EVALUATION OF AUTHORING FOR ADAPTATION AND DELIVERY VIA LEARNING MANAGEMENT SYSTEMS

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ABSTRACT
Adaptive Hypermedia content offers personalization. However, (re-)using such material with regular Learning Management Systems is not yet straightforward. Ideally, materials created once should be usable anywhere. One such vehicle for reusability is represented by e-learning standards. Thus, here we describe the extension and evaluation of *My Online Teacher (MOT)*, an adaptive hypermedia authoring system, to which compatibility with *IMS Question and Test Interoperability (QTI)* and *IMS Content Packaging (CP)* was added. This way, MOT authors can use materials dedicated to learning process adaptation on any standards-compatible LMS. In this paper we evaluate the converters from MOT to IMS CP and IMS QTI via both qualitative and quantitative analyses. This paper reports our hypothetical findings, their implementations, and the joint results of the evaluations of the converters.

KEY WORDS
Evaluation, Adaptive authoring, MOT, QTI, CP.

1. Motivation

Adaptive and adaptable hypermedia authoring is challenging, especially with respect to moving on from standalone academia systems and endeavouring to deliver the created adaptation materials to students using regular learning management systems (LMS). Previous studies [11] have shown that, whilst adaptation authoring is a "difficult problem", there are at least two applicable approaches to solve it: 1) a common language, a lingua franca, used by all authors of Adaptive Educational Hypermedia (AEH); and 2) usage of converters between AEH systems. In the work reported in this paper, we follow a combined approach, by developing novel converters, which use authored adaptation materials as input and produce standardized material (the most widely accepted lingua franca) as output. This comes at a cost: very few adaptation features can be converted or interpreted, as we shall see further on.
The gain however is promising: we are allowing for at least partial interoperability with extant standards. Thus, we expand previous research, by limiting the lingua franca, to the degree it is possible, to existing standards. A large body of research states that standards cannot incorporate all requirements of an adaptive hypermedia [24]. However, as standards progress, it is unwise to ignore them. LMS rely heavily on standards, and are very popular. Therefore, if adaptive hypermedia is to move into the large-scale use and commercial market, it has to be able to interface with – or extend – existing LMS. Consequently, this paper presents an evaluation of integrating MOT, a relatively known and versatile adaptive hypermedia authoring environment, with Sakai[1]. We chose Sakai based on analysing the state of the art for learning management systems [17].

1.1 MOT and CAF

To understand the conversions, we shortly describe MOT [7] and its composing elements. MOT (My Online Teacher) is an authoring system for adaptive hypermedia based on the LAOS adaptation authoring framework [9]; which it maps onto three modules for authoring adaptation [10]: 1). Content model: a hierarchy of domain concepts, with a number of domain attributes; 2). Lesson model: also called goal model; filtering contents at attribute level or above; and 3). Adaptation to student and presentation; this represents the actual adaptation specification.
In order to keep the conversion general, instead of converting directly between the authoring system, MOT, to the popular LMS, Sakai, we use a conversion from a common interfacing format, CAF, for adaptive systems, to e-learning standards. In such a way, the conversion is completely system independent: any adaptive system reading CAF, and any LMS using e-learning standards, can use our approach.
The Common Adaptation Format (CAF) [11] describes the static part of the adaptive course structure, in XML representation, suitable for web conversions. CAF instantiates a representation [11] for two of the static modules of the AEH description (1) and (2) from above:

[1] http://sakaiproject.org/

domain and lesson maps). The DTD (Document Type Definition) of CAF XML is shown below:

```
<?xml version="1.0" encoding="UTF-8"?>
<!ELEMENT CAF (domainmodel+, goalmodel?)>
<!ELEMENT domainmodel (concept+)>
<!ELEMENT   concept   (name,   attribute*,
concept*)>
<!ELEMENT attribute (name, contents)>
<!ELEMENT name (#PCDATA)>
<!ELEMENT contents (#PCDATA)>
<!ATTLIST link weight CDATA "" label CDATA
"">
<!ELEMENT goalmodel (lesson)>
<!ELEMENT lesson (link*, lesson*)>
```

Thus, a CAF XML file has: 1) Domain model(s) (one or more): containing a set of domain concept(s), each with a set of domain attribute(s) that describe related concept data (the actual content). An attribute has a name (representing the name of its type), and a content. A concept may have sub-concept(s) that represent associations to other concepts. 2) Goal model: The goal model represents the actual lesson, which may have a set of sub-lesson(s). Each lesson contains a set of link(s).

2. E-Learning Scenario

We prepare straightforward scenarios in which the users create an adaptable course in MOT; they then use the converters to import the created course into Sakai. Additionally, they create a questionnaire in MOT and import it also into Sakai. These scenarios were applied with a group of users, who played two roles: 1) the first role is '*author*', where they created their own additional course materials and questionnaires in MOT, and converted them, respectively, to IMS QTI and IMS CP; 2) the second role as '*student*', where they answered a questionnaire converted the same way, and also used one of the converted courses.

3. Converting CAF to IMS QTI and IMS CP

Next, we show how content authored in MOT can be used on LMS platforms. This represents a unique and novel step towards applying adaptation on popular LMS platforms [15]. The conversion itself is a two step process (as justified previously in section 1): first we convert CAF to existing standards, such as QTI and CP, respectively[2]. Then we import these into a popular LMS, like Sakai. The impact of the mapping process, which is the information loss, is examined in the paper through hypotheses H1.6 and H2.6 in sections 5.1 and 5.2 respectively.

[2] The URL of the converters: http://als.dcs.warwick.ac.uk/mot/

3.1 Converting CAF to QTI

QTI is a data model and de facto standard for the representation of questionnaires and quizzes for TEL. The structures represented by QTI are: 1) *Item*: the smallest data unit in QTI, containing the 'question'. 2) *Section*: QTI may contain one or more sections, and a section may have item(s) and/or other section(s). 3) *Assessment*: QTI contains only one assessment, which contains at least one section. After carefully comparing QTI with the structure of CAF, we opted to map the main lesson of the goal model into one assessment, and the domain model into one section. Thus we can produce one assessment based on the domain model. Each attribute in CAF is mapped to one item in QTI. Still, CAF has a hierarchical structure, whilst QTI has a flat one. Therefore, the hierarchical structure must be flattened. This would only affect the conversion if we would have hierarchically structured questions, with complex inter-relations, which is usually not the case. If such structures would occur, a separate decision-making mechanism would be needed to decide how to allow the flattening: mapping on different assessments, for instance. Figure 1 shows the converted CAF file after importing it as QTI into Sakai. The converted material is visualized with the Sakai tool Samigo, as part of a 'Web Programming' course, the 'Web programming Demos' section (or tab). Here, a certain degree of adaptivity is achievable, in the sense that the answer of the question remains hidden to the student. This would correspond to an adaptation rule stating [6]:

```
IF concept.type == answer THEN
   concept.show = false
```

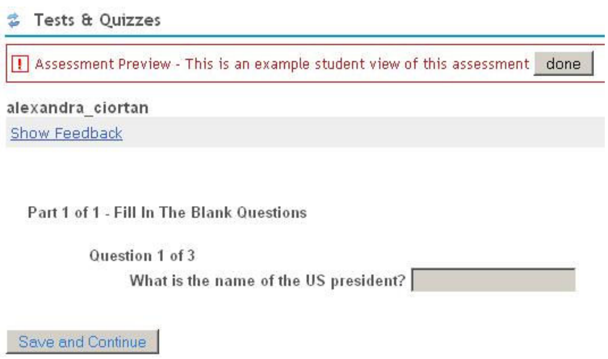

Fig. 1. CAF to QTI file, after the import into Sakai.

3.2 Converting CAF to CP

The IMS Content Packaging (CP) is a de facto standard that describes data structures that are used to provide interoperability for the contents of learning management systems (LMS). The structure of CP consists mainly of: 1) *Manifest* XML file: describing the contents' hierarchy, and pointers to the actual contents (physical files), and 2) the actual physical files (*resources*). CP has more flexibility than QTI, amongst which, the fact that it supports hierarchical structures (same as CAF). Moreover, the aim of both CP and CAF are to store courses (only the latter however stores adaptive courses). The steps of the conversion are as follows: 1) Parse the goal model to retrieve the actual course. 2) Each attribute in each concept is mapped onto an item in CP. 3) Each sub-concept is mapped onto a sub-item in CP. 4) For each generated item and/or sub-item, a new HTML file is created, which stores the content of the attribute. 5) Finally, a new manifest file is created, which contains all generated items and sub-items.

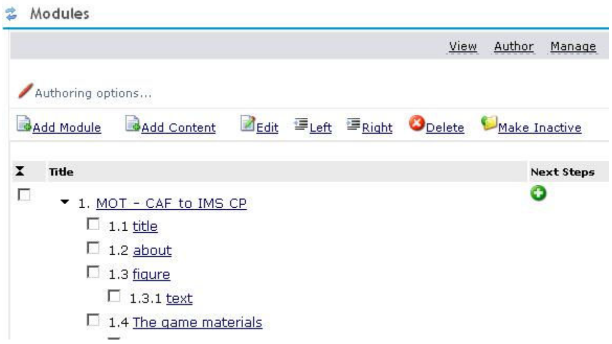

Fig. 2. MOT lesson in Sakai

The output of this conversion can be then visualized in Sakai, with the help of the MELETE tool, as is shown in Figure 2. After importing the converted CAF to CP, the teacher or author has the option to edit the structure of the lesson, as it is shown; students then can access the lesson after it is published.

4. Related Work

Brusilovsky [3] has been long advocating the importance of adaptivity for e-Learning. Adaptivity can enhance e-Learning and TEL [17] by providing *adaptive presentation support* (adapting learning materials via an assembly of fragments) or *adaptive navigation support* (various types of adaptation of visual links, e.g., hiding/ showing links). Additionally, Adaptive Hypermedia [13] research often ignores standards [24]. However, standards are occupying a growing part of the educational market share and even small, customer designed LMS cannot ignore the push towards standards [1]. Consequently it is vital to connect adaptive hypermedia to learning standards. [14,19] compile the few learning standards used in adaptive learning systems; whilst [24] considers a common adaptation language as the only approach to guarantee real interfacing, exchange, and reuse. [23] distinguishes between two different types of reuse, dynamic and static. [4,16] focus on creating an assessment framework for adaptive educational systems via the use of QTI. Thus, as the analysis of prior research shows, the issue of connecting adaptivity and standards is a hot topic, and there is a pressing need to offer new, viable solutions.

5. Evaluating the converters

The converters [15] have been tested with a group of about thirty 3rd year students of a course on "Web Programming", who study Computer Science (FILS direction) at the 'Politehnica' University of Bucharest. The "Web Programming" course was partially delivered via two weeks of face-to-face lectures, seminars and hands-on labs, and for the rest of the term, delivered via distance learning. Before the students had to answer to questionnaires, they were made familiar, via lectures, with CAF, QTI and CP, and via hands-on experiments, with authoring environments (MOT) and TEL environments (Sakai, AHA!). The students collaborated in the creation of new content in MOT and carried out conversions, visualized their own products, as well as other course material stored on Sakai. For our testing purposes, it was reasonable to use students for the evaluations, as the type of system we envision towards the end of our developments will involve students as co-authors and collaborative annotators of the extant created material, in the sense of exploiting Web 2.0 techniques and trends in order to enrich and adapt material to the current student population.

5.1 Hypotheses of the MOT to QTI Converter

The following set of initial design hypotheses were to be validated via the students' answers, for the CAF to QTI converter:

H1.1. Conversion to standards is useful for MOT: standards are vital in the context of test and quizzes for QTI.

H1.2. The converter is 'perfect' for its purpose; students believe to *learn* it quickly (learning curve).

H1.3. The converter is 'perfect' for its purpose; students believe to be able to *use* it quickly (easy to use).

H1.4. The converter's performance is adequate; time for response is acceptable (perceived user acceptance).

H1.5. The converter's performance is adequate; time < 30 sec for a regular UNIX server supporting multiple server processes, 2GB of RAM and 3GHz of dual CPU, accessed via the Web (connection: Romania-UK) for a small CAF questionnaire file (about 5 concepts with 10 attributes in total).

H1.6. The converter converts all required information from CAF.

H1.7. The converter is well-integrated with the other programs (that it is used with).

H1.8. The converter should cover all types of questions (not just fill-in-the-blanks, as in our experiment).

Hypothesis H1.1 targets the students' perception about the whole process of using standards. They are basically induced to ponder about the actual necessity (or superfluous nature) of these conversions. Hypotheses H1.2 and H1.3 seem related, but one is targeting the learning curve for a new tool, whilst the other one is targeting actual speed of use. Questions H1.4 and H1.5 target performance, from two perspectives: perceived performance, and actual performance. This is due to the fact that 20 seconds can be perceived as a long time by one person, and as a fast time by others, for instance. What we ultimately want is to relate the actual speed to the delay perceived as 'acceptable' by the majority of users. Hypothesis H1.6 checks if the users feel that something is 'lost in translation'. If they are missing some vital information. Hypotheses H1.7 and H1.8 are additional hypotheses about the appropriate direction of extension of the tools. We are checking if more integration is needed (H1.7) and if more types of questions should be converted (H1.8).

5.2 Hypotheses of the MOT to CP Converter

The following set of design hypotheses were to be tested via the students' answers, for the CAF to CP converter: Hypotheses **H2.1** to **H2.7** are identical to hypotheses H1.1 to H1.6, except for reflecting the conversion to CP instead of QTI. The last hypothesis is different, as follows. **H2.8.** CAF to CP conversion is more appropriate than CAF to QTI. As it can be seen, a question based on the last hypothesis would ask the students to compare the two conversions, and think about the actual purpose of this conversion.

5.3 Quantitative Analysis of the Hypotheses

We prepared two questionnaires based on our hypotheses, in which we asked eleven multiple-choice questions about the MOT to QTI converter and twelve about MOT to CP converter. Each answer needed to be justified. Due to lack of space in this paper, we have placed the questionnaires (including the questions and answers) online[3].

We applied a Chi-square test to verify if our observations match our hypotheses. We chose this test as our questionnaires used categorical data..As shown in Table 1 (for the MOT to QTI converter) and Table 2 (for the MOT to CP converter), most of the results are statistically significant, as tested with the help of the Chi-Square test (with significance level p<= 0.05). In the tables we add also the hypothesis label that is supported by the majority of answers for each question (proven significant by the Chi-square test), and if it is confirmed.

Table 1. MOT to QTI questionnaire statistics

Q	Chi-Square	Df	P	Hypotheses
Q1.1	24.667	3	.000	**H1.1-** ***confirmed***
Q1.2	93.44	1	.000	**H1.2-** ***confirmed***
Q1.3	93.44	1	.000	**H1.3-** ***confirmed***
Q1.4	25.138	1	.000	**H1.4-** ***confirmed***
Q1.6	0.034	1	.853	H1.6
Q1.7	25.483	3	.000	**H1.8-** ***confirmed***
Q1.8	0.310	1	.577	H1.7
Q1.9	0.034	1	.853	H1.7
Q1.10	1.690	1	.194	H1.6

Hypotheses H1.1, H1.2, H1.3, H1.4 and H1.8 were confirmed. Hypothesis H1.6, on the equivalence of the data in CAF and in QTI, was not confirmed. To understand why, we analyzed the qualitative data (the rationale given) and noticed that students oscillated between yes (meaning that the information content is similar) and no (because the structure is different). There were no direct complains about information loss. Additionally, H1.7 was not confirmed, which was tested by Q1.8 and Q1.9. By analyzing the qualitative data for Q1.8 and Q1.9, we found that the students fluctuated between preferring having the converter running in Sakai, or having the converter running in MOT. Overall, there seems to be a preference of having the converter as a separate application, but this preference is not statistically significant.

Hypothesis H1.5 which is tested by question five (Q1.5) cannot be evaluated using Chi-Square test, as it contains numerical data (not categorical one). Therefore, we used a one sample T-test to test whether a sample mean (30 answers of 30 students for Q1.5) significantly differs from a hypothesized value (H1.5. 30 seconds). The mean of Q1.5 for this particular sample of students is 3.35 seconds, which is statistically significantly different (p<0.05) from the test value of 30 seconds. We thus infer that this group of students has a significantly lower experienced processing mean, of 3.35 seconds.

As shown in Table 2, hypotheses H2.1, H2.2, H2.3, H2.4 and H2.8 were confirmed, and we conclude that the groups of users of MOT and its converters to Sakai are able, with a short introduction, to quickly and efficiently perform the requested conversions, and understand some of the basics of this work. Moreover, the usage of the currently implemented systems appear as straightforward, even for students, and the theoretical background on which these systems are based is comprehensible within a couple of sessions with explanations. Hypothesis H2.6 was not confirmed, for the same reason mentioned for H1.6 of the MOT to QTI questionnaire. Furthermore, H2.7 was also not confirmed, for the same reason mentioned for H1.7 for the MOT to QTI questionnaire.

Table 2. MOT to CP questionnaire statistics

Q	Chi-Square	Df	P	Hypotheses
Q2.1	15.000	3	.000	**H2.1-** ***confirmed***
Q2.2	24.142	1	.000	**H2.2-** ***confirmed***
Q2.3	24.142	1	.000	**H2.3-** ***confirmed***
Q2.4	9.143	1	.002	**H2.4-** ***confirmed***
Q2.6	3.571	1	.059	H2.6
Q2.7	17.286	1	.000	H2.6

[3] http://als.dcs.warwick.ac.uk/mot/MOT_IMSCP.pdf and http://als.dcs.warwick.ac.uk/mot/MOT_IMSQTI.pdf

Q2.8	2.286	1	.131	H2.7
Q2.9	2.286	1	.131	H2.7
Q2.10	0.143	1	.705	H2.6
Q2.12	14.286	1	.000	**H2.8- *confirmed***

As we illustrate in the first questionnaire, question Q2.5, which matches hypothesis H2.5 cannot be evaluated using the Chi-Square test, as it contains numerical data not categorical one. Thus, we applied a one sample T-test again to examine whether a sample mean (30 answers of 30 students for Q2.5) significantly differs from a hypothesized value (H2.5. 30 seconds). After applying the T-test, the mean for this particular sample of students is 5.27 seconds, which is statistically significantly different ($p < 0.05$) from the test value of 30 seconds. We thus conclude that this group of students has a significantly lower mean on the writing test, of 5.27 seconds.

5.4 Qualitative Analysis of the Hypotheses

As said, both questionnaires ask for a rationale for each question, where the students were requested to explain their answers. Additionally, question Q11 in each questionnaire covers free comments on the advantages and disadvantages of the converters. Analyzing the qualitative feedback from the experiments, this showed that the converters were mainly understood, easy to use, and useful. The most common mentioned advantages of the converters are: the converters are fast, easy to use, convert various types of content in the case of the MOT to CP converter, converting precisely (no information is lost in the conversion process), are built based on Java (which makes it easier to plug-in into other Learning Management Systems), and allow interoperability with systems that use learning standards. A few limitations of the converters were identified. Students noted the following drawbacks: the converters cannot work offline; there was a bug (the system crashes due to a misinterpretation of the file location) in uploading the CAF file, when the students use Internet Explorer v6 (but not for v7 or above; this bug was fixed by updating some libraries); MOT to CP is slower than MOT to QTI; and there are currently no online help guidelines.

6. Discussion

Converting material from the authoring system for adaptivity, MOT, into QTI, was pushing the capacity of MOT to some extent, as the authoring system was not initially designed to edit tests and questionnaires. However, this process has its benefits. It is acceptable that using assessments together with personalized learning access has a positive impact on the learning process, because it helps in: 1) checking if the learners have understood the materials correctly or not, and 2) providing feedback for both learners and teachers. Therefore, adding standard-based assessment potentials to adaptive TEL is expected to enhance the learning process and give the students the chance of tracing their learning progress [4]. Moreover, from the Sakai LMS point of view, benefits also exist. The CAF to QTI converter manipulates adaptive content in CAF XML format and generates the matched assessment in QTI format. Here we have two benefits from an adaptation point of view: 1) utilizing the adaptive features in CAF, and 2) enriching the generated assessment with new adaptive concepts.

Furthermore, creating adaptive content is considered costly and time-consuming [5]. Therefore, reusing already created content is valuable, and this can be done by providing facilities to export (part of) the adaptive content into standardised format, such as CP. The CAF to CP converter performs this by partitioning the adaptive content into unique granularly items that can be reused for different learners. Moreover, those items can be enriched with metadata that follow the LOM standard, to give a new dimension to applying adaptivity in TEL LMS that support CP. The granularity is already handled by concept and sub-concept relations in CAF; however, here we add the compatibility with the IMS CP learning standard.

Finally, a good degree of compatibility, not only for export from adaptive systems via CAF to CP and QTI, but also import, is vital. After the completion of the evaluations, from open discussions with students, as well as from discussions with other designers, it emerged that such a bilateral compatibility is essential. As a result, the import function has in the meantime also been implemented, although only peer-tested as of now. With such a function, extant standard materials can be introduced into an authoring system like MOT, where additions towards adaptation specification are possible. In this way, enriching standard-based static material from rich repositories with adaptation becomes easier.

7. Conclusion and Future Work

Most adaptive learning systems focus on personalizing the delivery of course materials to individual learners. However, not enough work has been performed on applying adaptivity to collaborative learning environments, such as popular LMS. Converting adaptive content into learning standards can supply a dynamic learning process which is compatible with all systems that support these standards. In this paper we present our work and evaluation thereof of converting CAF into QTI and CP, in which the authored adaptive materials in MOT can be imported into well-known LMS such as Sakai. This is a first step towards the novel endeavour of, on one hand, enabling adaptation via standard representation and popular LMS, as well as, in a second step, combining adaptation and collaboration in collaborative LMS, extending prior work on conversions to, e.g., Blackboard [21].For future work, we intend to apply adaptation on QTI and CP by using LOM (Learning Object Metadata) [18] - which QTI and CP both support - by enriching materials with further adaptation metadata, on, amongst others, adaptation strategies [11,1].

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