Domain-driven competence assessment in virtual learning environments. Application to planning and time management skills

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***Abstract*—The Learning Management Systems provide a set of facilities for the lecturer to manage his courses. Unfortunately, they have limitations when it comes to assessing generic skills. In most of them, every activity is assessable but just with a simple grade and there is not a direct link between activities and generic skills. In this work we present two alternatives to solve this issue: an assisted method based on a Model-driven architecture approach and a Rest Web service that facilitates the assessment of generic skills. We apply both approaches to a case study consisting in a Moodle-based course where we assess the ability of plan and manage time of each student. Results show that the approaches are complementary, the Web service provides more detailed formative feedback, but the Model-driven approach seems more scalable for courses with a high number of students, where it is more difficult to assess their generic skills.**

Keywords—model-driven architecture; learning analytics; generic skills assessment; learning management system; online learning; technological support in online education; Rest Web service

I. INTRODUCTION

In the past decade, the use of a sustained learning process in Internet has raised significantly. With the increasing use of the new technologies, besides the resources for getting them by the students of any educational framework, both the universities and other educational centres have been forced to move forward and focused their advances in this environment. While these technological changes have influence in our everyday life, there are improvements in the use of theories which support the development of learning tool [1]. An evidence of this increase in the new technologies is the installation of Learning Management Systems (LMS) in universities, high schools or education centres.

Almost simultaneously, the attention on higher education learning has turned from knowledge to skills. Projects like the Tuning Educational Structures in Europe (supported by the Lifelong Learning Program of the EU) show the importance of using the concept of skills as a basis for learning outcomes [2]. The learning outcomes are skills, and students must be assessed about these learning outcomes during the learning process [3]. Therefore, it is no enough for a new graduate to have knowledge of an academic subject. Increasingly it is necessary for students to gain those skills which will enhance their prospects of employment [4].

Each student must be assessed on his development of skills. Unfortunately, LMSs have limitations when it comes to assessing skills. In most of them, every activity is assessable but just with a simple grade (not according to different skills) and there is not a direct link between activities and skills. For instance, Moodle, one of the most popular LMSs, does not allow assessing skills, and it is very difficult to link their activities to skills. This way, student assessment without a proper computer support will be time consuming task, specially if the number of students is high. Could an assisted method facilitate the assessment of generic skills for the lecturer? This paper presents two alternatives to answer this question: the application of Model-Driven Architecture (MDA) development approach to assist the assessment of generic skills and a Rest Web service that facilitates the manually assessment of generic skills.

The rest of the paper is organized as follows: Section 2 reviews the state of the art. Section 3 introduces the tools used in this work: Gescompeval and EvalCourse. In Section 4 we describe a case study of the assessment of one of the skills that is more demanded in the business world: the ability of plan and manage time [5]. In the last one, we provide a discussion along with conclusions and future research lines.

II. STATE OF THE ART

Previous research evaluating students' achievement have demonstrated that many strategies promoting active learning are comparable to lectures in promoting the development of students' skills [6]. The key hypothesis of active learning is that if the learning algorithm is allowed to choose the data from which it learns, to be curious, it will perform better with less

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training [7]. In [8] the fundamental hypothesis tested was whether the implementation of active learning methodologies, such as cooperative learning and problem based learning, favours the achievement of these two generic skills: teamwork and planning and time management. The effect of active learning on the generic skills was examined by comparing the mean obtained in each generic skill measured both before and after active learning methods were implemented. Results showed no difference between the two means (beginning and end) detected for the skill of planning and time management. The authors concluded that students need some specific preparation on 'study techniques' and 'team work' before using them for active learning methodologies.

A working path to assess generic skills in engineering grades is based on using assessment instruments. For example, a set of rubrics were used in [9] to measure ability to function on teams, communicate effectively, apply creativity, and demonstrate a commitment to quality and timeliness. Another strategy is using peer assessment procedures, where it is very common the use of ePortfolios [10]. The last choice we can meet in the related bibliography is about serious games. They are computer systems that simulate situations based on real life to safely integrate these experiences in university curricula [11, 12].

Acquiring new skills is the central goal of modern education or knowledge management process. Therefore, it must be embedded in any based-technology educational framework. But none of these architectures offers this option. Distributed Workbench for the Engineering of Learning Systems are a web-based workbench to support the 35 main tasks of the Competency in an Instructional Engineering Method [13]. These tools are used to define a set of skills associated with a knowledge model that defines the content for a course. The author summarizes that the major challenge is to integrate them in a coherent, flexible, user-friendly, and scalable way, within the new context provided by the semantic web and the ontology-driven architecture of TelELearning Operating System (TELOS).

The increase of the usage of LMSs amongst institutions generates new problems arising that need to be solved. The multiplicity of platforms and approaches used for various systems implementation difficults to manage them. In [14] a study to overcome the aforementioned difficulties by using the MDA approach is presented. Their goal was to define a generalized model of LMSs consisting of features of all other LMSs that can be mapped into it.

In [15] is developed an interaction analysis within online educational contexts based on collaborative learning strategies. The author stated that the interactions among learners were very complex and they require an appropriate model to be deeply investigated.

Through a MDA approach, our proposal is to automatically obtain indicators from LMS logs to assess different generic skills. Technology enhanced learning (TEL) environments represent a promising alternative to traditional learning methods in both face-to-face and distance learning situations. In order to analyze the efficiency of these environments a common practice consists in collecting interaction traces to record learners' activity when using a learning tool [16].

The ability to plan and manage time is the skill assessed in this experience. Already in 1983, a prospective study tested the hypothesis that college grade point average (GPA) would be predicted by time-management practices [17].

III. Software Architecture

In this section two approaches are compared. Firstly, a Rest Web service, that is, a non MDA approach through the application of Gescompeval. Secondly, a MDA approach using EvalCourse, a system to obtain indicators from the LMS. Once conducted, we should be able to state if an assisted method facilitates the assessment of generic skills for the lecturer. The main limitation of the architecture is that the LMS has to be based on Moodle.

The lecturer has assessed their students manually in the ability of plan and manage time using Gescompeval. Gescompeval is a Rest Web service used for managing skills and learning outcomes. It allows lecturers assessing their students in skills through assessment tools integrated in a LMS. Secondly, once the course have finished, the lecturer has extracted indicators about the students' performance in this skill using EvalCourse. EvalCourse is a software system that runs assessment queries, providing in its output the indicators requested. We compare the results obtained automatically with those assigned directly by the lecturer.

A. Gescompeval

On one hand we have Gescompeval, a Rest Web service implementing a MVC (Model View Controller) architecture. It is used for managing skills and learning outcomes and retrieving information of them using its API. The skills and learning outcomes are in an educational context, therefore they refer to abilities and/or skills which a student acquires in an activity, course or career.

Gescompeval consists on a Web interface and a Web server. The API of Gescompeval only offers resources to get data, not to post them, so a Web interface is necessary. Through the Web interface the users can do CRUD (Create Read Update Delete) operations and connect the skills with some learning outcomes and vice versa. These connections are not used in other options, but through the API we can get them and use them in order to get information. For example, a use of this could be the next: in a LMS, a lecturer gives a grade G to a skill C for a student S. If the lecturer wants to get the grade of a learning outcome O which is connected with the previous skill C, he can keep in mind the grade of that skill through the connections to get an average mean for the grade of the learning outcome O.

Once an application for creating an index of skills and getting information is created, it has been integrated with a LMS to improve the usability. This integration is called Gescompeval_MD and it is a block extension for Moodle 2.X that uses Gescompeval's API for showing information about assessments of skills and learning outcomes. This extension allows assessing skills and learning outcomes through another

Web service focused on skills assessment called EvalCOMIX and a Moodle block called EvalCOMIX_MD, which uses the API of EvalCOMIX. This way, we will be able to know the grade of each student in a certain skill/outcome (Fig. 1).

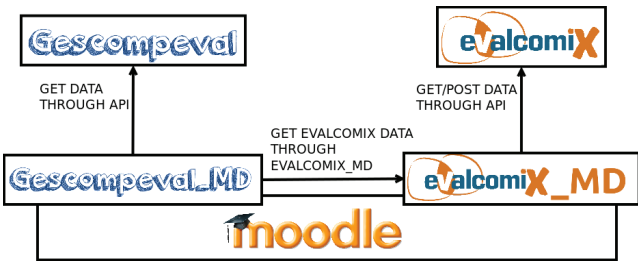

Fig. 1. Gescompeval architecture

EvalCOMIX is a Web service for e-Assessment that can be integrated into a LMS. Firstly, EvalCOMIX supports the design and management of assessment tools like Rating scales, Checklists, Rubrics, etc. Secondly, when integrated into an e-learning environment (Moodle, LAMS, etc.), it allows using the previous defined tools to be used for assessment [18]. These tools support assessment according to dimensions, subdimensions and attributes. Each subdimension will be connected with a skill or a learning outcome from Gescompeval_MD. Getting the students' grades in those subdimensions, reports will be able to be showed.

Firstly, Gescompeval_MD allows to a lecturer include the skills and learning outcomes that will be developed by the students through LMS course's activities. Previously, all the skills and learning outcomes have been created in Gescompeval Web service. For example, if a lecturer wants to include two skills which are developed by the students of the course, he must select those skills from a box which lists all the skills that are created in Gescompeval Web service. After selecting and adding them through a button, the desired skills will be included in the course.

Secondly, a lecturer can connect some of the skills added to the course with subdimensions of EvalCOMIX assessment tools. To do that, the lecturer must select a subdimension of his EvalCOMIX tools. An example of this is shown in Fig. 2. After that, he will be able to link some skills and learning outcomes included in the course with the subdimension previously selected. Now, the skills will get the grades from the subdimensions which they are connected with and will combine those grades to get the final one.

Finally, the grades of each skill will be shown to the user to provide formative feedback. There are two types of reports: a global report of all students in the course and an individual one of a certain student. Besides, through a check box a lecturer can choose if the connections between skills and learning outcomes must be kept in mind. These reports are dynamic graphics developed using Google Charts. When the user places the mouse over a graphic, some information is showed in a popup: code, name and value of the skill/outcome and tasks of the course where the skill/outcome has been developed.

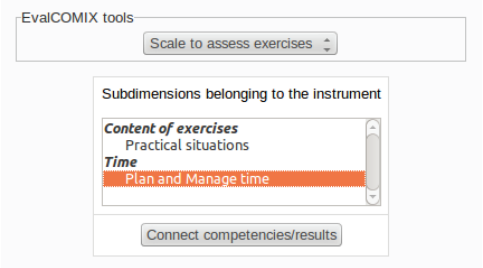

Fig. 2. Selection of subdimension snapshot

B. *EvalCourse*

On the other hand we have EvalCourse. EvalCourse has been developed to support lecturers when assessing students. It obtains some indicators of the work of students in a LMS (Learning Management System) which will be useful to get information about the compliance or not of them in some skills like the ability to planning and management time, leadership, etc. At the moment, Moodle is the only LMS supported by this software.

EvalCourse has been developed following a MDA approach. The proposal started with a model of the domain to be represented (the metamodel). Then, it continued through the remaining phases that an Eclipse Modeling Framework (EMF) project requires. EvalCourse is an assessment support environment that executes queries written in SASQL, a Domain Specific Language (DSL) to tackle with the complexity of customizing online learning assessments [19].

EvalCourse is presented to the user as a RCP application, which means that it consists on a desktop application based on the Eclipse framework but it is neither so heavy nor has so many features, it has just the necessary to run EvalCourse. One of the most important factors we have tried to achieve is the ease of use because it is directed to any lecturer with or without computer skills. This way, the user just has to download the tool, write the query and press a button in order to get the indicators.

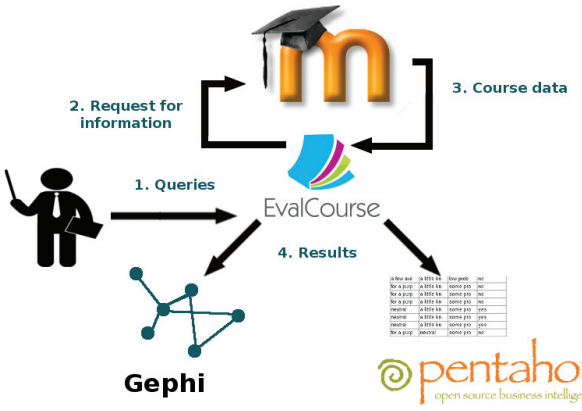

Fig. 3. EvalCourse architecture

Fig. 3 shows the process we follow to obtain the different results. Firstly, once we have created an EvalCourse project inside the RCP application, we must indicate with a textual query the information we want. Then, EvalCourse satisfies user queries analyzing LMS logs, offering the results in different formats. Internally it invokes Gephi, an open source graph visualization software, and Pentaho is a suite of open source Business Intelligence products which provide data integration, OLAP services, reporting, data mining, etc. which we use it to make multiple transformations to finally present the results in a XML and CSV file, a bar chart and a pie chart.

The user has two options to indicate the course he is referring to:

1. At the end of the query he indicates the id of the course. To do this the configuration with the database must be indicated. The connection with a possible central computer which has the LMS installed could be a problem. For example, in a university, all the lecturers may not have permission to access to it. For this reason, a second option has been developed.

2. This other option consists on making a backup of the course we are referring to inside the LMS. The user indicates at the end of the query that the course comes from a backup file. This backup file must be added to our EvalCourse project.

IV. CASE STUDY

In this section we introduce the scenario of our case study. It was developed in an elective course on Functional Programming of the degree on Computer Science and Engineering in University of Cadiz (Spain), in 2013/14 academic year. Six students enrolled the course, being all of them were final (fifth) year students. Therefore, we can think that passing this course was a priority for them to join professional world.

The assessment of the students was done manually using Gescompeval and we later applied EvalCourse. This course was coordinated by one author of this paper, who anonymized student's data. We assess students' performance in the skill of planning and time management. The lecturers involved have some experience in skills assessment because in every subjects of this, a subject tab with all the skills developed is designed.

A. Gescompeval

Firstly, we have used EvalCOMIX and Gescompeval to get grades for the developed skills. To do that we have created an assessment tool with EvalCOMIX which has two dimensions with one subdimension each one (Fig. 4). One subdimension is used for assessing the practical content of the assessed exercise, while the other one assesses the time of submission. The content is assessed with four attributes: correctness, efficiency, speed of execution and applied knowledge. They can be assessed with none (one or no exercise has the attribute), some (at least two exercises have it) and all (every exercise has it). On the other hand, the time of submission is assessed with one single attribute with four values: delayed (submitted after deadline), average planning (submitted one or two hours before deadline), good planned (submitted one day before) and excellent planning (more than two days before).

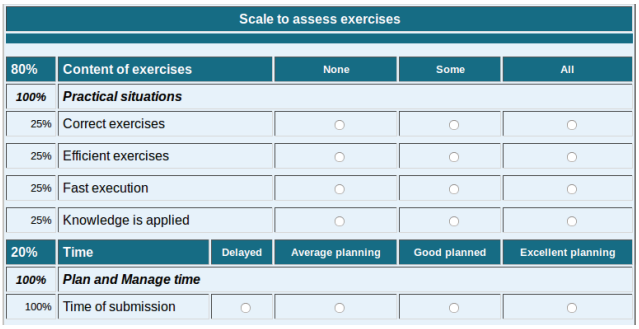

Fig. 4. EvalCOMIX tool snapshot

Once the tool is designed, we define the skills that we are going to use in Gescompeval. Later, we include them in the course and finally connect them with the subdimensions of the tool in this way:

- Practical situations subdimension with Ability to apply knowledge in practical situations
- Time subdimension with Ability to plan and manage time

Finally, after assessing the students, through Gescompeval reports we have obtained grades shown in TABLE I. . The grades range from 0 (minimum) to 100 (maximum).

TABLE I. GRADES OBTAINED WITH GESCOMPEVAL

	Plan and manage time	Knowledge in practical situations
anon4	91.75	94
anon5	50.50	94
anon7	66.67	96
anon8	58.75	94
anon9	42	100
anon10	25.25	100

With these grades, we can see that all the students have a high grade in applying knowledge in practical situations, because their grades are very high (from 94 to 100). However, we can also see that those students do not have so high grades in plan and manage time, because only anon4 has a high grade (91.75), the rest have less of 67 points. With a conventional assessment, every student should have high grades, but with this assessment method, an important skill like planning and managing time is assessed and considered for the grade too..

B. EvalCourse

When applying EvalCourse to the same course, the first aspect to analyze consists on checking if the students have delivered their assignments on time, delayed or even if they have some pending assignment. We can ask for that information with the SASQL code showed in listing 1. Then, we obtain information in several formats. Attending to Fig. 5, we can see which students have delivered all their assignments

on time, in this case only 3 students. In TABLE II. , we can see the same information more detailed.

Evidence Milestones_list:
get students
show milestones
in assignment.

Listing 1. Code to retrieve students' performance in assignments

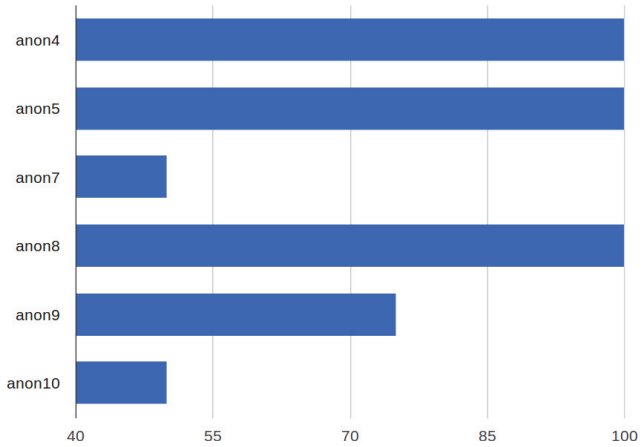

Fig. 5. Ratio of assignments delivered on time

Also, TABLE II. shows an interesting insight. Except for anon5, who can be considered an exception, we realize that those students who have delivered all their assignments on time, have more access to the course than the rest (anon4 and anon8). And the same applies to the opposite case, those who have the lowest ratio have accessed the course less often. We could assume that this is directly related with the interest in a course.

TABLE II. ASSIGNMENTS OF THE STUDENTS

Name	Ratio	Milestones	In-time	Pending	Access
anon4	100	4	4	0	218
anon5	100	4	4	0	78
anon7	50	3	2	1	135
anon8	100	4	4	0	171
anon9	75	4	3	0	149
anon10	50	4	2	0	117

Secondly we present the students' participation in a forum (TABLE III.). It has been extracted with the SASQL-code 2. If we compare both reports, assignment and forum, we can extract some important information. Again student anon5 has not accessed the forum many times, like with the assignments. But he has the highest collaboration figure, like he had all the assignments in time. Regarding these two cases, we could assume that student anon5 checks the LMS very frequently. Such information could indicate that he manages the time quite well and the number of times he has started a debate in the forum could mean that he is a good leader.

Student anon4 is the one with more accesses to the LMS, while the number of his collaborations in the forum is fine. It seems that he has to make a bigger effort than the rest to fulfill the objectives.

Evidence forum_interaction:
get students
show interaction
in forum.

Listing 2. Forum interaction code

TABLE III. PARTICIPATION IN FORUM

Name	Debate-starter	Debate-participation	Total	Access
anon4	1	2	3	64
anon5	3	1	4	36
anon7	1	3	4	75
anon8	0	0	0	48
anon9	0	2	3	28
anon10	3	1	4	41

C. *Comparison*

Once we have obtained all the indicators from EvalCourse, it is time to interpret them to contrast with the grades assigned directly by the lecturer using Gescompeval. If we took only the set of activities delivered on time as the indicator linked competition with planning, we would say that there are 3 students who have achieved the level of maturity in this skill (anon4, anon5 and anon8).

However, if we take into account two indicators at the same time: number of submitted on time tasks and an above-average number of accesses to the virtual campus, only the student anon4 would fulfill both indicators.

These are examples of interpretations that the lecturer could assume with the obtained indicators, but the validity of the application of these indicators to a particular skill is outside the scope of this work. What the lecturer stated, is that the application of EvalCourse allowed him to refine the assessment and it successfully assisted the assessment task. Actually, this is what concerns our work. Of course, this work requires deeper research, but it is a valid first approach. It shows that the indicators are there, and the lecturer just has to investigate how to interpret them. If the lecturer manages to refine the indicators, he would be able to obtain an objective assessment of skills in massive online courses using EvalCourse.

V. CONCLUSION

Generic skills are important in most professions. Their development enables students to integrate successfully in employment and social contexts. Unfortunately, in the academic context assessing certain competencies is a complex and/or a subjective task. In recent years several alternatives to solve this issue have been presented. In this paper we have made a comparative study between two different approaches to assess the work done in a course supported by a LMS.

On the one hand the lecturer applied Gescompeval_MD. Gescompeval_MD allows a lecturer to include the competencies and learning outcomes that will be developed by the students through course's activities. Besides, the lecturer can connect some of the competencies added to the course before with subdimensions of EvalCOMIX assessment tools. To do that, the lecturer must select a subdimension of his EvalCOMIX tools. After that, he will be able to link some

competencies and learning outcomes included in the course with the subdimension previously selected. Now, the competencies will get the grades from the subdimensions which they are connected with and will do an average of those grades to get the final one. In summary, the lecturer conducted this process in a manual way and achieved its goal effectively.

On the other hand the lecturer applied EvalCourse once the course finished. EvalCourse was been developed following the MDA approach to deal with vocabulary and key concepts of an educational domain model. In EvalCourse, the lecturer wrote a couple of queries in an assessment-specific domain language to obtain two listings with the indicators related to the activities submitted by the students, as well as several figures that support them.

Results are promising, the reports of Gescompeval provided the students with formative feedback about the skills they developed. The feedback was composed of specific values because it came from the assessments done manually by the lecturer. As a future work, the possibility of exporting these reports with customize options would add more feedback to the lecturer and it could be a more specific information.

Besides, the assisted assessment provided by EvalCourse was really useful for the lecturer. He could refine the previously done assessment using Gescompeval without much effort. Furthermore, he got many indicators that could somehow be applied to the assessment of generic skills. The course in which both tools were applied had a small number of students. Although Gescompeval was very useful for the lecturer and let him perform a very strict assessment of generic skills, this labour might present scalability problems if the course had a higher number of students.

We can conclude that our proposal can be applied to assess skills of students in terms of their interaction with LMS in other computer-supported learning experiences of any educational level and topic. For the time being, the main limitation to perform a new experience is that the LMS has to be based on Moodle. Obviously, we need further study to get a stronger conclusion on the validity of our proposal. So we will apply our system to a course with a high number of students interacting in a LMS. Whereas previously, trying to assess generic skills was intractable.

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