INTELLIGENT AND ADAPTIVE QUIZZES FOR SEMI-AUTOMATIC MONITORING OF STUDENT PREPARATION

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— COMUNICAZIONE —

TOPIC*: Higher Education*

Abstract

Learning Management Systems (LMSs) have become very successful in e-Education but, at the time of writing, there are some important facilities they lack: i) providing full-fledged adaptivity to the level of knowledge of students and ii) providing automatic assistance for evaluators when building an exam. This paper proposes two solutions: "Adaptive Quiz" and "Score Assistant". An "Adaptive Quiz" is an intelligent quiz whose difficulty changes automatically while the student answers quiz questions. The "Score Assistant" is an intelligent tool able to compute the optimal set of scores to be assigned to every choice of a quiz question. The solutions are based on Answer Set Programming (ASP), a truly declarative programming paradigm proposed in the area of non-monotonic reasoning, logic-programming and Artificial Intelligence. We are presently in the process of developing a Moodle plugin, seamlessly integrating our solutions, to assist educators in evaluating the preparedness of students within the Moodle environment.

Keywords – e-Learning, Artificial Intelligence, Logic Programming, ASP, DLV.

1   INTRODUCTION

Traditionally, educational courses have depended on in-person instructional methods, but contemporary technology has empowered online platforms, with e-Learning relying on information and communication technology (ICT) to enhance learning [1]. Moreover, the global COVID-19 pandemic accelerated e-Learning in higher education, making it a vital component of modern teaching. This shift has provided an effective means for learning in online environments and has gained significant prominence in higher education worldwide [2].

Learning Management Systems (LMSs) such as *Moodle*, *Google Classroom* and *Blackboard* have become very successful in e-Education, providing a rich mixture of parameter settings for an e-quiz, such as time limit, grading strategies, question behaviors and many review options. However, to the best of our knowledge, there are some important facilities they lack: *i)* providing full-fledged adaptivity to the student's level of knowledge and *ii)* providing automatic assistance for evaluators when building an exam.

In this paper, we propose two potential solutions to overcome the aforementioned shortcomings, which for the sake of readability we will call "Adaptive Quiz" and "Score Assistant". An "Adaptive Quiz" is an intelligent quiz whose difficulty changes automatically while the student keeps answering its questions, enabling a quiz to automatically self-adapt to the level of knowledge of a student. The "Score Assistant" is an intelligent feature that helps educators to define the best set of scores to be assigned for every choice of a quiz question. Our goal is to develop a *Moodle plugin* with intelligent quiz features to assist teachers and educators, especially in educational institutions, in semi-automatically assessing the readiness of students on specific topics within *Moodle*.

The proposed features heavily rely on *Answer Set Programming (ASP)* [3, 4, 8], an expressive and versatile [5, 6] logic programming paradigm introduced in the field of *Knowledge Representation and Reasoning* [9] which allows for defining complex computational problems in a clear and fully declarative fashion. With *ASP*, a problem can be expressed via a rule-based logic program, whose intended models, called answer sets, correspond one-to-one to solutions. These solutions are computed by an *ASP system*. The intrinsic declarative nature of ASP, along with its high expressive power, has fueled the development of numerous applications in various fields [10].

For our proposal, we created two ASP programs and exploited *DLV2* [7], a robust and dependable integrated *ASP system* that incorporates the most recent *ASP* research findings.

2   THE PROPOSED SYSTEM

We developed a prototypical system for creating intelligent quizzes, having a User Interface similar to *Google Forms*. Each quiz question consists of a multiple-choice question where the teacher can assign points whenever the answer is correct or not; moreover, the questions can be interconnected based on user responses.

We equipped this system by introducing two intelligent features, called "Adaptive Quiz" and "Score Assistant", which exploit *Answer Set Programming (ASP)* for the intelligent part. In particular, an "Adaptive Quiz" is an intelligent quiz whose difficulty changes automatically while the student keeps answering its questions, whereas the "Score Assistant" is an intelligent feature able to compute the optimal set of scores to be assigned to every choice of a quiz question, given as input the percentage of importance of each topic involved in the quiz.

In the following, we start describing some background concepts and then we describe in detail the "Adaptive Quiz" and "Score Assistant" features.

Concept of Topic. A *topic* is a general, broad, overarching area that a question is referred to: examples of topics can be "Geography", "Cultural Heritage", etc... In our framework, a *topic* can be "linked" to another *topic* by a relationship of dependence specifying a weight whose value is a percentage (from 0 to 100). This setting is represented by the use of a graph called *topic graph*. Figure 1 shows an example of a *topic graph*: in particular we have "Art", Archaeology", "History", "Geography" and "Cultural Heritage" where "History" depends on "Art" and "Archaeology" with weights of 20% (weak dependency) and 80% (strong dependency) respectively and "Cultural Heritage" depends of "Geography" (weight 60%) and "History" (40%).
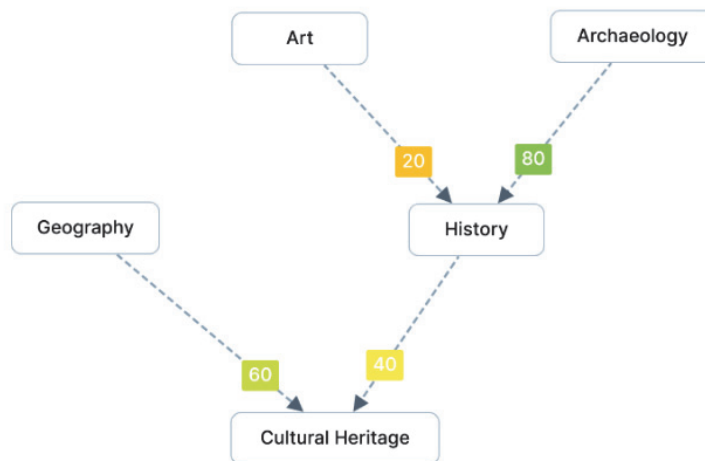

Figure 1 – The graph that models the relationship of dependence among topics

Concept of Importance. By exploiting our system, teachers can assign an "importance" value, represented as a percentage, to each topic. These *importance* values signify the relevance and consideration questions related to each topic deserve. In e-Education, this means emphasizing a topic

in a quiz by assigning the highest possible score values to its questions (specifically, the correct choices), linking topic *importance* to the achievable scores within the quiz.

Topic Knowledge Score (TKS). The *Topic Knowledge Score (TKS)* measures how well students know specific topics., aiding in pinpointing areas needing further attention. Specifically, it provides a tangible assessment of a topic-specific knowledge of students. *TKS* values are indirectly influenced by dependencies between topics; for instance, if a student answers T2 questions correctly (related to T1), the TKS for T1 may not be 0, even if T1 questions were answered incorrectly.

3   SYSTEM DESCRIPTION

In the following, we describe in detail the "Adaptive Quiz" and the "Score Assistant" features, by showing some use case examples.

3.1   Adaptive Quiz

In an "Adaptive Quiz", the difficulty changes automatically while the student keeps answering its questions. According to our framework, a quiz contains several questions associated with certain topics. A teacher builds the quiz by carefully choosing questions and topics so that every student can be properly assessed.

While the student keeps answering its questions, the *TKS* of every topic involved in the quiz is computed. This value is used by the system to choose the next "best" question to be submitted, according to the following requirements:

- if the current *TKS* is below the average, it minimizes the difference between the new TKS value and the average *TKS*. In other words, a question whose *TKS* is as near as possible to the average *TKS* is likely to be selected as the next question;

- if the current *TKS* is above the average, it maximizes the new *TKS*. In other words, a question with the highest possible *TKS* value is selected.

Conceptually, in both cases the quiz tries to select the question that better fits the *TKS* achieved by the student so far; if it is below the average then it tries to reach at least the average, otherwise, it tries with questions that maximize the *TKS*. It is worth noting that a question with high *TKS* can be intrinsically considered a difficult question. We can assume that a question whose correct answer is associated with a high score is potentially difficult. Since the *TKS* depends on scores, we can assume that questions whose *TKS* is high are difficult questions.

Further global objectives of the "Adaptive Quiz" while suggesting the next question are:

- minimizing the number of questions to submit;

- maximizing the number of topics that have been covered so far.

For the sake of completeness, here follows a real-world use-case scenario of the proposed feature.

The following example illustrates a quiz made of 31 questions associated with 5 different topics whose dependencies are represented by the *topic graph* of Figure 1.

Suppose the case of a student who is very knowledgeable on all topics, except "Geography". The resulting sequence of questions can be summarized in Figure 2. As shown in Figure 2, wrong answers were given by the student to "Geography" questions, as a matter of fact, the "Geography" TKS is very low (19%). After giving a wrong answer to question 5, the system tried to adapt the quiz difficulty by asking him easier questions about "Geography" (indeed, questions 6 and 7 give 1 point respectively). Next, wrong answers were given also to questions 6 and 7, thus the system noticed that no more questions could be submitted in order to reach an acceptable TKS for "Geography", while still having a sufficient level of knowledge for the other topics.

3.2   Score Assistant

The "Score Assistant" is an intelligent feature able to compute the optimal set of scores to be assigned to every choice of a quiz question, given as input the percentage of *importance* of each topic involved in the quiz. The main contribution of the proposed feature is that it provides a quick and automatic way to assign an appropriate set of scores to the correct answers to each question in a quiz. If a quiz is made

up of several questions (as in so many cases in the context of education), the teacher should assign a score to every choice of each and every question of the quiz. Let us also assume that a teacher would like to give more importance to a set of questions than others, thus the reader can see how this process may easily become costly and confusing.
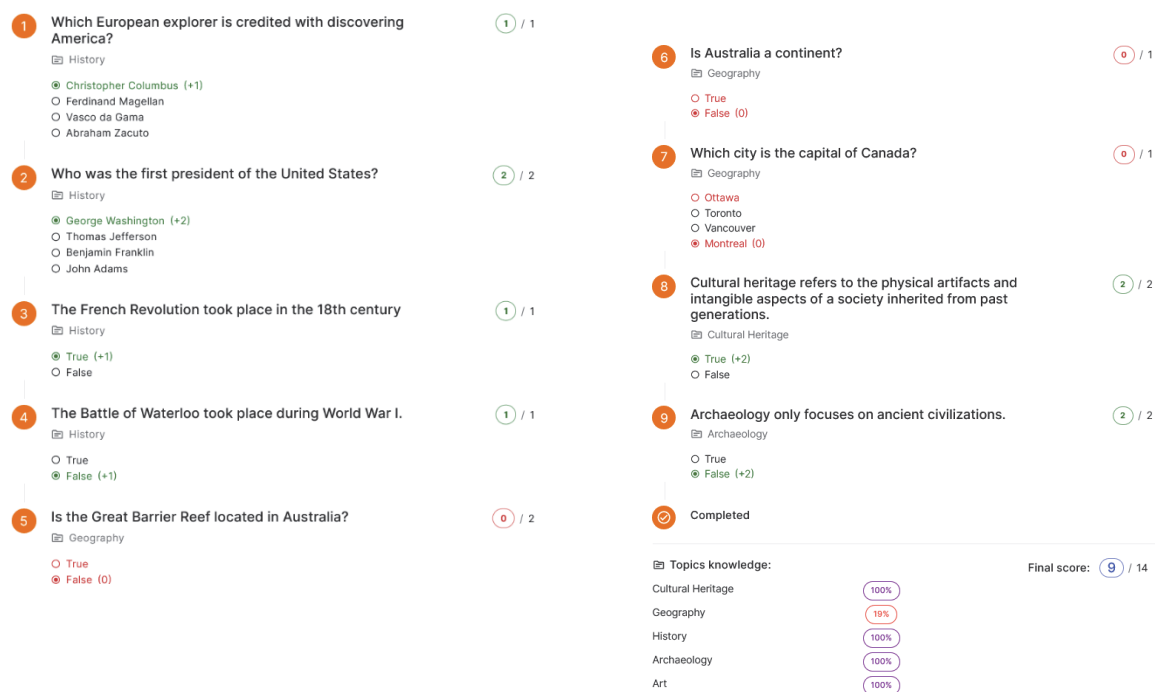

Figure 2 – Adaptive Quiz Simulation

In this context, the "Score Assistant" can help a teacher by gathering all the burden of choosing and assigning proper scores. The teacher is only required to fill in the importance value for each topic involved in the quiz. This is important because it gives a strong indication of how every question is relevant overall.

More specifically, the proposed framework provides that, during the quiz building process:

- the teacher sets an *importance* value for each topic involved in the quiz;

- the teacher invokes the "Score Assistant" in order to get optimal scores;

- The "Score Assistant" takes as input the quiz with the set of questions, the correct choices, the involved topics, and their Importance values.

- The "Score Assistant" runs the computation of a logic program by means of DLV2. This algorithm is able to compute the set of scores such that:

  o *i)* the importance value of each topic is greater or equal to the expected required importance and

  o *ii)* the computed *importance* value is the highest possible.

For the sake of completeness, Figure 3 shows a real-world use-case scenario of the proposed feature (fig. 3). In particular, the teacher sets an importance value for each topic involved in the quiz (left part of the Figure) and the "Score Assistant" computes and shows the optimal set scores given the required importance values (right part of the Figure). The teacher can approve or refuse the proposals.

4   CONCLUSION

Several motivations drive the need for this framework. Quizzes are typically predefined sets of questions, sometimes randomized, given to students within a set timeframe. From the perspective of

the authors, this is a basic and static way to evaluate student knowledge, lacking adaptability to modern methods. Learning environments that account for variations in the affective states and knowledge levels of students improve learning outcomes and the evaluation process [11]. The "Adaptive Quiz", for example, is crafted to match the knowledge levels of students, suggesting questions for areas needing more examination during the exam.
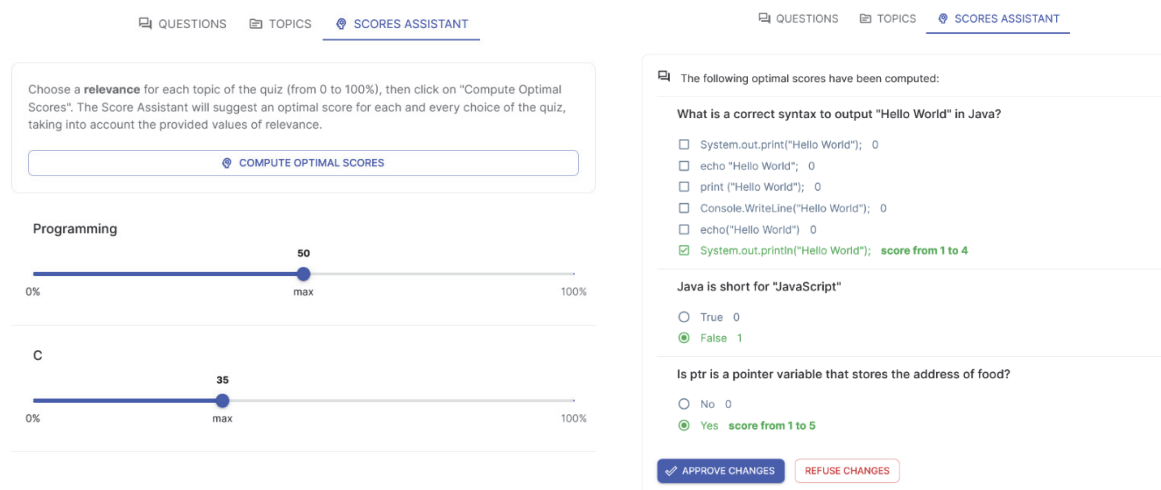

Figure 3 – Computing the best scores with the "Score Assistant".

Our proposal is a research endeavor focused on enhancing *Moodle* with new AI features. The work will undergo experiments to be conducted in both high schools and university courses to validate the effectiveness of our solutions in real-world scenarios and to further refine these features.

This work was also showcased as a poster presentation at *Moodlemoot Global 2023* held in Barcelona (https://moodlemoot.org), underscoring the significance of the proposed features.

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