Template-based Approach to Development of Interactive Tests with IMS Question & Test Interoperability

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Abstract: A basic problem of an application of IMS Question & Test Interoperability (QTI) standard for development of questions and tests in Learning Management Systems is a so-called impedance mismatch between the features offered by the standard and the concrete features needed in a particular subject domain. Typically, such concrete features can be realized in the QTI standard only with a sophisticated combination of a number of the QTI features. The first part of this paper presents a template-based solution to this problem that effectively bridges the gap between the QTI standard and its concrete applications. Although such a template-based approach resolves the impedance mismatch problem it also introduces a new level of complexity in the development process – development of templates themselves. The second part of the paper describes a possible solution for development of the templates.

1. Introduction

IMS Question & Test Interoperability (QTI) (IMS QTI, 2005) is a de facto standard for cross-platform representation of questions and tests in Learning Management Systems (LMS). The benefits of such a common representation are manifold. First, it provides a question/test format for authoring tools therewith allowing the developers of these tools to concentrate on the usability issues instead of the question/test features. Second, it supports development of question/test databases that are easily integrated and shared among a variety of LMS because of a common question/test database schema. Last but not least, it provides a clearly defined interface for retrieving of test results which can be very important for management and adaptation of the learning process in accordance with the test results (Davis and Davis, 2005).

Because of such advantages of the QTI standard we decided to apply this format for development of interactive tests in the scope of the Ephras project (http://www.ephras.org/) (Ephras, 2005). The Ephras project is a project funded by the European Commission under the Socrates/Lingua2 programme. The goal of the project is to develop a computer supported phraseology learning material for students of foreign languages for four European languages - German, Slovak, Slovenian and Hungarian language. The project aims to eliminate the lack of such phraseology learning material, as well as to meet the demands for multilingual learning material in the enlarged European Union. The Ephras learning material is composed of a searchable database of 4x1000 phraseology data items in four languages (i.e. 1000 data items in each of the languages) accompanied with about 150 interactive tests to selected phrases in four languages. These questions and tests serve to check understanding and knowledge of the phrases in question, as well as for improvement of skills for producing these phrases in a written and spoken foreign language. As such they follow a sound didactic approach developed within the project in the form of an exercise typology. Moreover, the questions and tests are aligned according to language, topic, knowledge, and skill level of the students.

Even though the QTI standard offers the above mentioned benefits its application in the Ephras project is related with a number of difficulties. These difficulties are caused by an impedance mismatch between the QTI standard and its concrete application in a specific subject area such as foreign language teaching. This impedance mismatch is visible at two levels. First, the QTI standard is a technical specification which supports development of questions and tests for various subject domains where the questions and tests are interoperable at the level of authoring tools, question/test databases or LMS. As such the QTI standard defines a number of general question types that might be applied in a number of areas and does not take into account specific question and test types of a particular domain (Milligan, 2003). However, there exist a number of specific question types which are commonly used in foreign language teaching but are not reflected in the QTI standard, with crossword puzzles being only one typical example. Second, the QTI

standard is not concerned with didactical issues and, as a matter of fact, it tries to be as didactically neutral as possible (Smythe and Roberts, 2000). Yet the basis for development of the interactive tests in the Ephras project is a sound and successful didactical approach for teaching phrases in foreign languages. This approach includes learning activities such as phrase recognition, phrase meaning or phrase pragmatics identification, phrase form and grammar understanding, consolidation and reflection. Each of these activities is typically represented by a number of exercise types which are used in accordance with the current context, as well as the student's knowledge and skill level. For example, identifying of phrase meaning can be realized with a multiple choice question where the student needs to select the correct meaning of a phrase from a number of possible answers, with a short text essay where the student needs to write down the meaning of the phrase, or with a combination of these two question types.

In this paper a template-based solution to this impedance mismatch and the problems caused by that mismatch is presented. As the experience in the Ephras project shows such a template-based solution works very efficiently once when the templates are identified and defined. However, some new problems arise during the templates definition phase. A thorough discussion of such problems and a possible solution for them concludes this paper.

2. Template-Based Approach to Development of Questions and Tests

To resolve the impedance mismatch and tackle the problems caused by that mismatch a template-based solution has been applied. Thus, a number of question and test templates have been developed. Each of these templates bridges a single gap between the features from the Ephras tests and the features offered by the QTI standard.

For example, a crossword puzzle template has been developed to support creation of typical crossword tests. To create a crossword puzzle a number of parameters need to be defined including the number of rows, the number of columns, the row questions, and the solution of the crossword puzzle. These parameters are defined by operating a QTI compliant editor (see Figure 1). In the Ephras project we used the Author from the Canvas Learning (http://www.canvaslearning.com/) (Canvas Learning, 2005).

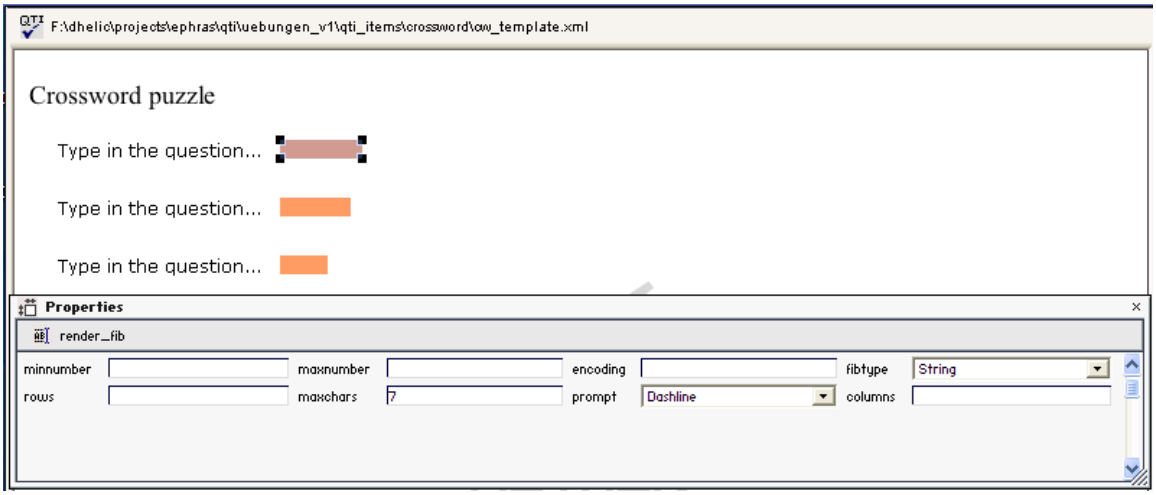

Figure 1: Editing the crossword puzzle template

Internally, the crossword puzzle is mapped onto QTI questions, such as single and multiple fill-in-gap questions with appropriate layout. However, through the abstraction offered by the crossword puzzle template the authors do not need to deal with the underlying low-level QTI solution. The Listing 1 shows the QTI representation of a single row in the crossword puzzle template.

The same template-based solution has been applied to resolve the impedance mismatch problem at the didactical level. Thus, for each learning activity mentioned above several templates have been developed. Each of these templates reflects a single possibility for supporting a particular activity. For example, to support phrase meaning identification activity three templates have been developed. The first template comprises a multiple choice question and a number of possible answers where only one single answer is

correct. The second template includes a short essay question, where students need to type in their own textual explanation of the phrase meaning. The third template combines the first two, i.e., it includes a multiple choice question together with a short essay question.

```
…
<flow>
    <material>
        <mattext texttype="text/plain"><![CDATA[Type in the question...]]></mattext>
    </material>
    <response_str ident="CLZ_2005120673443302" rcardinality="Single">
        <render_fib fibtype="String" prompt="Dashline" maxchars="7">
            <response_label ident="A"/>
        </render_fib>
    </response_str>
</flow>
…
```

Listing 1: QTI crossword puzzle template

Again, the teachers do not need to be concerned with the internals of the QTI standard. Rather they work with the QTI editor and only define a couple of parameters to create a working template instance (see Figure 2).

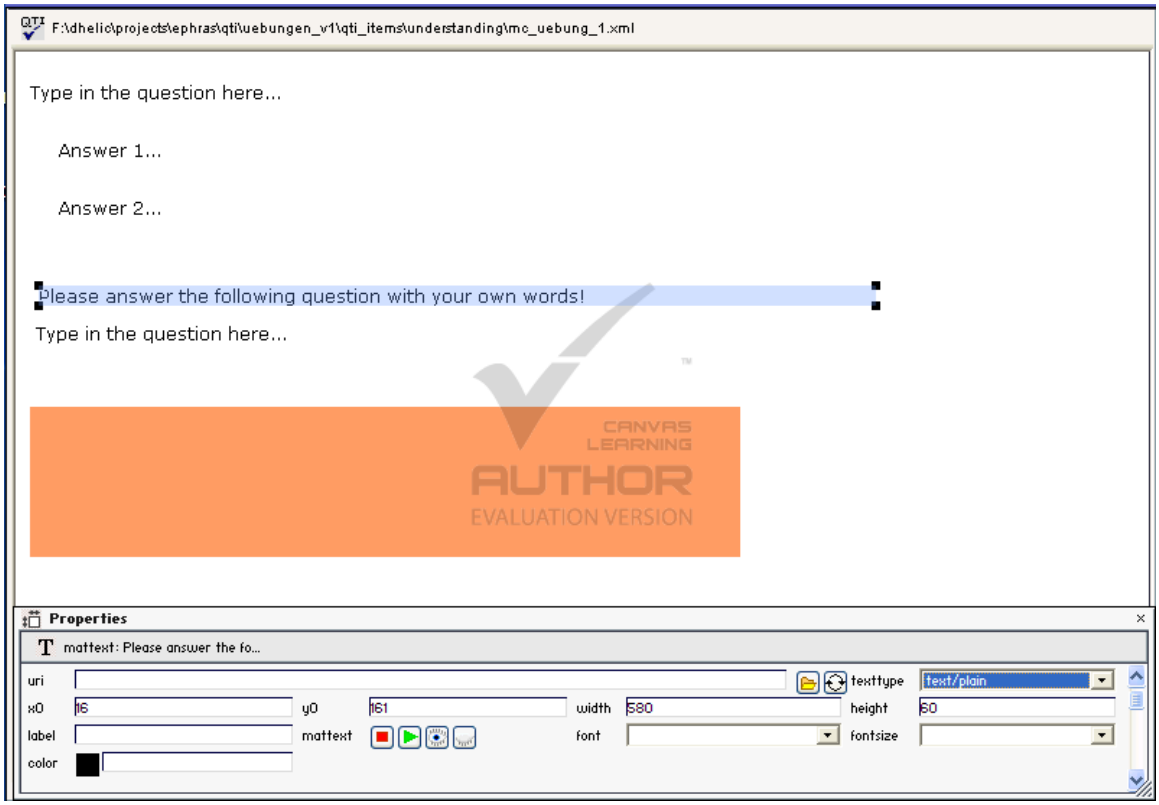

Figure 2: Editing the phrase understanding template

It is important to note here that the applied template-based solution is a general one, i.e. this solution is not limited only to an application in foreign language teaching. In fact, such a template-based solution might be easily applied in any other subject area. Basically, this solution hides the underlying QTI-based implementation and works at a higher abstraction level. That abstraction level is much closer to the subject

area in question. Thus, the authors deal only with entities from the subject domain that they are already familiar with.

The benefits of this approach in the Ephras project resulted in efficiency and productivity increase during the development of the interactive tests. However, to achieve that increase in productivity some additional efforts have been needed to produce the templates themselves. The next section describes the templates development phase in details.

3. Development of Question/Test Templates

Basically, development of templates is an iterative process with a number of repeating steps. The whole process requires collaborative efforts on the side of the system developers and the authors. The iteration steps of this development process include:

- Initial discussion between the system developers and the authors. The main goal of this session is to achieve a better understanding of both the didactical requirements for questions and tests and the technical possibilities offered by the QTI standard. Thus, the authors explain the types of questions and tests that are needed, whereas the system developers explain the features of the QTI standard.
- Preparation of several QTI samples to illustrate the possibilities of the QTI standard. The prepared samples already deal with the questions and tests from the subject matter.
- Agreement on a text-based informal format for defining the questions and tests by the authors. Usually, such an informal format is needed because the authors are not familiar with creation of formal specifications.
- Realization of templates by means of QTI standard.
- Test and improvement phase.

Note that the steps can be repeated a couple of times to obtain optimal results. Thus, the sheer amount of the development steps, as well as the amount of work needed for communication, testing or improvement result in a very tedious work. Moreover, because of misunderstandings, communication problems, or implementation difficulties the whole development process is very error prone.

The difficulties of the template development process can be summarized as follows:

- Learning curve for the QTI standard for the authors is very steep. There are no sufficient manuals, help files, tutorials or tools that would decrease the time needed to learn the standard.
- Informal nature of format for defining the needed templates leads to misunderstanding problems between the authors. The consequences of such problems become even more serious with an increasing number of authors, because format disparity between different authors also increases.
- Realization of templates using such an informal format is also very difficult because of misunderstanding problems between the authors and the systems developers. Again, the disadvantages become more visible as the number of authors increases.

The simplest solution to those difficulties is to develop a very simple formal format for defining the templates. Because of the simplicity of such a format an intuitive and usable graphical user interface can be built that supports the authors during the definition process. Moreover, the templates defined in this simple formal format might be first automatically processed to obtain an initial QTI version of the template. Subsequently, the system developers can manually adjust the QTI template to obtain the final template version.

However, another problem still exists – the authors do not posses enough knowledge of the QTI standard to be able to produce such formal definitions. An obvious solution to this problem would be to try to connect the process of definition of templates with the process of learning the QTI standard. For example, another tool that supports the authors in exploring and learning about the features and possibilities of the QTI standard might be developed. At the next step, this tool can be combined with the templates definition tool, thus allowing the authors to select a particular feature while they read and learn about it. For example, while reading about the multiple choice question the authors can select it and include it into the current template. In this way, whenever a particular learning session is finished the authors obtain automatically a formal definition of a template. From this formal definition an initial QTI template can be obtained so that the authors can immediately check the template. Sometimes it might be necessary to adjust

the obtained template. However, these adjustments are typically carried out by the system developers. In this way the templates development process is reduced to the following steps:

- Learning and exploration phase where the authors can select a particular QTI feature to include in the current template.
- Test and improvement phase with possible adjustments of the QTI template.

The next section describes a so-called Features Explorer and Selection Tool that implements the proposed solution.

4. Features Explorer and Selection Tool

The basis for the Features Explorer and Selection Tool is a very simple hierarchical representation of the QTI features. Each feature is represented as a node in a tree structure. Each node can have a number of sub-nodes which are used to represent specializations of a particular feature or its sub-features. Additionally, each node may have zero or more so-called tags which reference other nodes in the hierarchy. Thus, using tags it is possible to express that a particular feature is related to other features in the hierarchy besides its own parent feature. For example, a fact that a feature has multiple parent features can be easily expressed in this way. Thus, general graph-based representations of the features are possible. To describe features in details certain additional information is attached to each node. This information includes:

- Name of the feature
- Short info describing the basic properties of the feature
- Detailed description of the feature that might also include examples of its use
- A list of difference descriptions between the current feature and all of its sibling features
- A question that is put to the users to decide whether to select the feature for the current template.

On the top of this simple model a graphical user interface following a wizard-like interface paradigm has been implemented. Thus, the authors can navigate trough this hierarchical structure exploring and learning in this way the QTI features.

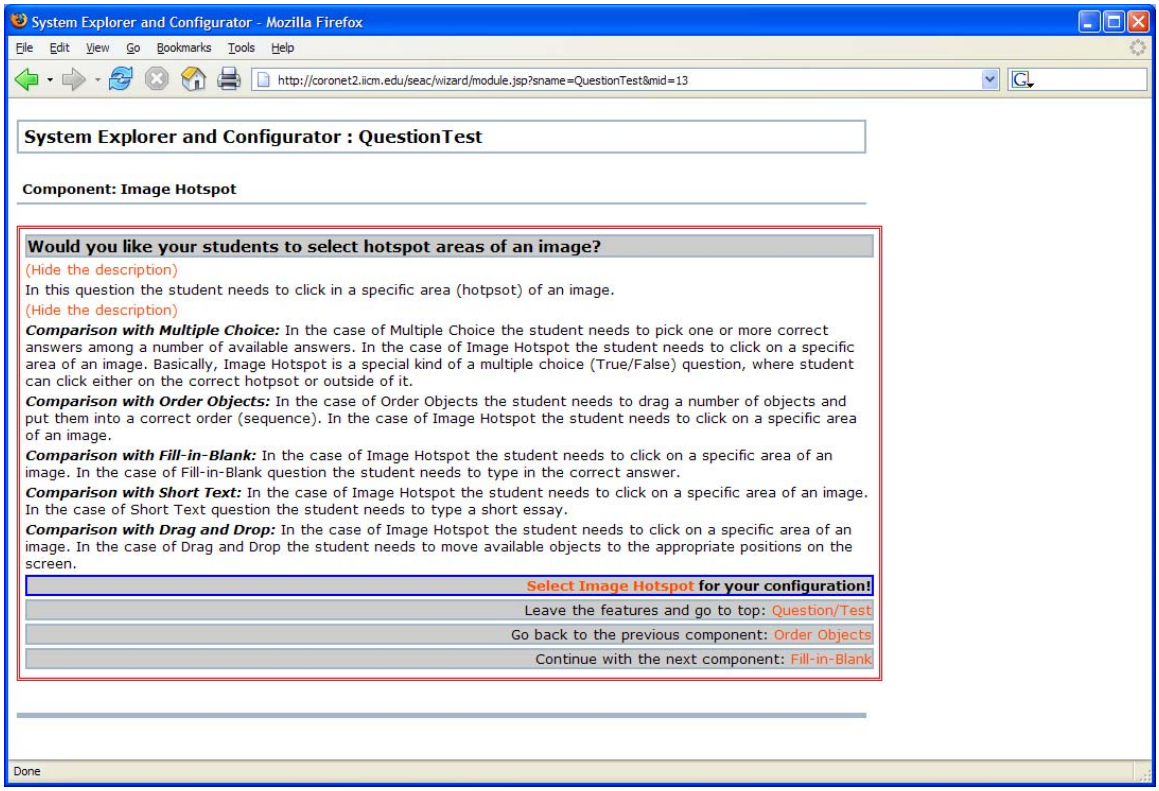

Figure 3: Exploring the QTI features

Additionally, at each navigation step the authors might select a particular feature to include it in the current template (see Figure 3). Thus, after the authors finish their learning session a simple XML-based formal description of the current template is obtained. That description lists all of the selected features (see Figure 4).

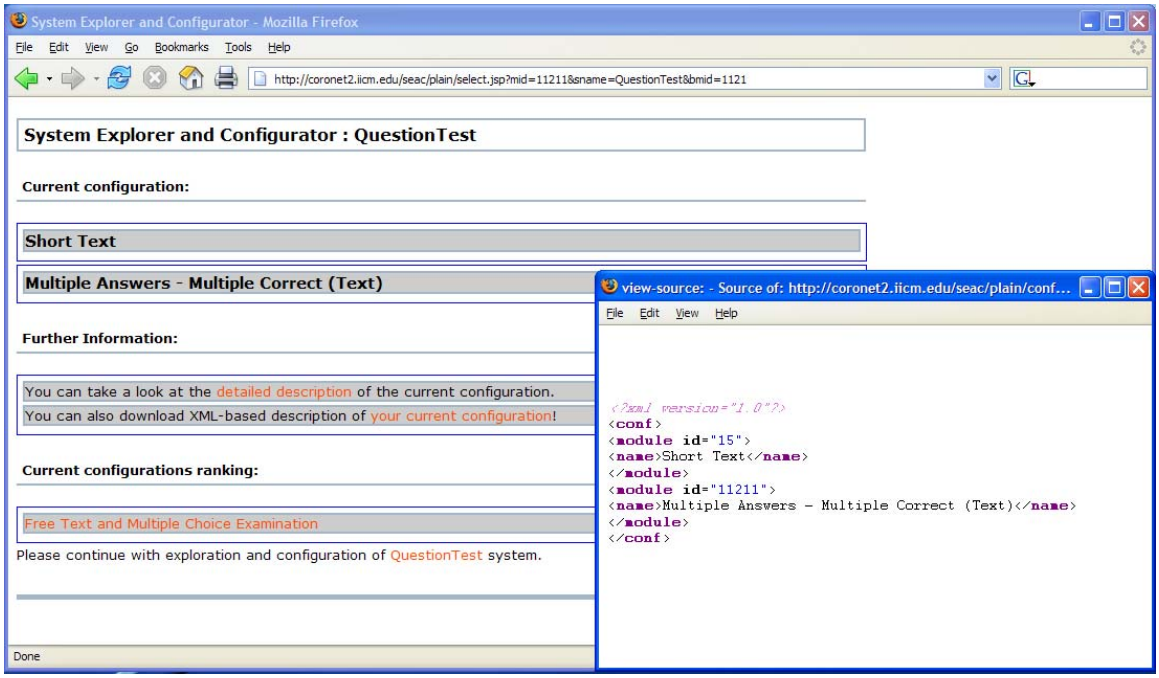

Figure 4: Formal representation of the current template

At the next step the list is transformed into a QTI-based template using XSLT transformation technology. Finally, the obtained QTI template might be loaded into a QTI editor to provide the template parameters and create a working instance of a question (see Figure 5).

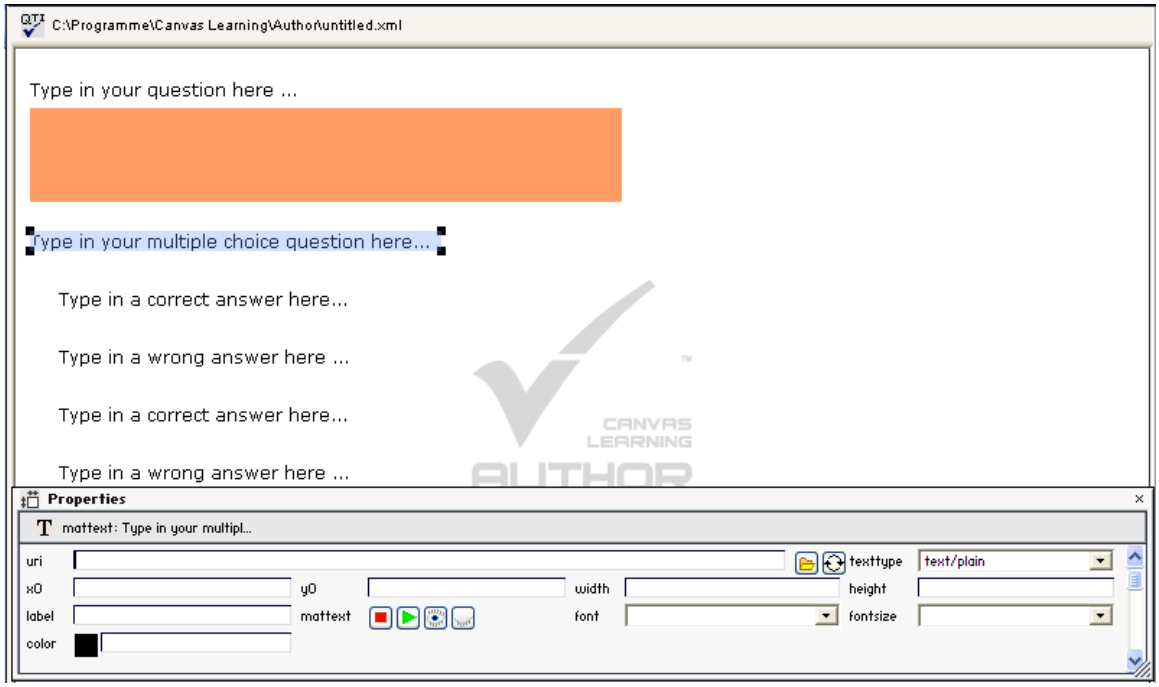

Figure 5: Automatically obtained template

5. Conclusion

In this paper a template-based approach to development of questions and tests in LMS using the QTI standard has been presented. Such an approach resolves a so-called impedance mismatch problem between the QTI standard and the concrete features which are required in a particular subject domain. This presentation has been concluded with our experiences in applying that approach in a foreign language teaching project called Ephras.

Nevertheless, templates introduce another level of complexity in the test and questions development process. The reason for this is that the templates themselves need to be identified, defined and implemented before any other development can be started. This template development process is related with a number of difficulties, such as steep learning curve for the authors, communication and understanding problems, as well as a number of technical problems. In this paper a solution based on a dynamic creation of templates using a simple model of the QTI features has been presented. This approach simplifies the template development process and improves its efficiency and productivity. It has been successfully put into the practice in the Ephras project.

Still there are some improvements that might be implemented in the future. For instance, templates can be currently only defined in isolation from each other, i.e. each template is defined independently of all other templates. However, questions are typically related to each other. For example, they are organized into larger units such as tests, which define how the questions should be sequenced at the run-time. Therefore, a possibility to define how templates and the questions created by applying them should be sequenced and organized into larger units would be a very welcome feature for the Features Explorer and Selection Tool. Thus, our future work in this area will include development of such a possibility.

Acknowledgments

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