on the configuration [22].

In the context of the research presented within this paper, the MD remains disconnected from the Internet most of the time. The internet connection is sporadic and should receive assignments and evaluations (accessed through an adapted version of Moodle), returning the tasks performed by the student. In this context, none of the investigated architectures could be easily adapted as a solution.

III.   OVERVIEW OF OUR SOLUTION

In this section, we outline PEDRO architecture, along with the Moodle-based adaptation, and the respective usage.

A. PEDRO Architecture

From a theoretical perspective, PEDRO architecture is composed by a Embedded Learning Environment (ELE) and a VLE, as shown in Figure 2. Basically, the participant interacts

with the system through MB (the ELE at Figure 2). After the login, the interaction and embedded modules are activated. Here, the participant can explore the available courses and assignments, having all the activities logged. When the participant accesses the internet, the communication module gets the next available assignments and sends the assignments already answered, along with any additional information that should be exchanged within the main server.
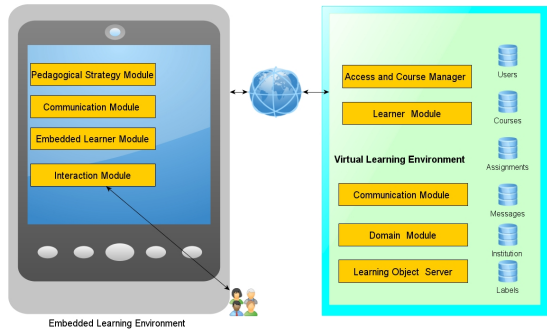

Figure 2: PEDRO architecture.

The ELE consists of four modules: the pedagogical strategy model, the communication module, the embedded learner module, and the interaction module.

The pedagogical strategy module is responsible for setting and controlling how instructional materials (videos, PDFs, assignments, etc.) will be accessed by the student. Three types of assignment strategies were adopted:

- Simple: assignments are accessed one by one, according to a specific order. This order was set by the teacher during the authoring process. Consider for example, that a specific course is divided into 12 topics, and all the available participants explore them, one by one, in an ordered sequence.

- Conditional: assignments are accessed only if aspecific condition happens. Consider for example, that a participant have to provice an answer to an assignment only if the average grade is less than a specific value.

- Random or free: the student has the freedom to access the assignment if he/she wants. It is not necessary to follow any order.

Note that the pedagogical strategy model is implemented through modules and sections of the available course.

The communication module is responsible for communication with the MD with the VLE. It mainly which information (such as assignment answers) is exchanged with the VLE. Note that the exchange information is stored within XML files.

The embedded learner module is a structure which stores information activities and instructional materials that still have to be accessed.

And finally, the interaction module is responsible for the student interaction with the MD, along with the log of this interaction.

The VLE provides five modules: the access and course manager module, the learner module, the communication module, the domain module, and the learning Objects server. The access and course manager module identifies which courses a student is enrolled (along with related information). This module comprises the information modified by the system administration.

The learner module comprises a structure which stores the tasks and instructional materials accessed by participants. The communication module is responsible for communicating with the MD. The domain module stores the course instructional materials. The learning objects server manages a set of learning objects, evaluation, and pedagogical strategy defined by the course author.

At the server side, the course and access manager receives the participant request access, and processes the following requests:

- Verify if the participant is registered within the system (through Moodle);

- If the participant is not registered within the system, the user will have access to the registration form available in the system;

- If the participant is registered within the system:
  1) Log the activities already performed by the participant;
  2) Check the course assignments for the respective participant;
  3) Compare the available activities with the performed activities by the participant;
  4) If the lists have different items, proceed with the next assignments that should be send to the participant;
  5) Check available space at MD, and compare with the required space for the next assignments that should be sent to the participant. If any issue arise, the manager should be informed;
  6) Pack all the required information and send to MD though the communication module; and
  7) Log all the required information.

The random access to the ELE with the VLE is the main requirement of the architecture presented within this paper. Since the user does not have full-time access to internet, there is an effort to identify which set of information should be presented to the student.

So, in this sporadic access, the environments should exchange the greater amount of relevant information to the educational process. This type of information exchanged between the mobile device and the VLE have already been called "Context Sensitive Information" [23].

In closing this sporadic access, the ELE is able to partially track and monitor the student. This task consists of monitoring and recording the following information: i) answers to assignments, ii) tasks, iii) readings, iv) videos, v) applications used in MD, and vi) MD storage space.

Unlike some of the initiatives presented in Section 2, the selection of information to be sent to the MD does not consider
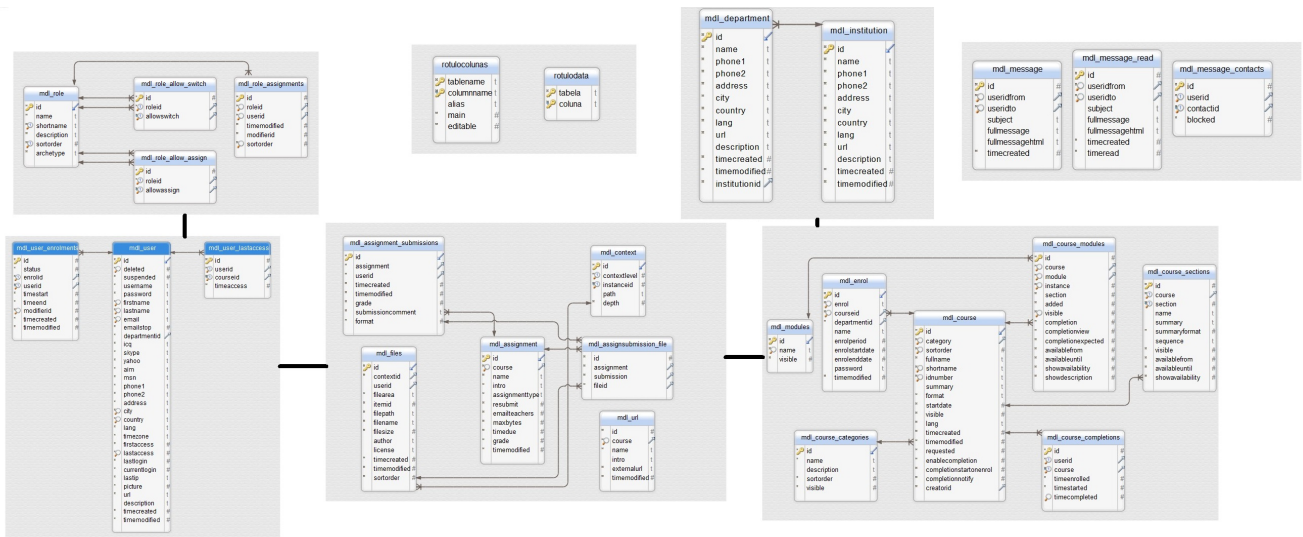
Figure 3: The complete set of database tables grouped by module.

the location of the student [16], [23], the effect of long-term reading texts on screen [24], among other criteria.

In summary, the architecture shares the following features between ELE and VLE: (i) log the student's interactions with the assignments; (ii) report student activities in MD; (iii) identify which instructional materials should be sent to the MD; (iv) allow the student to have access to free and guided instructional materials; (v) interpolate the various types of instructional materials; and (vi) explore mobility not only within an learning environment, but also through the management context.
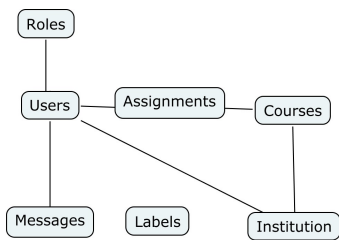
B. Adapting Moodle

Figure 4: The main modules used within the project.

As a background to store all the information within the ELE and VLE environments, Moodle was adopted (the environment was already used as a basic software within the institution). The initial 2.4 version database (305 tables) was enhanced to a smaller set of tables (27 - Figure 3), resumed in 5 modules (Figure 4): roles, users, course, messages and assignments. The role module is responsible for defining roles, their names, permissions and how they are assigned to users. The users module is used to registering all the users within the system, along with their last access, and enrollments. The course module stores all the information within available courses. The message module is responsible for storing messages exchanged

among users. Finally, the assignment module is used to assign an activity for a student enrolled within a course.

Besides the available modules, two new groups of information were created (as shown in Figure 4): institution and labels. The institution module is responsible for storing all available institutions within the project, with respective departments. Since Moodle is an english-based system, the label module has the objective of creating user-friendly descriptions for the available tables.

Note that *mdl_enrol* table, initially available at Moodle enrollments module, is represented here within the *course* module. The complete list of tables is listed within Figure 3, divided by module. Each table was also adapted to store only the relevant attributes for the project. In order to enhance optimization, foreign keys and tablespaces were added.

C. PEDRO Usage

PEDRO usage is explored under the VLE by a remote management web page, and under the ELE by the MD interface. The remote management web page has the objective of providing a flexible way of locally or remotely update the database structure, data, and labels to administrative users.

Within PEDRO architecture (Figure 2), the remote management web page explores the access and course manager module. The 27 Moodle-based tables (shown in Figure 4) can be explored through (i) their table structure (with respective columns, primary and foreign keys), (ii) data, and (iii) labels.

Figure 5 presents a printscreen from the database tables. If an administrator needs to update the data structure from table mdl_assignment for example, the administrator is redirected to another web page (Figure 6). Labels are used in order to present a more friendly portuguese description to users. So, despite using an english-based system, a manager could update a specific table (such as mdl_assignment shown in Figure 5) to have a friendly translation to participants.

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Lista das Tabelas

Estrutura de Telas

#	table_name	Estrutura	Dados	Rótulo
1	mdl_assignment	Visualizar	Visualizar	Alterar
2	mdl_assignment_submissions	Visualizar	Visualizar	Alterar
3	mdl_assignsubmission_file	Visualizar	Visualizar	Alterar
4	mdl_context	Visualizar	Visualizar	Alterar
5	mdl_course	Visualizar	Visualizar	Alterar
6	mdl_course_categories	Visualizar	Visualizar	Alterar
7	mdl_course_completions	Visualizar	Visualizar	Alterar
8	mdl_course_modules	Visualizar	Visualizar	Alterar
9	mdl_course_sections	Visualizar	Visualizar	Alterar
10	mdl_department	Visualizar	Visualizar	Alterar
11	mdl_enrol	Visualizar	Visualizar	Alterar
12	mdl_files	Visualizar	Visualizar	Alterar
13	mdl_institution	Visualizar	Visualizar	Alterar
14	mdl_message	Visualizar	Visualizar	Alterar
15	mdl_message_contacts	Visualizar	Visualizar	Alterar
16	mdl_message_read	Visualizar	Visualizar	Alterar
17	mdl_modules	Visualizar	Visualizar	Alterar
18	mdl_role	Visualizar	Visualizar	Alterar
19	mdl_role_allow_assign	Visualizar	Visualizar	Alterar
20	mdl_role_allow_switch	Visualizar	Visualizar	Alterar
21	mdl_role_assignments	Visualizar	Visualizar	Alterar

Figure 5: The main development web page for to visualize and alter the structure, data and labels.

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Lista os Rótulos das Colunas da Tabela mdl_assignment

#	column_name	data_type	is_nullable	main	editable	alias	Alterar Rótulo
1	timemodified	bigint	NO	0	0	Data da Ultima Modificacao	Data da Ultima Modificacao — Editable — Main ☐
2	grade	bigint	NO	0	0	Nota	Nota — Editable — Main ☐
3	timedue	bigint	NO	0	0	Data Maxima para Submissao	Data Maxima para Submissao — Editable — Main ☐
4	maxbytes	bigint	NO	0	0	Tamanho Maximo do Arquivo	Tamanho Maximo do Arquivo — Editable — Main ☐
5	emailteachers	smallint	NO	0	0	Email dos Professores	Email dos Professores — Editable — Main ☐
6	resubmit	smallint	NO	0	0	Permissao para Resubmissao da Tarefa	Permissao para Resubmissao — Editable — Main ☐
7	assignmenttype	character varying	NO	0	0	Tipo da Tarefa	Tipo da Tarefa — Editable — Main ☐
8	intro	text	NO	0	0	Descricao	Descricao — Editable — Main ☐
9	name	character varying	NO	0	0	Nome da Tarefa	Nome da Tarefa — Editable — Main ☐
10	course	bigint	NO	0	0	Identificador do Curso	Identificador do Curso — Editable — Main ☐
11	id	bigint	NO	1	0	Identificador da Tarefa	Identificador da Tarefa — Editable — ☑ Main ☐

Voltar Salvar

Figure 6: The main development web page for alter table mdl_assignment table.

Finally, Figure 7 presents the graphical interface available at the ELE. Note that at the left side three courses are presented (mathematics, portuguese, and history), along with the portuguese course structure at the left side of the image. The information exchange between VLE and ELE is provided by an XML file, as shown in Figure 8. Note that (i) the first block shows the studen information (such as name, number of courses, etc.), (ii) the second block presents the information for the first course (such as name, author, and amount of classes), (iii) the third block presents the information for the first class, followed by (iv) the list of the available activities comprising the first class.

As long as the participant finishes each of the available tasks, tag "when" is completed with the respective date/time of the action (as shown in the last line from the fourth block from Figure 7). Note that the ELE interface (in java) is quite simple (in sense of design) in order to process the XML file along with the integrated files, under the available MD memory.

Our solution used Moodle version 2.14, Postgres 9.1.9, PHP, Java, and Android-Java. In particular, the same architecture could be easily translated to other languages, and explored under other domains, such as basic learning in industry (for home office employees). This strategy can provide a flexible way of foster knowledge dissemination, under a low cost, and reusing an available infrastructure.

The course "Portuguese Language: necessary revisions I", is the pilot project, which will be realized in School Francisco Zardo (Curitiba, Paraná), with 18 students from 12th grade, using PDF and MP4 video files. The available Moodle server will be located at UTFPR Curitiba, which distances 11 KM from the school. Next experiments include all other campus locations provided by Figure 1.
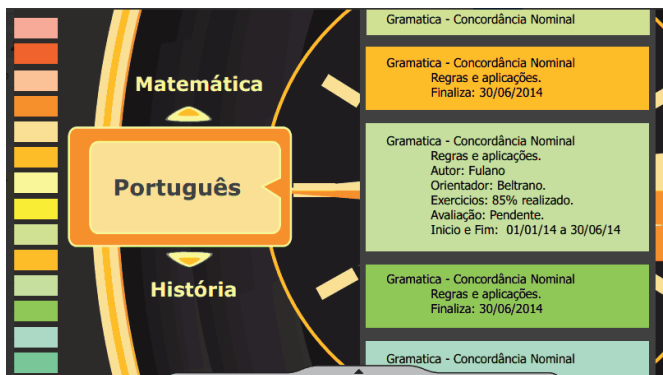
Figure 7: The graphical interface available at the ELE.

```xml
<student>
    <name>John</name>
    <password>1234</password>
    <numberOfCourse>3</numberOfCourse>
    <typeOfNavigation>1</typeOfNavigation>
    <course>
        <id> 1</id>
        <name>Gramática – Concordância Nominal</name>
        <author> Robinson Vida Noronha </author>
        <status> on  </status>
        <amountOfClass> 2 </amountOfClass>
        <class>
            <id>1</id>
            <title>Introdução as conceitos básicos da disciplina</title>
            <intro>Neste tópico, voce irá estudar alguns dos conceitos
que definiram essa disciplina</intro>
            <assessment>false </assessment>
            <amountOfTask>3</amountOfTask>
            <task>
                <id>9</id>
                <titleTask>Video to be watch</titleTask>
                <typeTask> VIDEO </typeTask>
                <file>File9.mp4</file>
                <completed>false</completed>
                <when>null</when>
            </task>
            <task>
                <id>1</id>
                <titleTask>File to be read</titleTask>
                <typeTask> PDF </typeTask>
                <file>File1.pdf</file>
                <completed>false</completed>
                <when>null</when>
            </task>
            <task>
                <id>2</id>
                <titleTask>File to be read</titleTask>
                <typeTask> PDF </typeTask>
                <file>File2.pdf</file>
                <completed>true</completed>
                <when>03/15/2014 ; 15:00:00</when>
            </task>
            <completed>33.0</completed>
        </class>
        ....
    </course>
</student>
```

Figure 8: The XML file comprising the information exchanged between VLE and ELE.

IV. CONCLUSION

With the use of mobile technologies, each student will have a personal interaction in the sense that they may use the application any time and anywhere, in informal settings, in the course. This does not mean, however, that the use of mobile devices is a panacea [5].

In this paper, we addressed this issue with a case study (within Federal University of Technology) through the Moodle adaptation, a remote management web page, and PEDRO, a generic architecture concerning an Asynchronous Learning Management System and an Offline Development Tool. The proposed architecture describes the integration of i) the VLE and ii) the ELE for MD. The novelty resides on the idea that not only participants may interact with a remote and offline learning system, but also administrators and professors.

A straightforward future work consists in the inclusion of other Moodle modules (such as Scorm, Wiki, etc.), along with the architecture performance study, and a georeferenced location module.

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