New Moodle Blocks for Knowledge Management

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Abstract. The paper shows the development of a module for Moodle, used to manage the knowledge involved in the process of teaching and learning, that includes Lessons Learned, Yellow Pages and FAQs, in addition to that we developed a Knowledge-Based Monitor which performs management of the students' activities. To evaluate the module developed, we used three validations, a usability test based on Nielsen's protocol for heuristic evaluation, the functionality test where 6 users completed 41 test cases, with satisfactory results, and finally the satisfaction survey, applied to 450 Moodle users.
Keywords: Knowledge Management, Moodle, LMS, Knowledge Based System.

1 Context

The Learning Management Systems (LMS), also known as Course Management Systems (CMS), are web-based platforms that are used in e-learning. Their general functions are managing, monitoring and reporting the student interaction with the content, teacher and other students [1].

After the pioneer, Programmed Logic for Automated Teaching Operation (Plato) [2], hundreds of similar systems were introduced. An important milestone happened in 1997 when WebCT 1.0 was released and Blackboard was founded, because these two LMSs attracted millions of users. Moreover, after WebCT and Blackboard, the second milestone was the LMS Moodle (Modular Object Oriented Dynamic Learning Environment). It was introduced in 1998 and finally released in 2001[3].

In [4], the author indicates that Moodle is the most common LMS with the largest community of developers around the world and versions in many languages [4]. Data obtained in March 2016, from official Moodle statics sites confirm the mentioned fact. It has been used by more than 83 million registered users, in more than 70k registered sites around the world, and it is available in more than 100 languages [5].

Moodle and LMS have many advantages in the field of distance education, creating a student-teacher connection that results in an educational success [6]. The LMS can promote communication and interaction between students and teachers, and it is an useful tool that can contribute to the realization of an effective teaching and learning process.

The Moodle functions are accomplished in modules: site management, user management, course management, task modules, chat room module, selecting module, forum module, logging module, test module, resource module, etc., which can be integrated and applied in a course design [7]. Moodle has also an ability of tracking the learner's progress that can be monitored by both teachers and learners [3].

In addition to that, students need to be self-disciplined, meeting deadlines and working steadily over the course. Thus, immature students who are not used to taking responsibility for their own learning can struggle even with well-designed courses [8].

In Moodle, these modules are offered to teachers separately, for its use in the different courses they structure. These tools are applied to the discretion of each teacher, without being aware of effectiveness of these resources, and if the tools are used they will lead to better results. Neither of them take into account the experience that can provide them other teachers and Moodle users.

In that sense, Herrera and Latapie [9] say that in the virtual classroom, it is not enough making available to the student the necessary resources to build their knowledge, it is important that it is truly usable, intuitive and ergonomic to transform the user experience more comfortable, enjoyable and significant.

In fact in [10] the author establishes that in terms of usability, Moodle is not easy to use for both students and teachers. He describes the feeling that the platform passes in the first entry is of bewilderment. Besides that, many tools and features make it loses important aspects, for example ease of use, comfort, and usability.

Using Moodle, teachers and students gain experience, that is tacit and individual knowledge, and all the track information about the use and the student's iteration with Moodle is loaded into its database, being a tacit knowledge too, until it is analyzed and used to improve the learning and teaching process in Moodle, and somehow, this knowledge is wasted currently.

The teachers and students experience is required to be used by others. It is necessary to know what knowledge teachers acquire using Moodle, who is who and management to track information and to monitor students in Moodle, namely working with knowledge. These aspects can help to improve the usability and accessibility in Moodle use.

Peter Drucker [11] used the concept "knowledge worker" in his book "Landmarks of Tomorrow" in 1959. After this, many important authors have written about Knowledge Management (KM), as Thomas Steward [12], Ikujiro Nonaka [13], Nonaka and Takeuchi [14], Davenport [15], Prusak [16] and many others [17]. Simply, there are processes for making available the knowledge they need, to those in need, where they need them, as needed and when needed.

Then, it is necessary to structure and develop KM tools within Moodle, thus allowing better use of knowledge to harness the benefits of KM process, which the main purpose is to translate knowledge into action and this into results, and this goal is achieved when the tacit knowledge becomes explicit knowledge.

Some authors have written about the KM Techniques, [18] describes some of them, but we observe that some cannot be used with TICs, that is to say, they could not be integrated with Moodle, and we should consider only implementable techniques with Moodle.

Some papers report KM tools related with LMS. In [19] the authors present FindYourHelp, which is an additional module for Moodle that enables automatic identification of experts who make their contribution to discussion forums. This tool is based on applying text mining techniques as a supplementary analysis of students' participation in the existing environment. It allows the identification of who is who in the Moodle forum, a king of Yellow Pages.

Kuldeep Nagi [20] obtained the tracks registered in Moodle logs that were integrated with a Customer Relationship Management (CRM) application for four SME training courses offered as a part of SME Certificate program. The author's idea is to analyze the students' behavior in Moodle, to offer them alternatives and activities that can improve teaching and learning process.

Also, [21] presents an experience using Moodle wiki as an online didactic tool to develop KM processes in higher education. Throughout the study, 27 Egyptian students and 36 Italian students took part in online activities and developed interdisciplinary projects for the primary and preparatory stages while collaborating in a Wiki experience within Moodle platform.

Since now, this work has showed the development of the KM module in Moodle which includes: Lessons Learned by students and teachers, Yellow Pages of teachers, FAQs related to the use of the Moodle activities and a Knowledge-Based Monitor (KBM) which can check the student activities. These KM tools had already been conceptualized in previous work [22].

2 The Development

We developed four new tools to be inserted into Moodle, specifically we suggested: Yellow Pages, FAQs, Lessons Learned and the KBM. The KBM is a kind of a reactive agent which executes some rules for monitoring the students' activities in Moodle.

For the development of the Knowledge Management tools, we used the Scott Ambler Methodology [23], known as Agile Model Driven Development (AMDD) (Fig.1).

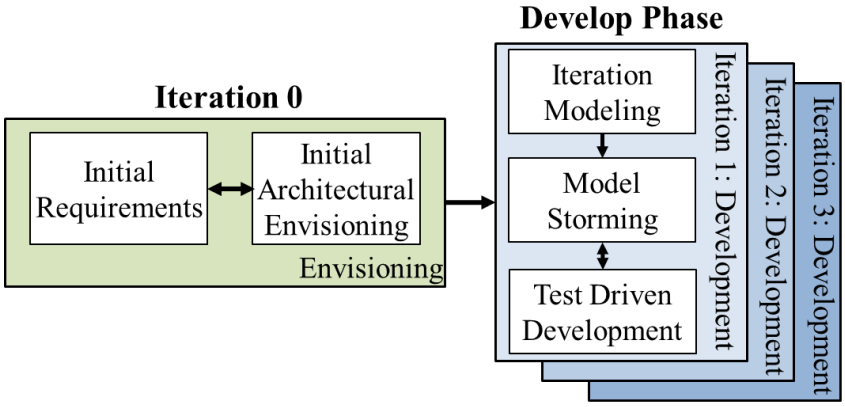

Fig. 1. Agile Model Driven Development [23]

AMDD is iterative and incremental, divided in two phases: Iteration 0, which has two activities (Initial Requirements and Initial Architectural Envisioning) and Develop phase, which has three activities: Iteration Modeling, Model Storming and Test Driven Development.

2.1 .Iteration 0

At the first phase, we developed the following three tasks:

1. The requirements analysis in which we determined the functional requirements of the KM tools that we implemented in Moodle. In this analysis, we applied knowledge acquisition techniques, specifically opening interviews and questionnaires, in which 3 teachers participated. They work in Database course, and they were very interested in this project.

The functional requirements were defined for user roles (teacher, administrator, and student) and the KBM rules that will run with the Moodle activities (forum, assignment, quiz, questionnaire, wiki, FAQ, Lessons Learned and Yellow Pages). The Figure 2 presents the use case diagram in which we show the functional requirements defined for each user role.

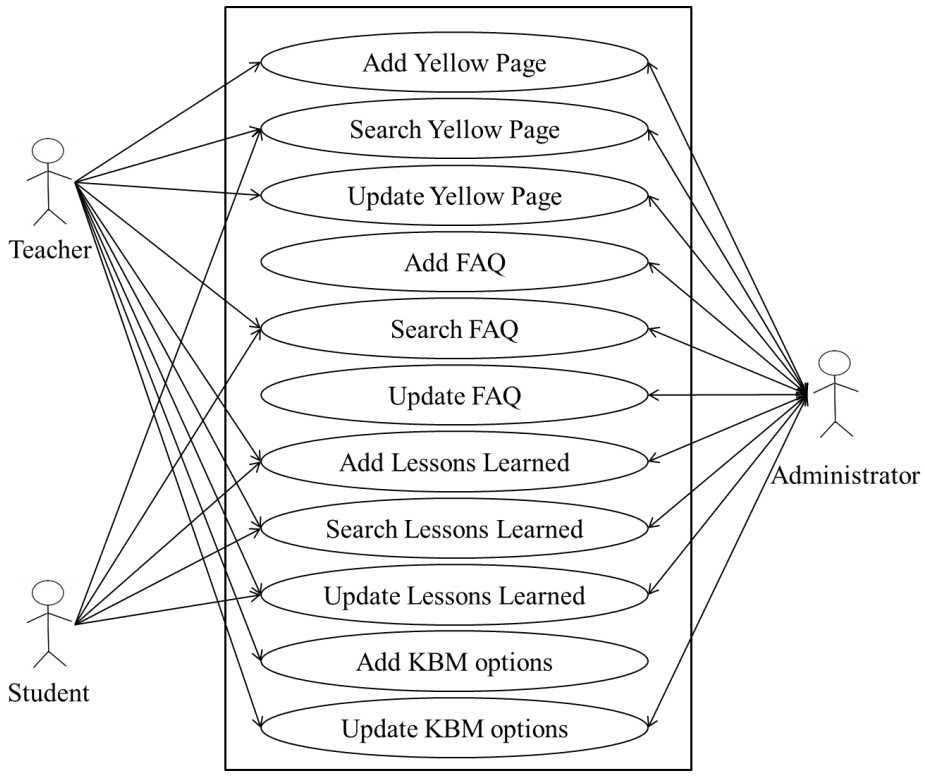

Fig. 2. Use Case of the functional requirements defined for each user role

2. The definition of the KBM rules that will run with the Moodle activities (forum, assignment, questionnaire, quiz and wiki). These rules were structured for each activity, as shown below.

- Forum (KBM's rules for the Forum)
  - RF1: When adding or modifying a forum, send a SMS and email all students.
  - RF2: 24 hours after creating a forum, send a SMS and email students who have not seen the forum.
  - RF3: 48 hours after creating a forum, send a SMS and email students who have not participated in the forum.
  - RF4: Every 24 hours send a SMS and email students who have not participated.
- Assignment (KBM's rules for the assignment)
  - RA1: When scheduling any activity, send a SMS and email all students.
  - RA2: 24 hours before any scheduled activity, send a SMS and email all students.
  - RA3: 1 hour before any scheduled activity, send a SMS and email all students.
- Questionnaire (KBM's rules for the questionnaire)
  - RQ1: When adding a questionnaire, send a SMS and email all students.
  - RQ2: 24 hours after it created a questionnaire, send a SMS and email students who have not responded the questionnaire.
  - RQ3: 48 hours after it created a questionnaire, send a SMS and email students who have not responded the questionnaire.
  - RQ4: When any student submits a questionnaire, send a SMS and email the teacher student data.
- Quiz (KBM's rules to the quiz)
  - RQZ1: When adding a quiz, send a SMS and email all students.
  - RQZ2: 24 hours after creating a quiz, send a SMS and email students who have not responded the quiz.
  - RQZ3: 48 hours after creating a quiz, send a SMS and email students who have not responded the quiz.
  - RQZ4: when closing a quiz, send SMS and email the teacher with student data.
- Wiki (KBM's rules for the wiki)
  - RW1: When adding a Wiki, send a SMS and email all students and the teacher.
  - RW2: 24 hours after creating a wiki, send a SMS and email students who have not participated in the wiki.
  - RW3: 48 hours after creating a wiki, send a SMS and email students who have not participated in the wiki.
  - RW4: When any student participates in the wiki, send SMS and email the teacher with student data.

3. The analysis of the Moodle software (programing language, database), which we determined the software tools that we should use: we should use the Moodle's programming languages (PHP and HTML), CCS that facilitates the design of the HTML page, separating structure from presentation (colors, backgrounds, and letters), and JQuery which allows the fields validation during the execution, as well as interaction with the user's server without page refresh. The Moodle's Database Management System is MySQL. We must modify and add some tables.

The other step in Iteration 0 is the Initial Architectural Envisioning, which we proposed two architectures, the first is the general architecture for the project, based on Model-View-Controller (MVC) in order to separate data, interface and control logic into three distinct components [24] (Fig.3). The second architecture is related to KBM.

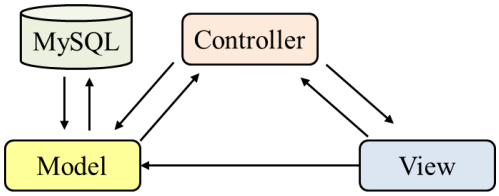

Fig 3. MVC architecture and the used software tools

The other architecture corresponds to the KBM one. It was designed as a simple reactive element which compares inputs from environments with predetermined rules to determine actions to carry out. The Figure 4 shows the KBM's architecture developed in this project.

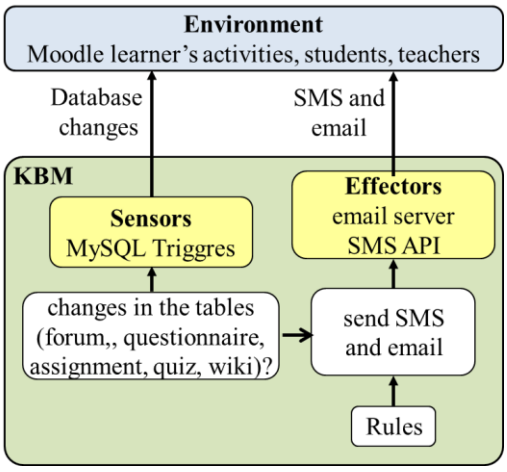

Fig 4. The Knowledge-Based Monitor

After completed the analysis and design of these architectures, we analyze how the new tools could help to manage knowledge involved in the process (Fig. 5).

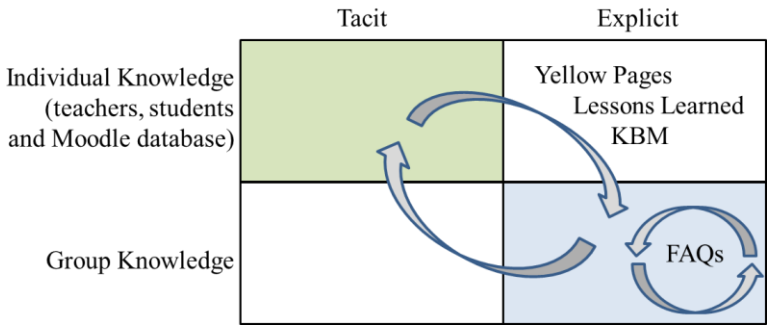

Fig. 5. The knowledge conversion: from tacit to explicit knowledge

The new tools can move the individual (tacit) knowledge to the group's domain, and transform it in explicit knowledge. Particularly, the FAQ begins in the group knowledge (teacher's group) and it flows to the student's group. In the next section, we explain the developed tools and the conversion of knowledge with these.

After Iteration 0, the Development Iterations begins, in which we modified the Moodle Database and Interface, and included the new activities (FAQs, Lesson Learned, Yellow Pages and KBM) into Moodle.

2.2 Development Iterations

This phase activities were developed in two iterations. In the first interaction, we proposed the software to develop, in compliance with the MVC architecture (Fig. 3), as shown the following:

- Controlling
  - Control_KM: The parameters are required by Moodle to recognize the additional blocks**.**
- Model
  - Md_Sql: commands for managing the database, and also verifies all parameters for each action.
- View
  - All interfaces developed in HTML with PHP and CSS for managing the KM tools in Moodle, for example insert, update or search Yellow Page, FAQs, Lessons Learned or track in the KBM.

In this iteration, we also did the Database modifications. Figure 6 shows the new tables inserted in Moodle Database, where we include: tables FAQs (mdl_faqs), Yellow Pages (mdl_pa) and Lessons Learned (mdl_lecap).

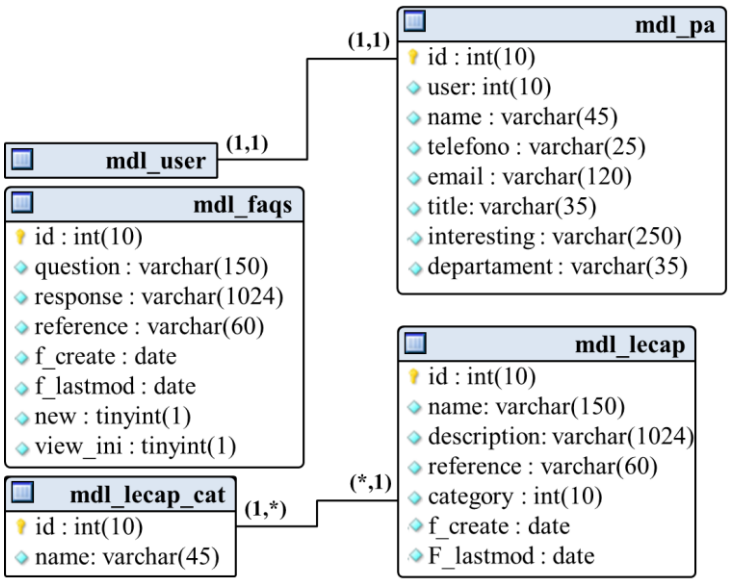

Fig. 6. New tables created in Moodle database

We also got into detail the information stored in Moodle about the student activities (logs). Above we have said that Moodle has the ability of tracking the Moodle activities. The activities tracks are recorded in its Database, and the teacher or administrator could investigate it by functionality of auditing, using the Reports Module in the Administration Block (Fig. 7).

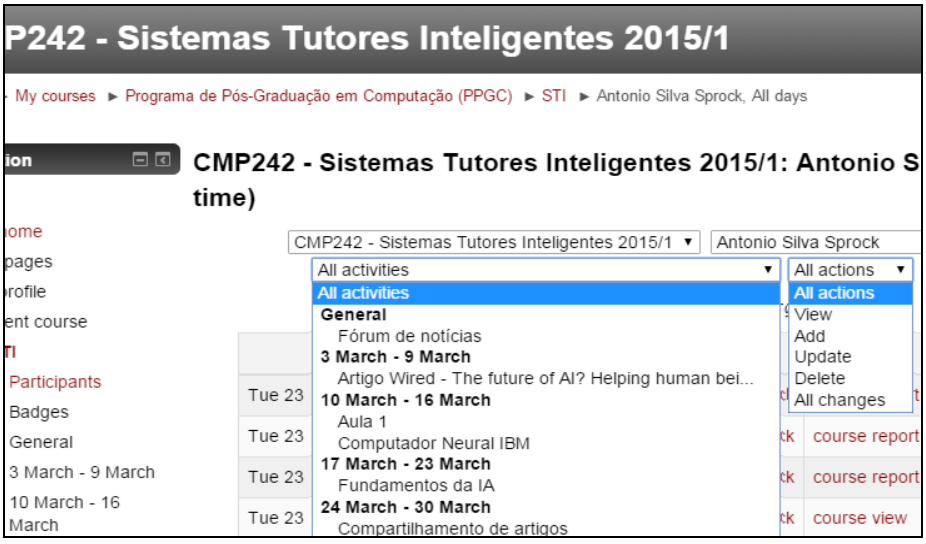

Fig. 7. Reports Module in the Moodle Administration Block

The Reports Module displays many parameters as time, group, activity, IP address, user name, actions, even they can be used for filtering as shown in Table 1.

Table 1. Activities and view options in the Moodle report module

Activities	View Options	Update Options
Forum	view discussion, search, view forum	add discussion, delete discussion, move discussion, add post, delete post, update post
Chat	view, report	Talk
Assignment	view, submission, view feedback	upload, submit
Questionnaire	view, view all	upload, submit
Quiz	view, view all, report, review	attempt, attempt, preview, edit questions, delete attempts
Wiki	Views	Post

In the second iteration, we developed the new blocks into Moodle interface, related with View and Model of the MVC. The Figure 8 shows the Moodle blocks developed, related to KM tools.

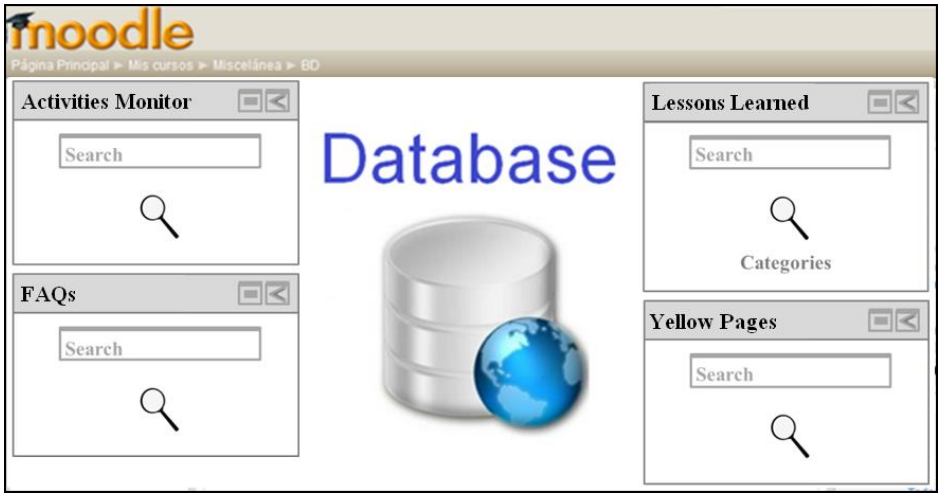

Fig. 8. KM tools blocks

In an educational environment, specifically in Moodle, users can "know who knows what" by finding and calling other teachers with specialized knowledge and skills. A good solution is Yellow Pages, used as white pages or personal directories, where personal information is collected, as well as areas of knowledge and interests of each person [25]. When the personal information is stored in the Yellow Pages, it

becomes an explicit knowledge, because it goes from each teacher until a public and general domain (Fig 9).

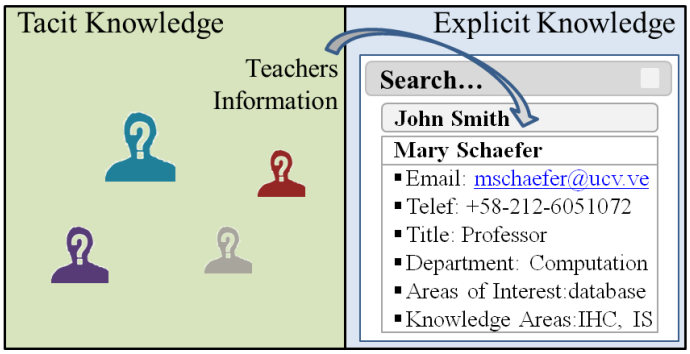

Fig. 9. The knowledge conversion with Yellow Pages

Then, when someone needs information about a topic, that person can search the list of the organization that knows him/her better and ask directly for help. These Yellow Pages are based on a technology that allows the user to find related information with users of the KM system, and in turn, it serves to encourage dialogue with people within an institution. The yellow pages help to drive the dynamism process.

The second tool is Lessons Learned, they convey knowledge gained through experience, which are applicable to a task, decision or process so that when this knowledge is reused it impacts positively on results [26]. Lessons Learned helps to convert tacit knowledge (which is in the mind and comes from the experience of teachers and students, gained using Moodle) in explicit knowledge (Fig 10).

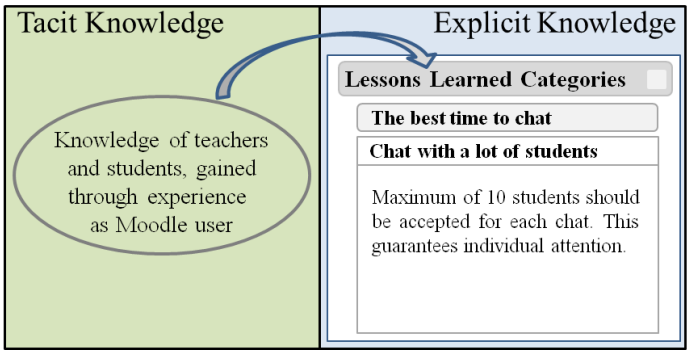

Fig. 10. The knowledge conversion with Lesson Learned

Teachers to implement a course in Moodle, effectively and efficiently, must have a comprehensive and detailed knowledge about important aspects of the activities and the platform for development course.

The other tool is FAQs. The purpose of them is to provide a tool that helps to find FAQs documents related for a query, stored in a database to help teachers in solving problems and questions that appear frequently [27].

According to [27], FAQs include the most common questions on a particular topic, by providing knowledge and strategies to assist them in finding a solution to the problem they are facing.

In this project, FAQs were structured in consensus with teachers during the process of knowledge acquisition. At this moment, knowledge became explicit for one group of teachers and when we implemented FAQ in Moodle, the knowledge moved to a larger group of teachers (Fig. 11).

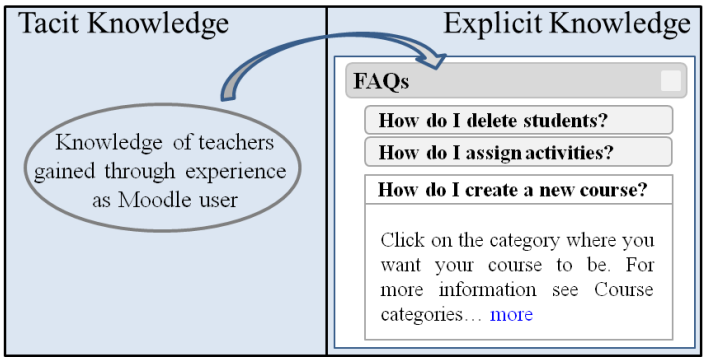

Fig. 11. The knowledge conversion with FAQs

The last developed tool is the KBM. This is composed of PHP code and Database Triggers for managing the Moodle Logs. This Log stores the student activities, indicated in Table 1. This information is tacit knowledge, and when it is manipulated for student tracking, then the knowledge conversion occurs and the tacit knowledge becomes explicit knowledge (Fig. 12).

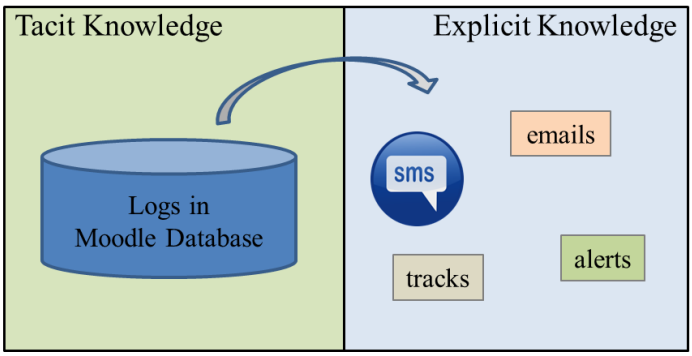

Fig. 12. The knowledge conversion with the KBM

The KBM options are shown in Fig.13, where you can include all possible options for a new track, according to the rules of KBM indicated previously.

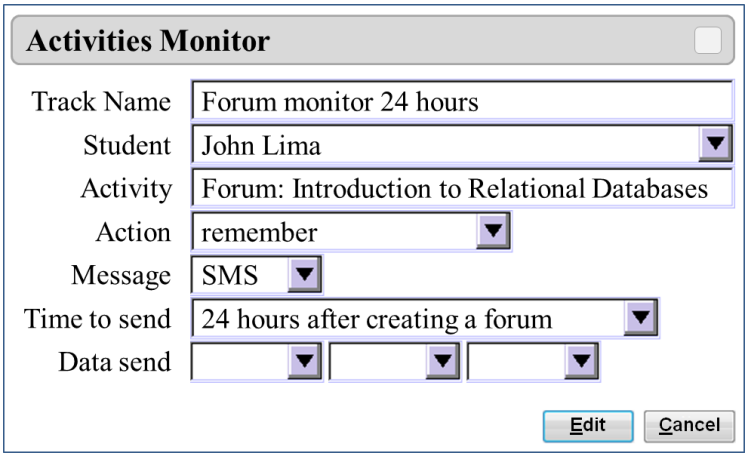

Fig. 13. KBM options

3 Validation

For the validation process of the blocks incorporated in Moodle, we did three types of validation. The first was the usability validation, the second was the functional validation and the third one was a satisfaction survey.

3.1 Usability Validation

ISO defines usability as the ability of a product to be used by specific users to achieve specific goals with effectiveness, efficiency and satisfaction in a specific context of use [28]. This definition is very enlightening due to the following aspects: effectiveness, efficiency and satisfaction.

One of the usability evaluation systems of "inspection" type is the heuristic evaluation, in which some evaluators examine the interface, following the usability principles (heuristics). The review is done individually and must assume the role of a user. Until the evaluation is not completely performed, you are not allowed to communicate the results to evaluators [29].

Some authors have worked on the evaluation called user-centered [30, 31, 32, 33]. In that sense, Mari-Carmen Marcos [29] indicates that Nielsen's proposal [31] is one of the most used one.

In the usability validation, we did the test that consisted of analyzing the conformity of the interface with recognized usability principles (heuristics) and correspond to Jakob Nielsen's 10 general principles for interaction design [31]:

1) Visibility of system status
2) Match between system and the real world
3) User control and freedom
4) Consistency and standards
5) Error prevention
6) Recognition rather than recall
7) Flexibility and efficiency of use
8) Aesthetic and minimalist design
9) Help users recognizing, diagnosing, and recovering from errors
10) Help and documentation

The scale used for assessment of the problems was: 0 (there is a usability problem), 1 (cosmetic problem), 2 (minor problem), 3 (major usability problem) and 4 (catastrophic usability imperative fix solution). It was applied to 6 users (3 teachers and 3 students).

Table 2 shows the most outstanding problems encountered with the heuristic evaluation.

Table 2. Problems encountered with the heuristic evaluation

Problem	Heuristic	Assessment	Solution
The categories of the Lessons Learned have not been sorted	H1	4	Organize content
Some Yellow Pages data are not mandatory	H4	5	All fields are required
Not showing the shortcuts in the KBM options	H7	4	Include shortcuts in each attribute and each option

The test had positive opinions about usability. It is necessary to note that the questionnaire sought opinions related to investigate usability issues reported by Nielsen [31], therefore to obtain a greater number of favorable responses, it means that the application was approved in the usability test.

3.2 Functional Validation

The second validation consisted of forty-one (41) cases of evaluation, covering fully all functional levels of the new blocks for the KM tools and the KBM. The importance of this test is to validate the proper functioning into Moodle, of each and every one of the functions defined, that it is to say if it meets all the functional requirements previously defined. If any test fails, the related function should be repaired.

6 users (3 teachers and 3 students) participated in these tests. They entered in the system as teacher, administrator and student. The tests, as it was indicated previously, related each functional requirement defined and the KBM Rules defined in each Moodle activity.

The new Moodle blocks were tested in the Database course, so three teachers belong to the Database area, and three students represent a sample of twelve students enrolled in the course. It is a first evaluation which will be extended to a larger sample in the future.

We used the Likert scales [34] with the typical format of five levels of responses (5. strongly agree, 4. agree, 3. neither agree nor disagree, 2. disagree and 1. strongly disagree).

Then we show the questions and the percentages of responses given to each question, by the group from 6 users.

- Questions of functional requirements:

    1) TFR1: Search Yellow Pages is successfully?: 100% strongly agree.
    2) TFR1: Search FAQs is successfully?: 100% strongly agree.
    3) TFR1: Search Lessons Learned is successfully?: 83.33% strongly agree and 16.66% agree.
    4) TFR2: Adding Yellow Pages is successfully?: 100% strongly agree.
    5) TFR2: Adding Lessons Learned is successfully?: 100% strongly agree.
    6) TFR3: Update Yellow Page attributes is successfully?: 100% strongly agree.
    7) TFR4: Update Lessons Learned is successfully?: 100% strongly agree.
    8) TFR5: Update KBM options is successfully?: 100% strongly agree.
    9) AFR1: Search Yellow Pages is successfully?: 83.33% strongly agree and 16.66% agree.
    10) AFR1: Search FAQs is successfully?: 100% strongly agree.
    11) AFR1: Search Lessons Learned is successfully?: 100% strongly agree.
    12) AFR2: Adding Yellow Pages is successfully?: 83.33% strongly agree and 16.66% agree.
    13) AFR2: Adding FAQs is successfully?: 100% strongly agree.
    14) AFR2: Adding Lessons Learned is successfully?: 83.33% strongly agree and 16.66% agree.
    15) AFR3: Update Yellow Pages attributes is successfully?: 100% strongly agree.
    16) AFR4: Update Lessons Learned is successfully?: 83.33% strongly agree and 16.66% agree.
    17) AFR5: Update KBM options is successfully?: 100% strongly agree.
    18) SFR1: Search Yellow Pages is successfully?: 100% strongly agree.
    19) SFR1: Search FAQs is successfully?: 83.33% strongly agree and 16.66% agree.
    20) SFR1: Search Lessons Learned is successfully?: 100% strongly agree.
    21) SFR2: Adding Lessons Learned is successfully?: 100% strongly agree.
    22) SFR3: Update Lessons Learned is successfully?: 83.33% strongly agree and 16.66% agree.

- Questions of KBM Rules:

23) RF1: When adding or modifying a forum, should the system send a SMS and email all students?: 100% strongly agree.
24) RF2: 24 hours after creating a forum, should the system send a SMS and email all students who have not seen the forum?: 100% strongly agree.
25) RF3: 48 hours after creating a forum, should the system send a SMS and email students who have not participated in the forum?: 83.33% strongly agree and 16.66% agree.
26) RF4: Every 24 hours, should the system send a SMS and email students who have not participated in the forum?: 83.33% strongly agree and 16.66% agree.
27) RA1: When scheduling any activity, should the system send a SMS and email all students?: 83.33% strongly agree and 16.66% agree.
28) RA2: 24 hours before any scheduling activity, should the system send a SMS and email all students?: 83.33% strongly agree and 16.66% agree.
29) RA3: 1 hour prior to any scheduled activity, should the system send a SMS and email all students, is it successfully?: 66.66% strongly agree and 33.33% agree.
30) RQ1: By adding a questionnaire, should the system send a SMS and email all students?: 83.33% strongly agree and 16.66% agree.
31) RQ2: 24 hours after creating a questionnaire, should the system send a SMS and email students who have not responded to the questionnaire?: 100% strongly agree.
32) RQ3: 48 hours after creating a questionnaire, should the system send a SMS and email students who have not responded to the questionnaire?: 100% strongly agree.
33) RQ4: When performing submits a questionnaire, should the system send a SMS and email a student data to the teacher?: 83.33% strongly agree and 16.66% agree.
34) RQZ1: To add a quiz, should the system send a SMS and email all students?: 100% strongly agree.
35) RQZ2: 24 hours after creating a quiz, should the system send a SMS and email students who have not responded the quiz?: 83.33% strongly agree and 16.66% agree.
36) RQZ3: 48 hours after creating a quiz, should the system send a SMS and email students who have not responded the quiz?: 100% strongly agree.
37) RQZ4: When closing a quiz, should the system send a SMS and email the teacher with student data?: 100% strongly agree.
38) RW1: To add a Wiki, should the system send a SMS and email all students and the teacher?: 83.33% strongly agree and 16.66% agree.
39) RW2: 24 hours after creating a wiki, should the system send a SMS and email students who have not participated?: 100% strongly agree.
40) RW3: 48 hours after creating a wiki, should the system send a SMS and email students who have not participated in the wiki?: 66.66% strongly agree and 33.33% agree.

41) RW4: When making a wiki post, should the system send a SMS and email the student data to the teacher?: 100% strongly agree.

20 (48.78%) of the cases had responses with 6 users strongly agree, 12 (29.26%) of the cases had 5 users strongly agree and 1 user agree responses and finally 9 (21.95%) of the cases had 4 users strongly agree and 1 users agree responses. The options "neither agree nor disagree", "disagree" and "strongly disagree" were not used (Fig. 14). This result allows the validation of the system functionally, because 100% of the answers were strongly agree or agree.

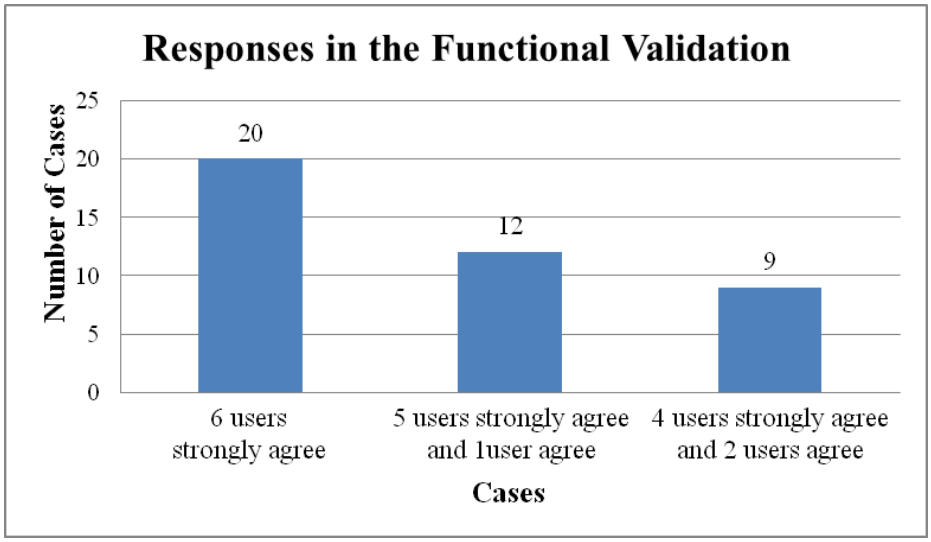

Fig. 14. Responses of the functional validation

3.3 Satisfaction Survey

The third and last validation was a satisfaction survey applied to 40 professors and 400 students at the Universidad Central de Venezuela. The 450 evaluators were being Moodle users at the university. The survey had the following 4 questions:

1) When do you use the new Moodle blocks, is it intuitively performed?
2) The knowledge management is the processes of making available the knowledge they need, to those in need, where they need them, as needed and when needed. According to this statement, do the new Moodle blocks satisfy the expectations of knowledge management?
3) The usability is the ability of a product to be used by specific users to achieve specific goals with effectiveness, efficiency and satisfaction in a specific context of use. According to this statement, are the interfaces developed usable?
4) Would you recommend the system developed to colleagues and other students?

The responses associated to a Likert scale [34] with five levels of responses (5. strongly agree, 4. agree, 3. neither agree nor disagree, 2. disagree and 1. strongly disagree) (Fig. 15).

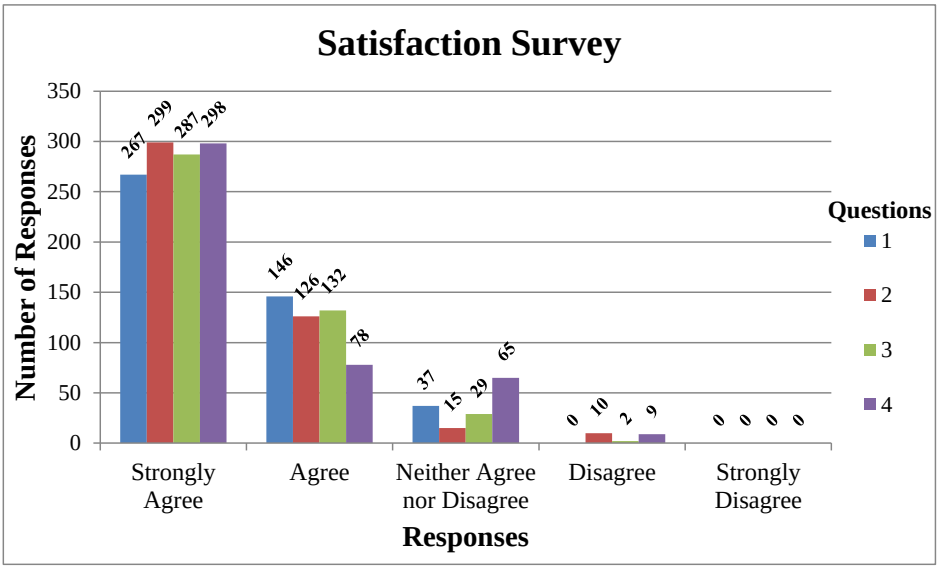

Fig. 15. Satisfaction survey responses

In question 1: When do you use the new Moodle blocks, is it intuitively performed?, 59.33% of the responses were "strongly agree" and 32.45% were "agree", this represents 91.78% of users that think that it is performed intuitively. 8.22% of the responses were "neither agree nor disagree".

In question 2: Do the new Moodle blocks satisfy the expectations of knowledge management?, 66.44% of the responses were "strongly agree" and 28% were "agree", this represents the 94.44% of users that think that the new Moodle blocks satisfy the expectations of knowledge management. 3.33% of the responses were "neither agree nor disagree", and 2.22% were "disagree".

In question 3: Are the interfaces developed usable?, the answers were similar, 63.78% of the responses were "strongly agree" and 29.33% were "agree", this represents the 93.11% of users that think that the developed interfaces are usable. 6.44% of the responses were "neither agree nor disagree" and only 0.44% of the responses were "disagree".

In question 4: Would you recommend the system developed to colleagues and other students?, 66.22% of the responses were "strongly agree" to recommend it, 17.33% were "agree", 14.44% were "neither agree nor disagree", and finally 2% of the respondents disagree about this. 83.55% of them would recommend it.

All questions had similar responses. The "strongly agree" option had the highest responses, the second most chosen option was "agree" and third most chosen option

"neither agree nor disagree". The option "disagree" was the less answered, and the option "strongly disagree" did not appear in any response.

4 Conclusions

The use of LMS has grown in education institutions to offer new alternatives in the teaching and learning process, allowing us to offer e-learning courses, or supporting in a system of classroom education. However, it is always looking for new resources or services that may be offered, for that reason four tools of knowledge management were developed: Yellow Pages, Lessons Learned, FAQs and a Knowledge-Based Monitor, which were integrated into Moodle LMS. Until the completion of this work it was possible to successfully develop a set of tools, to provide tangible support for teachers and students that make this platform a vital tool in the teaching and learning process.

The developed tools have the following advantages: they are free, not limited to any specific educational area, they enable knowledge management, they ensure that data and experiences of other teachers and students are not wasted and they offer continuing improvements in materials and courses.

For the validation of the developed tools, we did three processes, the usability validation, the functional validation and the satisfaction survey. We obtained satisfactory results on these, and this allowed the validation of: usability, functionality and satisfaction.

As future works, we suggest testing in some others courses implemented, considering control groups and experimentation in order to evaluate the management of knowledge and its impact on real cases. Likewise, it is recommended as a possible extension of this work, the implementation of a module that allows teachers subscribing to specific topics of interest, and which in turn they are notified by sending email when there are new entries.

Similarly, in the future it is important that the learning and teaching environment could be an intelligent environment based on semantic web which can find and recommend significant contents to the students.

In addition to that, the KBM developed is merely reactive and this approach did not incorporate intelligence. We could add some automatic learning or Bayesian models in the KBM in order to analyze some user behaviors and to recommend different strategies among yellow pages, Lessons learned and FAQ.

Finally, the development will be released within the Moodle development community to be incorporated in new versions.

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