Overview of a Factual Question Generator System

Aguilar, Gabriela
Unidad Monterrey
Cinvestav
Mexico
gburguete@cinvestav.mx

Kaijiri, Kenji
Faculty of Engineering
Shinshu University
Japan
kaijiri@cs.shinshu-u.ac.jp

Abstract: The simultaneous fostering of formative assessment from the point of view of the Social Constructivism is a challenge for the teacher in science education. We assume this challenge through the implementation of the Factual Questions Generator System (FQGS). The FQGS uses text documents as its underlying knowledge source and combines various natural language processing techniques to extract and construct questions. The implemented techniques include: a shallow parser and rules, which match the Spanish grammar patterns and it will include: named-entity recognition and co-reference resolution. The FQGS generates what, how and why questions. One interesting characteristics of this prototype is that learners will be able to decide by themselves, what are their best learning paths trough the selection of the topics that they want to evaluate. The FQGS is the result of the implementation of the first prototype of SPEBC, an adaptive computer-based assessment system.

Keywords: Adaptive Computer-based Assessment System, Classroom Communication System

Introduction

The simultaneous fostering of formative assessment from the point of view of the Social Constructivism is a challenge for the teacher in science education. Limited time, large class size and the long list of topics to be studied are some aspects that make difficult the implementation of mechanisms for personalized pedagogical support. Given the complexity of the teaching-learning process, we assume this challenge using several means of support. One of them is the Factual Question Generator System (FQGS), designed to give support to teachers in the generation of questions and answers in real-time, furthermore, this system will provide information about the learners' achievement and it will allow a continuous assessment of the teaching-learning process (Aguilar, et al., 2006).

Factual questions are those, which assess the learner's understanding of facts and processes. It is important to evaluate this because facts are important for thinking and problem solving (National Research Council, 2000). By generating these kinds of questions, we are trying to gather information about different levels of understanding about entities, processes, causes, and conditions of chemical events.

There are previous works about the development of assessment systems such as those of Alfonseca, (et al., 2005) and Pear (et al., 2002). Alfonseca proposes the evaluation of open-ended questions adapted to each learner. The adaptation process done by Alfonseca is based on the determination of personal features and preferences, learning styles and previous knowledge. On other hand, Pear (et al., 2002) implemented a constructivist tool, called CAPSI (Computer-Aided Personalized System of Instruction) in which the quality of the answer depends on how well it is argued as judged by the feedback that are evoked by others. Moreover, previous research (Wang, 2006) indicates the importance of including formative assessment practices for the regulation of the learning-process. And in this way, to foster meta-cognitive attitudes in the learners that help them learn to learn. The FQGS is the result of the implementation of the first prototype of SPEBC (Sistema Personalizado de Evaluación Basada en Computadora), an adaptive computer-based assessment system (Aguilar, et al., 2006). After finishing the implementation of the FQGS, learners will answer the generated questions in the classroom interacting with a Classroom Communication System (CCS) (Sharma & Khachan, 2005). The system will compute the right and wrong answers and it will deploy a histogram with the group's assessment results. Furthermore, learners will be able to interact with the FQGS at

home and they will be able to answer questions in order to regulate their own learning process. The FQGS will generate factual questions as multiple-choice questions. The FQGS can be used as formative assessment tool. Furthermore, teachers will be able to use the FQGS as a tool to foster in the learners meta-cognitive attitudes.

We think that the following will be some of the advantages for teachers and students when they use the FQGS. The advantages for teachers are:
- They are going to save time in the preparation of the questions
- They are going to be able to know in real-time using a voting system, the learners' understanding levels and in this way, to do a continuous assessment of the teaching-learning process.

The advantages for students are:
- They will be able to foster meta-cognitive attitudes that help them learn to learn.
- The formative assessment requirement included in the design of the FQGS will help learners to know their own understanding levels, in real-time in the classroom and at home.

The use of the FQGS together with a voting system will allow the teachers to know in real-time, the learners' understanding levels. On other hand, teachers will be able to use the FQGS as a tool to foster meta-cognitive attitudes in the learners that help them learn to learn. This can be done through the generated questions about the topic to be studied and through the learners' interaction with the FQGS in the classroom and at home, respectively.

The present paper introduces a work in progress which gives an overview of the FQGS, its functionality, and the identification of the possible problems when the system is used in real situation. Furthermore, the present paper shows the feasibility of the implemented approach. This paper is organized as follows: Second section introduces an overview of SPEBC. Third section gives an overview of the FQGS. Fourth section introduces the implementation approach. And at the end of this paper conclusions are given.

SPEBC, an Adaptive Computer-based Assessment System

The FQGS is the result of the implementation of the first prototype of SPEBC (Sistema Personalizado de Evaluación Basada en Computadora), an adaptive computer-based assessment system (Aguilar, et al., 2006). SPEBC combines an adaptive assessment system with a CCS (Sharma & Khachan, 2005). Teachers by using SPEBC, as a tool to attend the class diversity, will be able to request the generation of assignments and learners will use a voting system to send the answers in (See Figure 1). SPEBC will check the answers and will deploy a histogram with the assessment results. In this way, teachers will be able to evaluate the learners understanding levels in real-time. Furthermore, teachers will be able to take decisions about the actions to be taken in order to improve the teaching-learning process, for example, teachers and learners will be able to use the assessment results for their own teaching and learning process regulation. SPEBC will provide initial, formative, and summative assessments. The assessment strategies to be included are: Knowledge and Prior Study Inventory (Tamir & Lunetta, 1978), factual questions and essays. SPEBC will generate multiple-choice and open-ended questions, personalizing the responses according to each learner and knowledge content (Aguilar, et al., 2007a).

Figure 1: Students using a voting system in the classroom
(Image taken from: http://www.ambra-solutions.co.uk/product_images/CPS/trinity_remote2_r2_c2.jpg)

Overview of the FQGS

The FQGS generates what, how and why questions and their respective right answers. The implemented prototype consists of the following elements: The main menu of the FQGS has three bottoms (See Figure 2). The first left bottom is used to start the questions generation process. The middle bottom is used by teachers and learners to organize the generated questions. And the right bottom is used to exit from the system. Another option has to be implemented with the aim of providing the learners an interface in where they can answer and the system can grade, the generated questions.
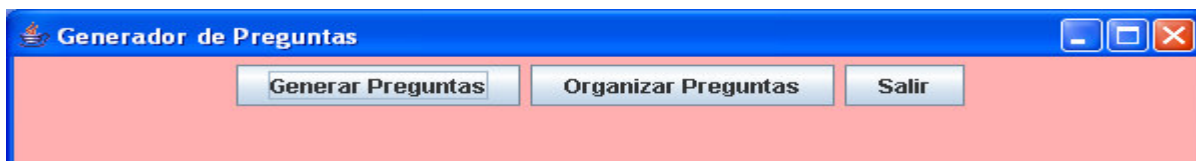

Figure 2. Main menu of the FQGS

Questions Generation

When teachers or learners request to the FQGS, the generation of questions, they introduce a text file from which questions will be generated. Having as an input a text file (See Figure 3), which contains the subjects to be studied in text format, the FQGS generates questions in natural language. The system assumes that the text file given as an input is a well-formed document, that is to say, that the text was written following the syntax and grammar rules of the Spanish language. And the FQGS will be able to generate questions, if the input is given as a text file and if there is a text contained in that text file. Teachers and students can input any text file and this implies that they can visit for example some web pages, to do a copy-paste to a text file and then, they can use this file as an input for the system. Some other times, teachers will have to capture a textbook and give a copy of that electronic textbook to the learners, in such a way, that these learners use it as an input for the system. Following the above recommendations, learners and teachers can input any text file and use the system in the same way.
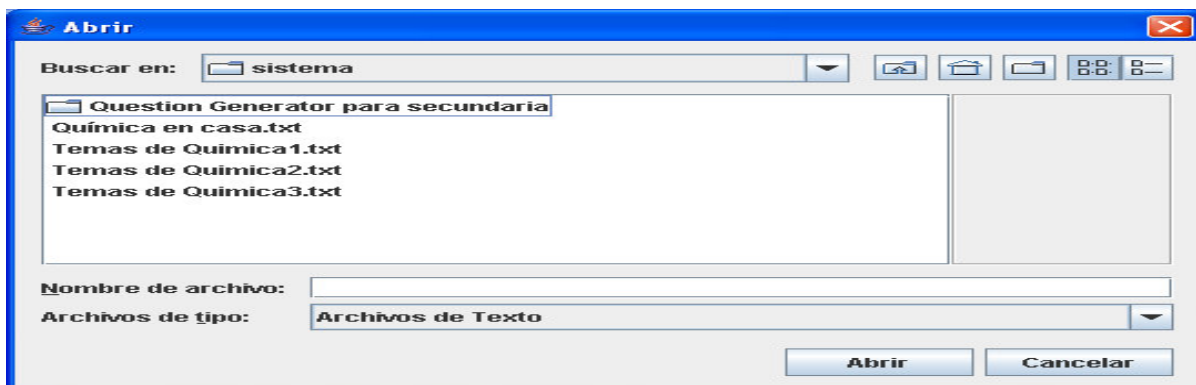

Figure 3. Interface to input the text file from which the questions will be generated

In the current state of implementation of the FQGS, this generates open-ended questions and questions to be used as multiple-choice questions. One question can be presented as open question or multiple-choice question by changing the wording of that given question. For example, the first question given in the examples below can be used as multiple-choice question, if we change the wording of that question we can obtain an open-ended question such as: What is the ground? (Qué es el suelo?).

The following are examples of the generated questions, in the current implementation state of the FQGS. It is important to clarify that the original sentence and the sentence given as the right answer are the same. This may bring a problem for elementary school students, because sometimes as in the examples given below, the right answer is too long and these students may get tired of reading among 4 long answers. In order to solve this problem, the FQGS generates questions using different wording, however, this not happen for every question because it depends on the matching of specific sentence grammar styles.

Original Sentence: El suelo es una capa delgada que cubre parte de la superficie del planeta y que contiene diferentes sustancias principalmente minerales además de pequeños organismos que permiten mantener la vida vegetal.

Translation: The ground is a thin layer that covers part of the surface of the planet and it contains different mainly mineral substances in addition to small organisms that allow the maintenance of vegetal life.

Generated Question: ¿(De) Qué es una capa delgada que cubre parte de la superficie del planeta y que contiene diferentes sustancias principalmente minerales además de pequeños organismos que permiten mantener la vida vegetal?

Translation: What is a thin layer that covers part of the surface of the planet and it contains different mainly mineral substances in addition to small organisms that allow the maintenance of vegetal life?

Original Sentence: Actualmente la acumulación de dióxido de carbono y otros gases en la atmósfera provoca que se incremente su temperatura ya que estas sustancias actúan como un invernadero con el calor proveniente del Sol lo cual produce el sobrecalentamiento del planeta.

Translation: Nowadays, the carbon dioxide accumulation and other gases in the atmosphere cause that its temperature is increased since these substances act like a conservatory with the originating heat of the Sun which produces the global warming.

Generated How Question: ¿Cómo provoca que se incremente su temperatura ya que estas sustancias actúan como un invernadero con el calor proveniente del Sol lo cual produce el sobrecalentamiento del planeta?

Translation: How causes that its temperature is increased since these substances act like a conservatory with the heat of the Sun which produces the global warming?

Original Sentence: En esa época como resultado de una glaciación descendió el nivel del mar por lo que tierras que ahora están sumergidas quedaron en la superficie uniendo Siberia y Alaska en lo que ahora es el estrecho de Bering.

Translation: At that time as resulting of a freezing the level of the sea descended reason why earth that now are submerged were in the surface uniting Siberia and Alaska in which now it is the Straits of Bering.

Generated Question: ¿Por qué tierras que ahora están sumergidas quedaron en la superficie uniendo Siberia y Alaska en lo que ahora es el estrecho de Bering?

Translation: Why lands that now are submerged were in the surface uniting Siberia and Alaska in which now is the Straits of Bering?

Questions Management

One interesting characteristics of this prototype is that learners will be able to decide by themselves, what are their best learning paths trough the selection of the topics that they want to evaluate. In the classroom teachers will be able to use this prototype for the questions generation and learners at home will be able to use the system to generate questions from the text file given as an input. Learners and teachers can use the system interacting with the same interface.

After the user clicked on the "organizar preguntas" option, the system will introduce to him or her, the window shown in Figure 4. Figure 4 shows the interface implemented for teachers and learners in order to organize the generated questions. The left side of the interface is the place in where the generated questions are deployed and the right side is the place in where teachers and learners will paste the questions that learners will answer. The top bottoms in Figure 4 are used to open a file, to save a file and to clean the right side of the interface. At the bottom of the interface, the user can make click on the first left bottom in such a way that he or she can copy a given question from the left side to the right side. Moreover, options are provided to filter what, how, why questions and the questions previously contained in the text file given as an input.

Implementation Approach

This section introduces the implementation approach of the FQGS. Previous works have been implemented such as those of Mitkov (et al., 2007). Mitkov describes a novel computer-aided procedure for generating multiple-choice tests from electronic instructional documents. In addition to employ various NLP techniques including term extraction and shallow parsing, the program makes use of language resources such as a corpus and WordNet. The system generates test questions and distracters, offering the user the option to post-edit the test items. The work proposed by Mitkov and the present work are very similar. However, some of the differences between these works

are: the work implemented by Mitkov generates questions in English and the proposed work in Spanish. Also the proposed work will be a computer-based system. The work given by Mitkov generates what and which questions and the present work generates what, how and why questions.

The FQGS uses text documents as its underlying knowledge source and combines various natural language processing techniques to extract and construct questions. Syntactic, semantic, and context processing will be done in order to generate questions. The implemented techniques include: a shallow parser and rules, which match the Spanish grammar patterns (Aguilar, et al., 2007b) and it will include: named-entity recognition (Humphreys, et al. 2000) and co-reference resolution (Humphreys, et al. 2000). The shallow parser analyses a sentence taken from the file given as an input without to specify their internal structure and then classifies each word in verbs or adverbs. The shallow parser uses Spanish syntax patterns which allow the processing of this classification. The syntax pattern rules allow the FQGS to be domain independent. The output of the shallow parser is the input for the sentence transformation process. The generation of each type of question depends on the verbs, adverbs and special tokens that are matched by the rules. What questions and how questions require the matching of a specific type of verbs and adverbs. And why questions require the matching of a special type of tokens. In Spanish, sometimes verbs are different for what and how questions. Through the implementation of the Spanish grammar rules we learned that the percentage of error in the generated questions is inversely proportional to the generality of the rules.
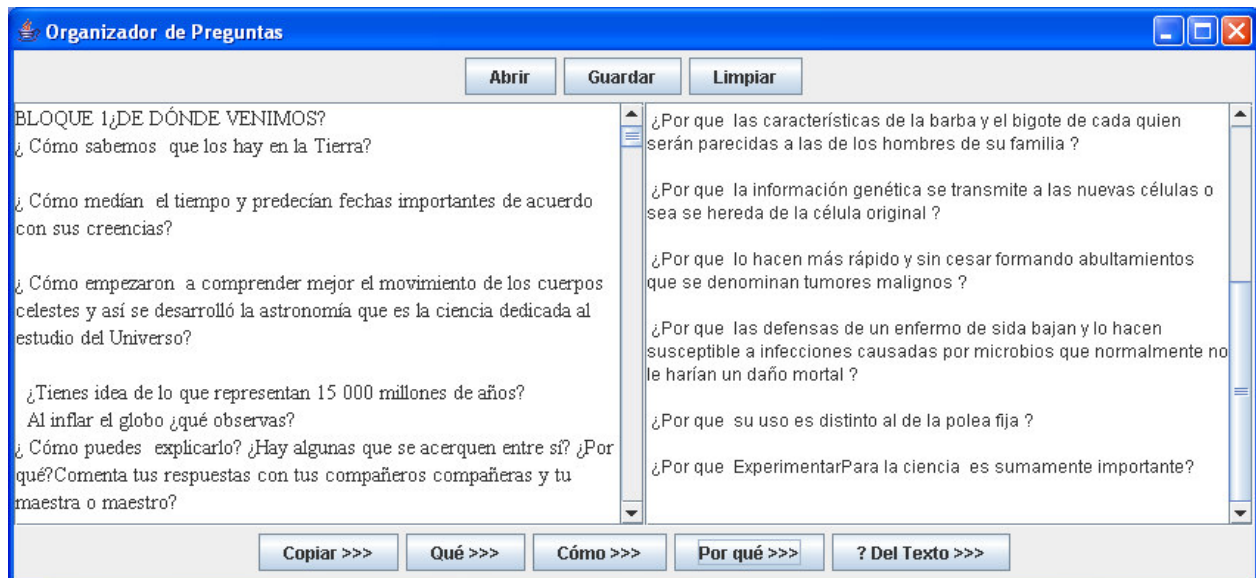

Figure 4. Interface to be used by teachers and learners to organize the generated questions.

Conclusions and Further Research

The present paper introduces a work in progress about a Factual Questions Generator System (FQGS). This system generates questions which start with what, how and why. The FQGS is domain independent, if in the text file given as an input, there is some text from which questions can be generated. Given as an input a text file, the FQGS generates automatically questions and their respective right answers. This represents an advantage over static questions databases. However, some effectiveness evaluation is required in order to exactly quantify the time saved in the question generation process. Also, we have to do an effectiveness evaluation study to determine the validity and reliability (Aguilar, et al., 2007b) of the generated questions.

On other hand, teachers will be able to use the FQGS together with a CCS, and this will allow them to know in real-time, the learners' understanding levels. The results of previous studies about the effectiveness of the incorporation of a CCS in the classroom indicated that the students were more engaged in learning when CCS was utilized. While teachers believed that the CCS positively impacted their teaching (Godfrey, 2006).

On other hand, Wang (et al., 2006) indicates the importance of including formative assessment practices for the regulation of the learning-process. This requirement was included in the FQGS. By using this system, learners

can control their own learning process regulation. More over, we need to work with teachers in the classroom, to generate recommendations about the use of the FQGS; in such a way, that teachers can know how to explore the potential of the FQGS to foster in the learners meta-cognitive attitudes that help them learn to learn.

We think that the requirements of the FQGS in order really help the learners to understand better the content of their textbooks, should be:

- The FQGS has to generate the alternative (wrong) answers which must be as nearer as possible to the right answer.
- The generated questions should be relevant to the concept to be learned.
- The generated questions should ask the same question using different wording.
- The FQGS should control different grades of difficulty based on the grade of difficulty of each question, based on each learner's background knowledge, based on each learner's understanding levels and based on the answers' presentation style.

In the current implementation state of the FQGS, the system only generates questions using different wording. Further research is required in order to determine an approach for the generation of relevant questions and for the generation of alternative answers. However, we think that these can be done through the generation of ontology for each text file given as an input. We have the hypothesis that what questions can be given to the learners as basic questions and how and why questions can be given to the students as difficult questions. However, it is required to determine whether the generated questions can be divided into these grades of difficulty. Further research also is required to include the personalization approach. However we have previously worked on this direction (Aguilar, et al., 2006, 2007a, 2007b, 2007c, 2007d). Moreover, we are thinking to include in further designs of SPEBC, a module which include the question posing approach. In such a way, that SPEBC helps the learners to understand a given topic by evaluating their own questions elaboration.

References

Aguilar, G., Gómez, A. & Kaijiri, K. (2006). Adaptive Teaching and Learning Using a Classroom Communication System and an Adaptive Computer-Based Assessment Tool. *e-Learn, 2006,* Association for the Advancement in Computing Education, Honolulu, Hawaii, 2701-2706.

Aguilar, G., Gómez, A. & Kaijiri, K. (2007a). Assessment Strategies for Learning Regulation to be Included in the Development of a Computer-based Assessment System. *SITE, 2007,* Association for the Advancement in Computing Education, San Antonio, Texas, 10-15.

Aguilar, G., Gómez, A. & Kaijiri, K. (2007b). Learners and Knowledge: A New Personalization Factor Perspective for Adaptive Computer-based Assessment Systems*, Ed-Media, 2007*, Association for the Advancement in Computing Education, Vancouver, Canada, 2143-2148.

Aguilar**, G.** & Kaijiri, K. (2007c) Adaptive Approach for the Integration of Homogeneous Teams, *E-Learn 2007*, Association for the Advancement in Computing Education, Quebec City Canada, 597-602 .

Aguilar, G. & Kaijiri, K. (2007d). Design Overview of an Adaptive Computer-based Assessment System. *Journal of Interactive Educational Multimedia*. Vol. 14, 116-130 (2007):116-130.

Alfonseca E., Carro R. M., Freire M., Ortigosa A., Perez D. & Rodriguez P. (2005). Authoring Of Adaptive Computer Assisted Assessment Of Free-Text Answers. *Educational Technology & Society,* 8(3), 53-65.

Godfrey, C. (2006). The Impact of a Classroom Communication System on the Learning Process in Eighth-Grade Special Education Classes. *ARE.* 5(1).

Humphreys K., Demetriou G. & Gaizauskas R. (2000), Two Applications of Information Extraction to Biological Science Journal Articles: Enzyme Interactions and Protein Structures. *PSB, 2000*, Proceedings of the Pacific Symposium on Biocomputing, Honolulu, Hawaii, 505-516.

Mitkov, R.; Ha, L.A.; Karamanis, N. A (2007) computer-aided environment for generating multiple-choice test items, Natural Language Engineering vol.12, 2 : 177-94.

National Research Council (2000). How people learn. Washington DC:National Academic Press.

Pear, J. J. & Crone-Todd, D. E. (2002). A Social Constructivist Approach to Computer Mediated Instruction. *Computers & Education,* 38(1-3), 221-231.

Sharma, M.D., Khachan, J., Chan, B. & O'Byrne, J. (2005). An Investigation of the Effectiveness of Electronic Classroom Communication Systems in Large Lecture Classes. *Australasian Journal Of Educational Technology*, 21(2), 137-54.

Tamir, P. & Lunetta, V. N. (1978). An analysis of laboratory activities in the BSCS. Yellow version, *American Biology Teacher,* 40, 426-428.

Wang K. H.; Wang T.H.; Wang W.L. & Huang S.C. (2006). Learning Styles and Formative Assessment Strategy: Enhancing Student Achievement in Web-Based Learning. *Journal of computer Assisted Learning,* 22 (3), 207-217.