Question generation for learning evaluation

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Abstract—**In the last decade the electronic learning became a very useful tool in the students' education from different activity domains. The accomplished studies indicated that the students substantially appreciate the e-learning method, due to the facilities: the facile information access, a better storage of the didactic material, the curricula harmonization between universities, personalized instruction. The paper presents a software tool that can be used in the e-learning process in order to automatically generate questions from course materials, based on a series of tags defined by the professor. The Test Creator tool permits generation of questions based on electronic materials that students have. The solution implies teachers to have a series of tags and templates that they manage. These tags are used to generate questions automatically.**

I. Introduction

IN THE last decade, the electronic learning became a very useful tool in the students' education from different activity domains. The accomplished studies indicate that the students substantially appreciate the e-learning method, due to the facilities offered [1], [2], [3], [6], [7]: the facile information access, a better storage of the didactic material, the curricula harmonization between universities, personalized instruction, informational content standardization, real time access to qualitative information resources and friendly interfaces. They don't consider it as a replacement of the traditional learning that has other advantages [8].

As it is known, an essential aspect in the learning process (either electronic or traditional) is the possibilities to evaluate the students. It is very important both for professor and student to test the understanding degree of the course. One of the best possibilities is to ask questions from the studied course. It is tested this way the degree of understanding of each studied material and the integration of new knowledge with the previous ones (that should already be known). These facts will have as a result an in-depth understanding of the learning materials. The studies showed that a high number of questions from the same subject in-depth understanding. That is why a series of questions can be found as exercises at the end of many high rated courses.

The paper presents the implementation of a tool that can generate questions automatically based on the tags defined by the professor. He can add new tags, delete the existing ones and generate questions specifying the part of the course that should be used for questions.

The structure of the paper is: in the second part it is presented the related work. In the third part it is presented the application, the architecture of the application, and in the last part, the conclusions.

II. Related Work

Taking into consideration the high number of learning material existing in electronic format, the importance of the testing and evaluation systems has increased. Most of these systems use tests that were generated by teachers that permit a good evaluation and pursuance of the student evolution.

In the last years, new preoccupations appear for automatic question generation. It's a subclass of Natural Language Generation (NLG) that is very important in a series of areas as: learning environment, data mining or information extraction. For example in [1] it is introduced a template-based approach to generate questions on four types of entities. It is considered that his approach failed in producing questions that can enhance the students' knowledge level. The authors present in [2] an interesting solution to the problem of presenting students with dynamically generated browser-based exams with significant engineering mathematics content. They introduce WTML (Web Testing Markup Language), which is an extension of HTML. A very interesting approach is found in [3]. Here, the main idea is to generate the questions automatically based on question templates which are created by training on many medical articles. This idea has advantages (easiness in building medical learning system, no additional work to build the question database or grading), but also disadvantages: the generated questions are factual and maybe less meaningful than the manual questions, time consuming to parse the articles and obtain the semantic interpretation, missing some important information.

Taking into account the advantages and disadvantages of the presented solutions, we tried to design and implement a software instrument (Test Creator) that permits generation of questions based on electronic materials that students have. The solution implies teachers to have a series of tags and templates that they have to manage. These tags can be used to generate questions automatically.

III. QUESTION GENERATION

A. General Description

In this paragraph there are presented concepts and the working style for the Test Creator software tool. The main window is organized in several sub-windows, each of them permitting some operations in a very simple manner. It is easily compatible with any learning domain: engineering, medical, or economical. In order to generate questions, based on a specific course material, there should be followed 3 steps:

1. Defining tags or questions categories
2. Defining templates for a specific tag
3. Parsing the text in order to generate the templates.

The basic idea for generating questions based on the course material is to define a list of tags, chosen by the teacher. Each tag represents a class of questions with similar formatting that are applicable for certain theoretical notions from the course.

For example, the <DEFINE> tag will be used to formulate some questions where the student has to define some concepts. The <EXAMPLE> tag will be used for questions where it should be presented an example for a specific concept.

In the TestCreator software tool there is a sub-window where there are presented the tags that already exists in the database. They can be updated using insert/delete operations. The most important thing is that the teacher has total freedom in choosing these tags, as he considers being most suitable for his course domain.

For each tag, the teacher defines one or several forms of a question, suitable for a specific category. These forms of the questions were called templates (figure 1).

For example, for the <DEFINE> tag it can be defined the following template: "DEFINE #". For the tag <WHAT IS>, the template can be "What is a/an #". The use of "#" sign represents for this application the reserved word or phrase to which it is applied the tag.

One of the problems was to have several forms for the same tag in order to give the possibility to the teacher to create questions that are correct from the syntactic and semantic point of view. Another situation that appears frequently refers to the possibility to formulate the same questions both in the native language and in an international language.

The final step is represented by the questions generation. The professor has to load first the course material in the main window. Then, in order to generate questions, he has to select the keyword or key-phrase from the text and then to select the tag and template. The "#" sign will be replaced with the chosen word/phrase from the course.

For example, for the DEFINE # template, and the keywords "Boyce-Codd normal form" there will be generated the question: DEFINE Boyce-Codd normal form.

As soon as it was generated, the question is displayed in another window of the software tool. The teacher has to decide if it is correct and if it should be kept and stored in the database (figure 2).
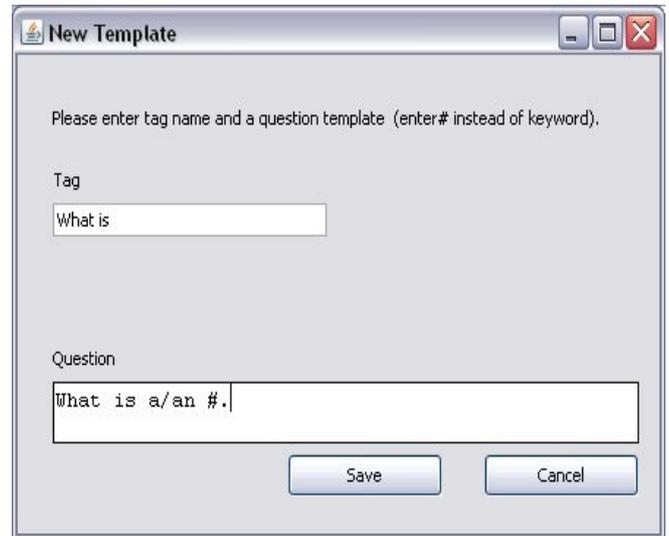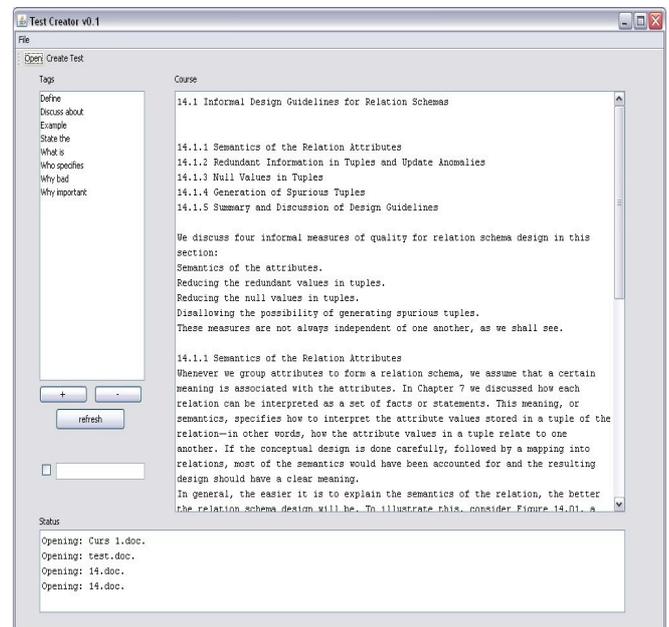

Fig. 1 Defining the question template

Fig. 2 The main window of the software tool

Another window of the application is the one in figure 3, where can be displayed all the questions generated by the teacher for the course material currently loaded in the system. These questions are managed by the teacher giving him the possibility to delete, update and store them in the database. He will also have the possibility to reload a course material and see the questions generated for it.

B. The Structure of the Database

The entity-relation model of the database used by the software tool is presented in the figure 4. The Tags table is the one that stores information about existing query categories. The Templates table has a connection of 1:m with the table Tags.
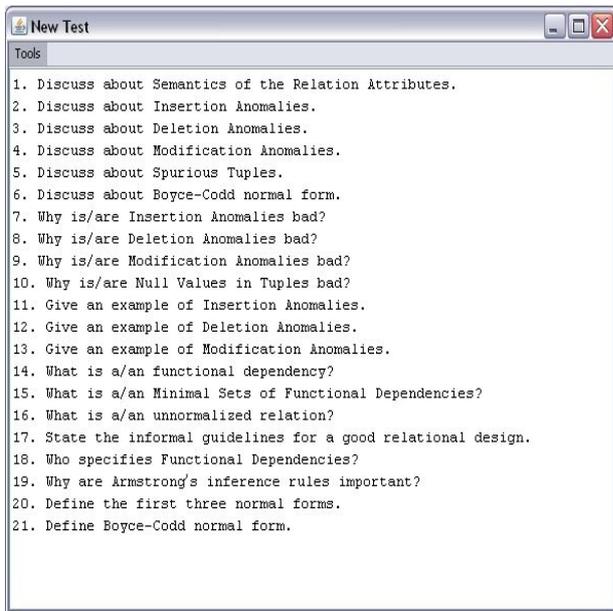
Fig. 3 The questions generated by the system

It is used to store for each query category, different forms of the queries. The tables Course and Chapters stores information about electronic courses and their chapters. Actually these chapters will be loaded into the application in order to generate questions from them. Between tables Chapters and templates there is a m:m connection. In the relational model this will lead to a new relation, called Questions where it is stored the effective content of the generated query
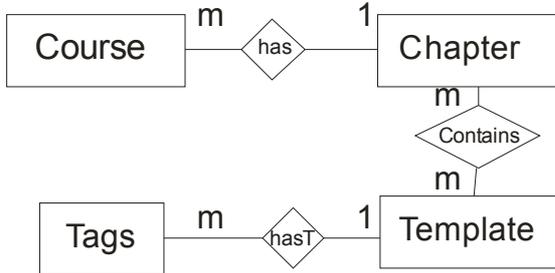

Fig. 4 The Entity-Relationship model for database structure

IV. SOFTWARE ARCHITECTURE

The document type that is the most used is the MS Word .doc type. For this we have implemented a class (POIDoc) that opens and returns the content of a MS Word document. This class uses Apache POI libraries: poi-3.0.1.jar, poi-contrib-3.0.1.jar, poi-scratchpad-3.0.1.jar.

The POI project consists of APIs for manipulating various file formats based upon Microsoft's OLE 2 Compound Document format using pure Java. We can read and write MS Word, Excel files using Java. POI is your Java Word solution as well as your Java Excel solution. HWPF is the name of our port of the Microsoft Word 97 file format to pure Java. It does not support the new Word 2007, .docx file format, which is not OLE2 based.

For basic text extraction, we make use of org.apache. poi.hwpf.extractor.WordExtractor. It accepts an input stream or a HWPFDocument. The getText() method can be used to get the text from all the paragraphs, or getParagraphText() can be used to fetch the text from each paragraph in turn. The other option is getTextFromPieces(), which is very fast, but tends to return things that aren't text from the page.

V. CONCEPT MAPS APPLIED FOR QUESTIONS GENERATION

A. General Description

Concept maps are a result of Novak and Gowin's (1984) research into human learning and knowledge construction. Novak (1977) proposed that the primary elements of knowledge are concepts and relationships between concepts are propositions. Novak (1998) defined concepts as "percei-ved regularities in events or objects, or records of events or objects, designated by a label." Propositions consist of two or more concept labels connected by a linking relationship that forms a semantic unit.

Concept maps are a graphical two-dimensional display of concepts (usually represented within boxes or circles), connected by directed arcs encoding brief relationships (linking phrases) between pairs of concepts forming propositions. The simplest concept map consists of two nodes connected by an arc representing a simple sentence such as 'flower is red,' but they can also become quite intricate.

One of the powerful uses of concept maps is not only as a learning tool but also as an evaluation tool, thus encouraging students to use meaningful-mode learning patterns.

Concept mapping may be used as a tool for understanding, collaborating, validating, and integrating curriculum content that is designed to develop specific competencies. Concept mapping, a tool originally developed to facilitate student learning by organizing key and supporting concepts into visual frameworks, can also facilitate communication among faculty and administrators about curricular structures, complex cognitive frameworks, and competency-based learning outcomes. To validate the relationships among the competencies articulated by specialized accrediting agencies, certification boards, and professional associations, faculty may find the concept mapping tool beneficial in illustratingrelationships among, approaches to, and compliance with competencies [9].

According to this approach, the responsibility for failure at school was to be attributed exclusively to the innate (and, therefore, unalterable) intellectual capacities of the pupil. The learning/ teaching process was, then, looked upon in a simplistic, linear way: the teacher transmits (and is the repo-sitory of) knowledge, while the learner is required to comply with the teacher and store the ideas being imparted [10].

It should be made a very important distinction between rote learning and meaningful learning.

Meaningful learning requires three conditions:

1. The material to be learned must be conceptually clear and presented with language and examples relatable to the learner's prior knowledge. Concept maps can be helpful to meet this condition, both by

identifying large general concepts held by the leaner prior to instruction of more specific concepts, and by assisting in the sequencing of learning tasks though progressively more explicit knowledge that can be anchored into developing conceptual frameworks;

2. The learner must possess relevant prior knowledge. This condition can be met after age 3 for virtually any domain of subject matter, but it is necessary to be careful and explicit in building concept frameworks if one hopes to present detailed specific knowledge in any field in subsequent lessons. We see, therefore, that conditions (1) and (2) are interrelated and both are important;

3. The learner must choose to learn meaningfully. The one condition over which the teacher or mentor has only indirect control is the motivation of students to choose to learn by attempting to incorporate new meanings into their prior knowledge, rather than simply memorizing concept definitions or propositional statements or computational procedures. The indirect control over this choice is primarily in instructional strategies used and the evaluation strategies used. Instructional strategies that emphasize relating new knowledge to the learner's existing knowledge foster meaningful learning. Evaluation strategies that encourage learners to relate ideas they possess with new ideas also encourage meaningful learning. Typical objective tests seldom require more than rote learning [7].

B. Concept maps for queries generation

The concept map helps the professor to have a better overview of the course and what aspect he should pay attentions. If he generate first a concepts map he will be able to define tags for every concept and implicit to have questions for each concept.

Before defining the tags position in the text the professor has to specify a list of concepts and the connections between them. The list of concepts that will be included is chosen by the professor. He will decide what the most important concepts in the course are and which are not.

There are many tools that generate concept maps. The most used are:

- C-TOOLS – Luckie (PI), Implemented to the University of Michigan NSF grant. It is available for download to the address:
  http://ctools.msu.edu/ctools/index.html

- TPL-KATS – Implemented to the University of Central Florida (e.g., Hoeft, Jentsch, Harper, Evans, Bowers, & Salas, 1990). TPL-KATS: concept map, a computerized knowledge assessment tool. Computers in Human Behavior, 19 (6), 653-657.

- SEMNET – Downloadable from:
  http://www.semanticresearch.com/about/

The steps that should be followed are:

1. The specialist will use one of these specialized tools to generate a concept map for the course material, similar to the one presented in figure 5.

2. Load the course in the system
3. Add/Delete existing tags templates to be according to his needs.
4. For each concept in the map define one or several templates that will be applied.
5. Generate questions. For each edge in the graph it will correspond a certain number of quiz questions.

The algorithm transforming the Concept Map into General Graph is strait forward. Each proposition becomes an edge with a weight assigned by domain knowledge expert. In this way it was obtained the Binary Search Tree General Graph. Once the General Graph has been set, up the professor has to set up the quiz questions for the chapter. For each edge in the graph it will correspond a certain number of quiz questions.

Once the quiz questions have been set up, for each student there may be constructed the learner's associated graph.
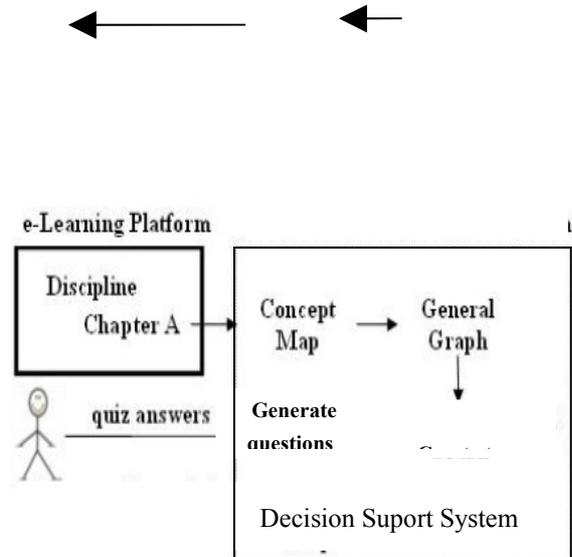

Fig. 6 Functionality of Test Creator tool using on Concept Maps.

This graph will have associated with the edges the history of correct and wrong answered questions. The Calculus engine will reconstruct an Annotated Concept Map which will present to the learner the current status of his knowledge level at Concept level. In this way, the learner will have an exact overview of his knowledge level regarding that chapter. The Annotated Concept Map may represent the important information for learner in having a decision regarding which part of the chapter needs more study.

VI. Conclusions and Future Work

The paper presented a software tool that can be used in the e-learning process in order to generate automatically questions from course materials. The professor can define tags and templates that will be used in query generation.

The Test Creator tool permits generation of questions based on electronic materials that students have. The solution implies teachers to have a series of tags and templates that they have to manage. These tags can be used to generate questions automatically.

In order to find the most important part in a course material and it will be created a list of concepts and a Concept map. For these steps of the process it should be used a third party software tool specialized in concept maps aspects.

It is preferable to include concept maps concepts in the learning process for two reasons:
- you can be sure that you will have questions about all important concepts existing in the course
- you can monitor learning activity to be sure that students learn meaningful and not only several separate aspects, with no connection between.

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