USING BLOOM'S COGNITIVE DOMAIN IN WEB EVALUATION ENVIRONMENTS

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Keywords: Assessment process, Bloom taxonomy, Web-based information system, ICT in education.

Abstract: This article proposes a web-based Information System based on Bloom Taxonomy, which aims to support the assessment and tracking of learning process. From an assessment methodology defined, a prototype of this model was implemented with focus on educational objectives, performance reports and feedbacks to the students and teachers - called Smart Education. A short experiment was run in a Software Engineering graduate course achieving key results in relation to its use and application.

1 INTRODUCTION

Information and Communication Technology (ICT) is provoking notable cultural and educational changes when used as important resources of instrumentation of research and academic renewal, benefiting professors, researchers and students (Levy, 1993). Considering the internet resource as one of the main actors, and its application in the classroom context, as an outstanding support tool to teaching activities, offering a "virtual extension of the actual classroom" (Gomes, 2005).

This new educational context provides education with greater flexibility and accessibility to information; however, it demands the construction of new pedagogical practices and concepts that respond to students and professors needs that benefit from the use of ICT. Particularly, there is the challenge of "learning assessment", looking for incorporating the peculiarities brought by the digital learning environments during the construction of instruments and assessment strategies that are appropriate for the new educational contexts. In this process, it is essential to define assessment objectives accurately, choosing the proper manners and methods, making it possible to evaluate with higher effectiveness (Bloom, 1977).

Educational objectives elaboration can be made based on classification schemes. The "Taxonomy of Educational Objectives - Cognitive Domain" is one of the most popular schemes, elaborated by Bloom and his contributors in (Bloom, 1977). Although Bloom's Taxonomy is divided in three areas (Affective, Psychomotor and Cognitive), the cognitive domain was selected as the center of this research, considering that the achievement of these objectives is an essential requirement for the majority of educational programs and training.

Considering the presented context, this article proposes an Information System model on the Web, based on Bloom's Taxonomy regarding the Cognitive Domain, with the purpose of supporting the assessment and accompaniment of the learning process. A prototype of this model was implemented, entitled Smart Education, starting from the definition of an assessment methodology focused in the definition of questions based on educational objectives, accompaniment and feedback reports for students and professors. Smart Education works attached to the virtual learning environment Moodle (free and open source) [www.moodle.org], from which are extracted all the basic information of courses, subjects, teachers and students. A case study was carried through a post-graduate course in Software Engineering, presenting satisfactory results regarding its application.

This article is divided into six sections. Section 2 presents some of the concepts used in the definition

H. S. Alexandre G., C. dos Santos S. and C. A. R. Tedesco P. (2010).
USING BLOOM'S COGNITIVE DOMAIN IN WEB EVALUATION ENVIRONMENTS.
In *Proceedings of the 2nd International Conference on Computer Supported Education*, pages 53-59
DOI: 10.5220/0002799600530059

of the assessment methodology, described in Section 3. Smart Education, developed from this assessment methodology, is described briefly in Section 4, as well as a carried through experiment, presented in Section 5. Finally, the last section presents the final conclusions and considerations.

2 ASSESSMENT IN THE LEARNING PROCESS

The assessment process as part of the learning process must be based on clear and well defined propositions. It is now necessary to make a distinction of the two words that were repeated in this article: assessment and evaluation. For this article the understanding of assessment focuses on learning, teaching and results. It provides information to improve teaching and learning. The information collected is used by teachers in order to improve the learning environment, and is still shared with students to help them navigate on their studies and better learning. The information is focused on the student and not the classification.

The term evaluation focuses on the comparison, classification. It is the summative evaluation of character. It is concerned only with what was learned. The ultimate goal is to achieve an overall grade / score.

In (Earl, 1998), six purposes of assessment are presented: (1) Know about the students, identifying the level of previous knowledge that they possess when initiating a course or discipline; (2) Verify which level of educational objectives have been reached; (3) Continuously improve the teaching and learning process; (4) Detect the learning difficulties, discriminating and characterizing its possible causes; (5) Promote students according to the proficiency level obtained in the evaluation and; (6) Motivate and provide feedback to students. In this context, the assessment of learning takes a central position within the process of teaching and learning in a cycle that begins with students' knowledge and the definition of educational objectives, proceeding with the choice of methods and criteria of assessment.

As already stated in the opening of this article, for the elaboration of educational objectives, professors can make use of classification schemes, such as the Taxonomy of Educational Objectives - Cognitive Domain, elaborated by Bloom and his contributors. The cognitive domain is concerned about information and knowledge. This way, the achievement of cognitive objectives is the fundamental activity of most educational programs and training. According to Bloom, this domain is subdivided in six main abilities:

- *Knowledge*: defined as the student's ability to memorize learned information. The assessment of this category verifies the capacity of the student to retain what was taught.
- *Comprehension*: student's capacity to reason, to understand or to learn the concepts and information worked by the professor. At this point, the assessment verifies student's interpretation and explanation capacity.
- *Application*: utilization of learned information in real situations. Once that a student already knows a concept and understands it, he is apt to apply it. When a student is able to correctly apply a concept, it can be said that he "learned", because he knows, understands and uses the new concept to solve real problems.
- *Analysis*: information must be decomposed and, thus, to relate and understand its formation and organization. The assessment of this cognitive ability has the intent to assess convergent production capacity.
- *Synthesis*: capacity of joining two or more concepts together to form a single one. The assessment of this ability verifies creative and productive capacity.
- *Evaluation*: assessment of information's importance to attend to a set of norms and criteria. Here the assessment verifies all the other categories.

The hierarchy of these cognitive abilities follows, according to its order, from the simplest and concrete (Knowledge) to most complex and abstract (Evaluation).

Bloom, in (1983), defines that three modalities of assessment can be carried through the circular process of assessment: Diagnostic, Formative and Summative.

The Diagnostic assessment is used to determine if the student has the necessary prerequisites for the acquisition of new specific knowledge. The recommendation is for this evaluation to be carried out at the beginning of the course, semester or unit of education (Haydt, 2000).

The Formative assessment is done with the intention of verifying if the student is reaching the established objectives during the course. This assessment aims at, basically, evaluating if the student will be able to continue to a subsequent stage of the course (Albuquerque, 1995). Therefore, formative assessment allows: to provide feedback to the student of what he learned and what he still needs to learn; to provide feedback to the professor, identifying students' failures and which aspects of instruction that must be modified; to look for the attendance to the individual differences of students

and prescription of alternative measures for recovering from learning failures (Bloom, 1977).

Finally, the Summative assessment, the assessment model most commonly used by educational institutions, is used to classify students. Held at the end of a school year or unit of instruction, it consists of classifying the students in accordance with levels of exploitation previously established, generally aiming at its promotion from a level to the next one, therefore it totalizes the results of a concluded study. Through the use of this assessment model it can be observed if the established objectives were reached by the students and also to provide data to refine the process of teach-learning (Haydt, 2000).

In (Santos, 2006), the author says that assessment functions should not have been used separately, because each one serves as complement to the other. Thus, diagnostic function would only mean something if used at the beginning of didactic-pedagogical process, which would serve to indicate the direction to be followed in the teach-learning process. This process should be constantly reviewed by the data gathered from the formative assessments, in order to keep educational objectives as designed, making it possible to classify each student by the average achieved in its exploitation, according to the metrics established by the educational institution.

3 AN ASSESSMENT METHODOLOGY PROPOSAL

An effective assessment methodology is the one that doesn't worry only about the condition of pass / fail, but which is concerned, especially in monitoring student's behaviour before an assessment, also providing resources to enable it to strengthen and improve his knowledge on the weak points identified by the assessment.

Article written by Kirti Garg and Vasudeva Varma propose a different methodology in pursuit of quality in teaching-learning process. This article proposes the use of case studies, carefully designed to be used as instruments of student assessment. The case studies help in assessing student competence on important aspects and learning goals and are still aligned with the goals to motivate, learn and make the feedback. (Garg, Varma, 2009)

Aiming at a really efficient assessment process, contemplating the main features and goals of assessments and, thus, allowing a better use of the different evaluation instruments, an assessment methodology was defined and systematized, based on Bloom's Taxonomy. Figure 1 illustrates this methodology stages and activities, divided in three

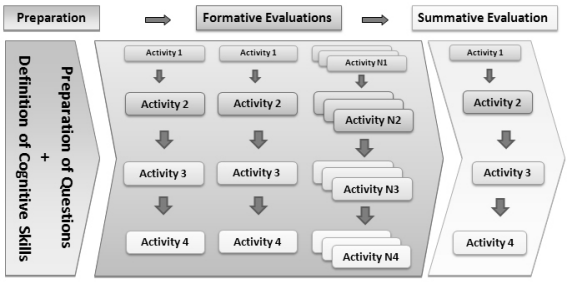


Figure 1: Proposed assessment methodology.

phases: Preparation, Formative Evaluations and Summative Evaluation.

At Preparation phase, questions that will form exams are created, both formative and summative. It is also in this phase that are defined which cognitive abilities the professor desires to evaluate. Professors must be very cautious during questions' creation, mainly referring to its difficulty level and the amount of questions available for each level. This precaution is vital for preventing the problem of "false expectations" for the student. The choice of which Bloom's cognitive abilities the professor wants to evaluate must be made following his own criterion, having the evolution of teaching and learning process as reference. Each chosen ability will have to be associated to one or more questions.

Second phase is dedicated to the elaboration and application of formative evaluations, focused on the accomplishment of continuous assessments, with the intention of identifying learning gaps. The amount of assessments to be applied in this phase is defined by the professor. However, it's necessary to always have an amount of formative evaluations equal or superior to the summative evaluations. The evaluations that are carried through in this phase won't determine the approval or failure of the students. Therefore, the values achieved by the students on these evaluations will serve only for the measurement of their acquisition of knowledge level.

Finally, at the third phase, summative evaluations are elaborated and applied, aiming at verifying the learning results achieved by the students, in accordance with the achievement levels that were established which will determine the approval or failure of the students.

Formative and Summative Evaluations stages are composed of four activities:

Activity 1 - *Performance Prediction*: in this stage students answer a self-assessment exam that will measure the degree of confidence each student has in answering questions related to subjects/topics that form the evaluation. The self-assessment exam consists of a questionnaire to be filled out by the

student, answering with one of the following options "Yes", "Perhaps" and "No" about his ability for solving questions related to subjects and topics that will form the exam.

Activity 2 - E*xam Resolution*: in this stage, exam is applied to the students, who must try to resolve the questions with the objective of identifying the degree of knowledge in each subject or topic of disciplines.

Activity 3 - E*xam Correction*: in this stage, professor corrects student's exams, comments on the given answers per item and releases the corrected exams so that the students can verify in which questions had gotten rightness and errors. It is in this stage that occurs the generation of quantitative and qualitative indices that will contribute for a successful accomplishment in the next stage.

Activity 4 - *Feedback and Orientation*: in this stage, professor elaborates and sends a feedback for the student, based on their performance. Using the quantitative and qualitative indices generated with the correction of evaluations during the previous stage, the professor will analyze them and will send his feedback to the student. The indices help to indicate with precision the aspects where the students are having better and worse performance, making the creation of a feedback easier for the professor.

4 THE INFORMATION SYSTEM SMART EDUCATION

With the purpose of validating the methodology proposed in section 3, an information system centered in an effective assessment process was implemented, named Smart Education. Its proposal is to assist in questions and evaluations management, as well as to facilitate learning accompaniment and proving feedback for students and professors.

This system is basically divided in two profiles: professor and student. Professors and students go through the login process, gaining access to system features in accordance with their profile. Figure 2 presents professor's profile interface.

Smart Education works attached to the virtual learning environment Moodle (free, open source) [www.moodle.org], from which are extracted all the basic information of courses, subjects, teachers and students, this way contents already registered doesn't need to be migrated and neither to reply the courses structure already created within the virtual learning environment, common nowadays in many educational institutions. So, to start using the system

Figure 2: Smart Education: Professor's profile UI.

it is necessary that users (teachers or students) are previously registered in Moodle. It is precisely with this registry, which both teachers and students may log into the system. After a successful authentication operation a window is shown with its content related to teacher or student, depending on the profile registered on Moodle.

In general, professor can create exams for all three methodology phases (Preparation, Formative and Summative), to apply and correct them; create questions containing several formats and types associated with Bloom's cognitive abilities; organize questions by subjects and topics; consult reports with diversified information regarding students' performance in determined subjects, topics and cognitive abilities and to produce his students learning follow up. Professor can also visualize the assessment methodology indicated by the tool.

One of this system's differentials is in the feature "Questões", there professors can find the "Manter Questões" functionality, that allows them to register, modify, exclude, search and visualize questions, which can be both discursive (open) and objective (multiple choices) and which will be used on exams' creation. During the registration of a new question some information are requested by the system, such as, the difficulty level, subject, topic and to which Bloom's cognitive ability the question is related to, as illustrated at Figure 3. Thus, when a professor accesses the questions with the intention of elaborating an exam, he will also be able to check the difficulty level of each one of them, automatically calculated by the tool and will have the certainty that the exam will contain only questions related to the subjects, topics and cognitive abilities chosen.

Other important feature is "Acompanhamento", which is responsible for providing the student's and class's performance reports to professors, automatically after the correction of all exams are concluded. This report will provide the qualitative

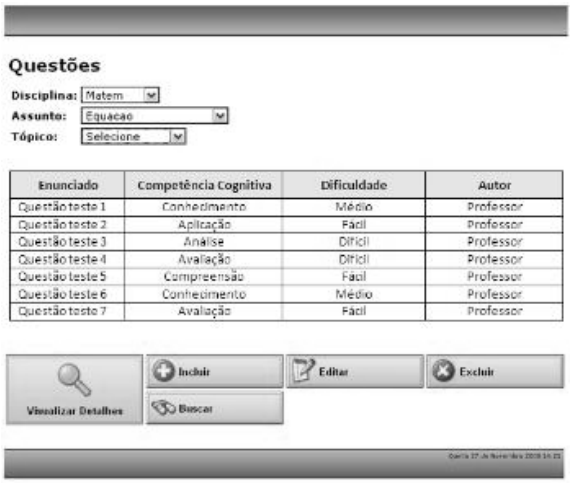


Figure 3: Smart Education: Professor UI.

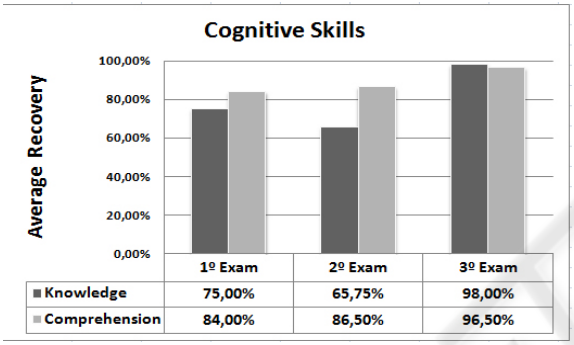


Figure 4: Sample performance report on assessments of a student.

indices referring to exams' results (as illustrated in Figure 4). It will also contain performance charts divided by topics, cognitive abilities and level of knowledge acquisition referring to the current exam or the last ones. Based on this information professor will be able to provide feedback to students, added by his personal opinion, if he believes to be necessary. This report will be automatically stored in the database, to count as historical data of student's learning development.

For students there are features like answering exams; consulting accompaniment reports containing results achieved in the exams; to visualize his exam correction and the comments made by his professor; and to visualize all the grades achieved for all exams of all disciplines.

5 EVALUATING SMART EDUCATION TOOL

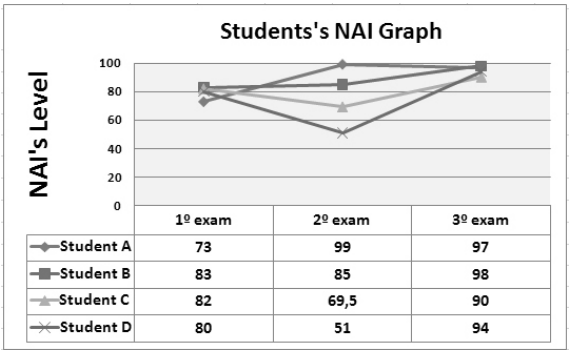
Smart Education tool has been used in "Software Testing" discipline of a Master course at C.E.S.A.R. (www.cesar.org.br), an ICT innovation institute, to a group of four students, having three exams to be taken: two of formative character, each one of them including a self-assessment test, and one of summative character, ending the assessment cycle of the discipline. At the beginning of the two first exams, students received orientations regarding assessment methodology and discipline's related educational purposes.

Students and professors were registered in Moodle, so that they could obtain access to Smart Education. Professors created the amount of questions needed to be used in all exams. Altogether 30 questions were developed and for each one of them the professor was asked to inform, besides the actual question, subject, topic and knowledge area related to the question, and also registering the correct answers for multiple choice questions. System automatically created the self-assessment tests in accordance with the subjects of the chosen questions. After that, an email was sent to students, informing date, time to begin and to end the exam, followed by the instructions and rules for taking the exam.

Multiple choice questions were automatically corrected by the system, whereas subjective questions were corrected by the professor, adding comments on each given response. After corrections were concluded, corrected exams were sent by email to the students. Feedback reports were generated by the system, analysed, commented by the professor and sent via email to each student.

Finally, a research questionnaire was sent to everyone (professors and students) involved in the process, containing 15 questions, aiming at making it possible to collect opinions and impressions of the methodology applied. Great acceptance was identified, with an average 8,4 grade given by the ones involved, which stated to prefer this assessment format in order of the traditional assessment's methods.

For a better visualization of the results achieved during the three exams, graph displayed at Figure 5 presents each student performance. This graph represents NAI (Level of Acquisition of Information) that the students achieved in each of the exams. This metric, that was adapted from (Pimentel, Omar, 2006), is used to measure and monitor student's degree of knowledge for each subject or topic of disciplines, thus, the score achieved in each exam is a NAI.



	1º exam	2º exam	3º exam
Student A	73	99	97
Student B	83	85	98
Student C	82	69,5	90
Student D	80	51	94

Figure 5: Student's performance evaluation in Software Testing discipline.

It is possible to observe in this graph that two students had a better performance between the first and second exam and other two presented a performance decrease. Important to explain that, by following and doing all activities foreseen by the methodology, students were able to achieve a significant improvement in their NAIs, since it was possible to identify with precision their learning difficulties and to act in a precise way for correcting them. This improvement can be noticed by comparing the students' evolution throughout the hole assessment process, where three students (B, C and D) achieved at the third exam a better performance in relation to the others two previous ones. Student A practically kept his excellent performance, with a reduction of only 2 points in relation to the previous one.

It is worth mentioning that the performance report is a very complete instrument (an average, four pages of size), consisting of performance graphics referring to each exam and the class, besides abilities definition information and professor's opinion, not contemplated in this article for matters of space limitation.

6 CONCLUSIONS

Nowadays there is a great variety of systems that works with students' evaluation through the Web, such as, Sisa-Web, AvalWeb, WebTest, HotPotatoes, Net Class, WebCT and Moodle itself, which Smart Education is attached. However, these tools ignore important aspects of the learning assessment process, mainly regarding the creation of qualitative assessments, focused on student's learning accompaniment, seeking to identify learning gaps and allowing the generation of personalized and individualized feedback. The proposal of a web system that can automate some of these tasks and support others, represents an excellent alternative to support the teaching and learning process. By adopting Smart Education, the activities to evaluate and follow student's learning can be more agile and less costly, not representing a reduction of responsibility to professor as an educator, and giving them more solid and precise information for evaluating.

Regarding the experiment presented, it's known by the authors that it needs to be further explored, applying it to bigger groups and to a greater number of disciplines. However, it was already possible to notice that the definition of educational objectives using Bloom's taxonomy constituted a basic element in the assessment process, since it made possible for professors to previously define and plan the results to be reached by their students, as well as establishing which cognitive abilities would have to be developed. With the educational objectives definition, goals to be reached were made clear, since it made possible to measure learning quality and effectiveness. Additionally, it facilitated the selection of subjects to be taught during disciplines, listing those that had greater relevance and, therefore, would have to compose the exam according to professor's view.

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