An extension of the OeLE platform for generating semantic feedback for students and teachers


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Abstract

Feedback is an important component of assessment in learning environments, because it allows students to know their learning flaws. Feedback information is indeed useful for teachers to design learning contents adapted to the needs of the students. Therefore, the availability of feedback constitutes a new learning opportunity. In this paper we describe an approach based on Semantic Web technologies for generating useful semantic feedback for both teachers and students.

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1. Introduction

The Semantic Web (Berners-Lee et al., 2001) proposes the idea that web contents are defined and linked not only for visualization but for being used by applications. Moreover, Semantic Web technologies have been used in e-learning for the last years from different perspectives (see, for instance, (Stojanovic et al., 2001; Fensel et al., 2003; Devedzic, 2006)). However, researchers in this field have not paid enough attention to the application of these technologies to assessment. In this way, our research group developed the OeLE platform to support teachers in the assessment of open questions-based exams by applying such technologies (Castellanos-Nieves et al, 2008). In OeLE, the exams made by the students were automatically marked by using this software platform, which makes use of a series of Semantic Web-related elements. First, the knowledge of the course and the exams is modeled using a course ontology written in the Web Ontology Language. Second, semantic annotations were provided for any question included in an exam. A semantic annotation is the association of metadata to the questions. In particular, the metadata used in this platform are the elements of the course ontology. Each semantic annotation consists in associating one or more elements of the course ontology to the question or to part of the student answer.
Consequently, the expected answer to a question and the student’s actual answer to that question were semantically semi-automatically annotated using this platform.

Once the annotations have been obtained, OeLE gets automatically the marks for each question using the functions presented in (Castellanos-Nieves et al, 2008), which are described next. The evaluation function for a particular question is based on the calculation of the semantic similarity between the expected answer and the actual student’s one. This marking algorithm has a series of parameters that allow applying a particular marking strategy, so policies with different degree of strictness may be applied. This assessment approach demonstrated its usefulness in real courses for supporting exam marking. However, it did not allow students and teacher to know the main flaws of the students from the course knowledge perspective, that is, the generation of feedback for the students and teachers.

However, feedback is indeed an important part of assessment processes since they allow both teachers and students to take actions to overcome the learning flaws demonstrated in the assessment tests. Furthermore, its availability is a new learning opportunity, so the learning-teaching process is improved. In fact, the concept of feedback has received several definitions. The one provided in (Weiner, X) states that it is the control of the system through the reinsertion of the results of the process. If this information is capable of producing changes in the general method, this can be considered a learning process. If this process is then applied to students, feedback would be the return of information about the learning process according to particular predefined objectives. Consequently, we came to the conclusion that the OeLE platform had to be extended with feedback capabilities.

In our research we pursued the development of feedback mechanisms that produce semantically rich feedback to students and teachers during learning processes. In literature, three types of feedback are distinguished (Passier and Jeuring, 2004):

- Student feedback: Given to a student during learning.
- Author feedback: Given to an author during course authoring.
- Group feedback: Given to a group of learners who study a course to an author.

In this work, we will focus on the first two types of feedback, although the methods developed would be easily adapted for groups.

In summary, feedback is an important part of assessment processes that allows both teachers and students to take actions to overcome the learning flaws demonstrated in the assessment tests. In this work we address the generation of semantic feedback for both agents of the learning-teaching process by extending our OeLE platform, which supports teachers in the assessment of open questions-based exams by applying such Semantic Web technologies. As a result of this work, students will not only receive the mark for the exam, but will also know their learning flaws. On the other hand, teachers will know which are the strengths and weaknesses of the students by doing the semantic analysis of the results of the exams.

2. Extending OeLE with Semantic Feedback Capabilities

Feedback has been incorporated in the OeLE platform for both teachers and students. First, we will describe how feedback is generated. Then, we will describe how such feedback is provided to teachers and students. The algorithm of feedback generation reuses the semantic components included in the assessment method. The modus operandi of this algorithm is similar to the marking methods, since it works on a question-by-question basis. Indeed, the feedback items are generated in parallel to the calculation of the marking score, and they both constitute the new assessment method of the OeLe platform. This means that both processes are executed using the same configuration parameters are used. Next, we describe how feedback is generated for a particular answer of an open question.

For each semantic annotation of the student’s answer, the following process is executed. First, the semantic similarity between one semantic annotation of the student’s answer and all the annotations of the expected one of the same ontological category is obtained. The result of this process is a table whose rows are the annotations of the student’s answer, and whose columns are the annotations of the expected one. Each cell has then the value of the semantic similarity.

For each annotation of the expected answer, the most similar annotation of the student is selected. If such similarity is higher than a given threshold value, then it is marked as correct and included in the positive feedback group. Otherwise, it is marked as wrong and included in the negative group. It should be noticed that the algorithm checks that we can only select one item of the student’s answer for one item of the expected. Once the positive and
negative feedback groups are generated for each question and for each student, those groups can be analyzed from the teacher and student dimensions. As far as teachers are concerned, the following feedback information is generated for each exam:

- General statistical results, in terms of mean, standard deviation, highest and lowest scores, and the description of the marking criterion used.
- Semantic interpretation of the exams, using the course ontology to perform such analysis. This analysis calculates how many students have answered correctly each ontological entity associated to the questions, and how many have done it wrong. To this end, such entities are classified into two sets: a) entities acquired by the students; and b) entities not acquired by the students. Hence, the teacher has access to which concepts, relations and attributes have been acquired better or worse by the students.

On the student side, the feedback is not generated by exam but by exam question, and the semantic feedback is only generated for open questions. The feedback for closed questions does not provide any semantic information; the platform just shows the user answer and the correct one. Besides the marking oriented information already included in the original OeLE platform, that is, the description of the question, the score obtained for this question, and the expected answer in natural language, additional information is provided:

- Knowledge contained in the answer: The marking process obtains a set of semantic annotations from the student answer. The feedback is then generated by showing the correctness of each ontological entity extracted from the student answer. Figure 1 shows an example of the knowledge items contained in the answer of a student. There, the knowledge items correctly and wrongly answered by the students are shown in the second column with an appropriate symbol.

![Figure 1. The knowledge items answered by the student](image)

- Recommended reinforcement contents: The system is also capable of suggesting a series of reinforcement contents, as it is shown in Figure 2. This is possible because the OeLE platform incorporates a semantic learning object repository, which allows for associating semantic metadata to SCORM learning objects. In particular, the learning objects are annotated with the course ontologies, so that appropriate reinforcement contents can be automatically retrieved and recommended to the student. It should be noted that the same learning object can be use for reinforcing several knowledge items.

![Figure 2. The reinforcement contents recommended for the student](image)

We can see in these figures that the knowledge items have hyperlinks associated. These links would allow the student to navigate the course ontology and to have more information about the particular knowledge item. In
summary, the feedback provided to each student can be seen as a personalized recommendation of topics that should be reinforced.

3. Validation

The extended OeLE platform has been applied in the online course “Design and Production of Educational Materials”, which is taught in the BSc on Education in the University of Murcia. This course took place in the second semester of 2008/2009, and had 25 students. One of the phases of the final assessment of the students was done using the OeLE platform. This required some previous effort carried out by the teachers. In particular, the teachers of this subject were asked to develop the course ontology, and to annotate the reinforcement contents. Then, the experiment was divided in two exams to be completed and managed using the OeLE platform. The first exam consisted in 5 open questions created and annotated using OeLE. The students were given an hour to complete this exam using OeLE. For this task, the students were given permission to review the contents of the course in virtual environment and to browse the web. This exam was taken by 21 students. Then, the exams were marked using OeLE and manually by one of the teachers of the subject. Semantic feedback was automatically generated for each question and student by using the automatic methods implemented in OeLE.

At this moment, the students were given access to their semantic feedback. The teachers designed a second exam, which consisted on 5 open questions, that were different to the ones included in the first exam. The same process was followed. After generating the marking scores and the semantic feedback for the second time, the students were asked to complete a questionnaire evaluating the effectiveness and usefulness of the learning objects and the feedback received.

The whole experiment and the results can be found at klt.inf.um.es/~oele/feedback. Figure 3 shows the marks obtained by the students in both exams. For each exam, the best mark a student might get is 10. There, we can see that, on average, the performance is better in the second exam. In fact, the average mark for the first exam is 6.12 and 6.56 for the second. This might indicate the potential usefulness of the semantic feedback provided by the platform. It should be noted that we have only considered the marks of the students that took the two exams. However, this is a single, and small experiment so strong conclusions cannot be drawn from such results. Therefore, we asked the students to answer a questionnaire. This was designed from a pedagogical perspective and it included questions related to different issues such as usability, accessibility, quality of the learning objects and usefulness of the feedback.

![Figure 3. The reinforcement contents recommended for the student](image-url)
Next, we discuss the results of the three questions related to the feedback:

- Question 1: Knowing the errors made in my exam is a waste of time.
- Question 2: Showing the feedback information about the errors in my exam is positive.
- Question 3: I think I would have obtained the same mark in the second exam without the feedback generated by the system.

The students had to assign a value between 1 (maximum disagreement) and 4 (maximum agreement). In order to summarize the results, two groups have been created: agreement (3-4) and disagreement (1-2). Figure 4 displays graphically the results of this questionnaire, which suggest that the students found useful and effective the generation of the semantic feedback and that this can be useful for helping students in improving their academic performance.

![Figure 4. The reinforcement contents recommended for the student](image)

4. Conclusions

Assessment is a fundamental part of the teaching-learning process. Feedback is an important component of assessment, since it is the process through which students and teachers can get precise information about the learning flaws of the students and then take effective actions. However, most current eLearning systems do not offer possibilities for providing feedback, and in most cases, they only provide a numeric score for the closed questions. In this work, mechanisms based on Semantic Web technologies for providing semantic feedback for open questions have been proposed, and they have been implemented in an existing software platform. The approach has been applied in real settings and the results are promising.

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