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### Conférence I<sup>2</sup>LOR 2007

La présente atteste que **Lesage Martin** a participé à la conférence I<sup>2</sup>LOR 2007 qui s'est tenue du 4 au 7 novembre 2007 à Montréal sur le campus des sciences de l'UQÀM et que la somme de 85\$ a été payée à titre de frais d'inscription.

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This document certify that **Lesage Martin** attended the I<sup>2</sup>LOR 2007 Conference held in Montreal from November 4 to 7 at the UQÀM Science Campus and paid the subscription fee of 85\$ .



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## IMS-QTI Sub-standards in Computerized Adaptive Testing (CAT)

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### Abstract

*Over the last years, a growing trend for schools, colleges, universities and other learning institutions is to convert their traditional courses into E-Learning applications over the World Wide Web (WWW). This conversion process is either done in house or by outsourcing to consulting E-Learning firms. The course conversion process is often neglecting the evaluation aspect of E-Learning. Evaluation should be a mandatory part of the E-Learning applications by placing evaluation items (questions) at the end of chapters or teaching points. To implement evaluation in E-Learning applications, the authors are developing a Macromedia Flash E-Learning Web site able of item data input and adaptive testing capabilities using item response theory (IRT). The project's aim is evaluation capability improvement and reusability by the use of IMS-QTI standard. Application's adaptive testing functionalities will be implemented with IMS-QTI sub-standards for item parameters and interface parameters characterization.*

### 1. Introduction

This project considers four aspects of the learning field that are evaluation, individualization, adaptation and standardization of learning. It reaches the research domains of adaptive testing, computer science and networking with item response theory, self configurable graphics user interface modeling, XML standards improvement and E-Learning application development on the Internet.

The project places itself in the constructivism paradigm by reaching the field of instructional design for distance education with the use of information technologies by the development of E-Learning Web

sites with adaptive testing and self-configurable user interfaces capabilities. The technical improvements that will be developed in this project will have a metacognitive aspect by helping students to know if they had reached the standard. The E-Learning application will show the students the assimilated teaching points and the chapters needing further study in a formative evaluation approach.

In this project, we will first study the adaptive testing field, E-Learning standards, Macromedia Flash native script language ActionScript programming and user interface ergonomics. We will after implement IMS-QTI sub standards to include in XML testing objects that will be parsed by the Flash user interface. This project will finally produce a self configurable E-Learning application with adaptive functionalities supported with constructivist learning methods guiding the teachers for the use of E-Testing applications in academic curriculum. The item evaluation objects will have a standard that will facilitate the exchange of questions among institutions.

This paper will first present a theoretical background of adaptive testing, state user interface ergonomics of E-Learning applications, invoke constructivist paradigm for E-Learning and E-Learning standards. It will finally state the actual results and future work of this project.

### 2. Background

The essential notions of computerized adaptive testing, item response theory and the implementation of learning methods using item response theory are stated in Wainer (2000). All these notions are equally studied by Raïche(2004) with the implementation of adaptive learning applications in the province of Québec.

The constructivist approach of distance learning and some Web based learning models are proposed by Bonk & Wisher (2000). This reference also study military E-Learning application development and implementation.

User interface customization and adaptability have been studied and implemented by Weld, Anderson, Domingos, Etzioni, Gajos, Lau & Wolfman (2004).

IMS Global Learning Consortium ([www.imslobal.org](http://www.imslobal.org)) describes its XML based E-Learning standards and learning methods implementation on his Web site. This reference also describes IMS-QTI learning and testing objects.

Previous years have seen the development of applications similar to our project being client-server E-Learning applications having question data entry interfaces and adaptive testing based question (item) display engine where items are stored in a database on a Web server. We will mention four application in our field of development: SIETTE (Conejo, Guzmán, Millán, Trella, Pérez-De-La-Cruz, J.L., & Rios, 2004), QTIEDitor (Pacurar, Trigano & Alupoie, 2005), CosyQTI (Lalos, Retalis & Psaromiligkos, 2005) and PersonFIT (Sodoke, Kkambou, Raïche, Riopel & Lesage, 2007), the latter using IMS-QTI standard for question encoding. Another interesting application of E-Learning is the RATH (Relational Adaptive Tutoring) system using the knowledge space theory (Hockemeyer & Albert, 1999; Hockemeyer, Held & Albert, 1997).

A brief introduction on E-Learning standards can be found in Michel & Rouissi (2002) and also in Dunand, Fernandes & Spang-Bovey (2006). Learning objects definition and their relation to instructional design theory is stated in Wiley (2000).

### 3. Research problematic

The rapid growth of traditional course material conversion to electronic format is now an inevitable trend. The research problematic addressed in this project is: “How to implement E-Learning in academic cursus?”.

Many courses are now converted to electronic format but there some problems arise in the conversion standardization that could deny teachers of different learning institutions to exchange electronic format questions or course content.

The constructivist approach of distance learning states that E-Learning applications should include evaluation capabilities to allow the student an

opportunity to test his knowledge in a formative evaluation context (Bonk & Wisher, 2000)

The implementation of E-Learning into academic cursus should be a part of a learning method and consider the adaptation of the application to the student’s personality and grade.

The actual project wants to improve these issues by proposing learning methods supporting an E-Learning application with evaluation and interface self-configuration capabilities based on the IMS-QTI E-Learning standard.

This project considers the multidisciplinary fields of education by regrouping adaptive testing, learning methods implementation, computer programming of E-Learning applications and networking by launching and storing these applications over the World Wide Web (WWW).

## 4. Theoretical framework

### 4.1 Adaptive testing using item response theory

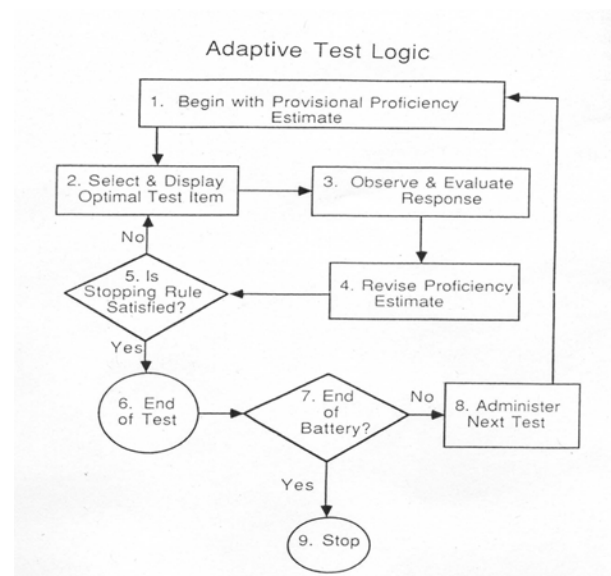


FIG. 5.2. A flowchart describing an adaptive test.  
 Fig. 1. Adaptive testing algorithm using item response theory (Wainer, 2000, p. 106)

Adaptive testing theory adds flexibility to testing by selecting the questions in accordance to the user’s knowledge level as shown in figure 1. Once the first question is selected in accordance to the student’s skills, the subsequent questions are selected in accordance to the student’s answer to the previous questions. Item response theory is a statistical estimator used to select the next questions in the system question database.

## 4.2 Learning objects or instructional objects

Learning objects are sharable and reusable electronic entities (data structures) used for learning. These entities are always available at any time but not stored only on the Internet. They are usually stored in data repositories controlled by their administrators or developers. Learning objects can be entire course or more granularly items such as audio/video clips, images or graphic animations.

## 4.3 Testing objects or Evaluation objects (Items)

An Item is a set of interactions (that could be void) digitized with all support material and can be analyzed with a set of rules enabling the conversion of a candidate's answer in evaluation results. Item size could vary from a single question composed of text and one input field to an entire multiple questions exam with instructions and multimedia support material.

## 4.4 IMS-QTI evaluation standard

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- This example adapted from the PET Handbook, copyright University of Cambridge
ESOL Examinations -->
<assessmentItem xmlns="http://www.imsglobal.org/xsd/imsqti_v2p0"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://www.imsglobal.org/xsd/imsqti_v2p0_imsqti_v2p0.xsd"
  identifier="choice" title="Unattended Luggage" adaptive="false" timeDependent="false">
  <responseDeclaration identifier="RESPONSE" cardinality="single"
  baseType="identifier">
    <correctResponse>
      <value>ChoiceA</value>
    </correctResponse>
  </responseDeclaration>
  <outcomeDeclaration identifier="SCORE" cardinality="single" baseType="integer">
    <defaultValue>
      <value>0</value>
    </defaultValue>
  </outcomeDeclaration>
  <itemBody>
    <p>Look at the text in the picture.</p>
    <p>
      
    </p>
    <choiceInteraction responseIdentifier="RESPONSE" shuffle="false" maxChoices="1">
      <prompt>What does it say?</prompt>
      <simpleChoice identifier="ChoiceA">You must stay with your luggage at all
times.</simpleChoice>
      <simpleChoice identifier="ChoiceB">Do not let someone else look after your
luggage.</simpleChoice>
      <simpleChoice identifier="ChoiceC">Remember your luggage when you
leave.</simpleChoice>
    </choiceInteraction>
  </itemBody>
  <responseProcessing
  template="http://www.imsglobal.org/question/qti_v2p0/rptemplates/match_correct"/>
</assessmentItem>
```

Fig. 2. A multiple choice question coded in IMS-QTI standard (Lesage, Raïche, Riobel, Sodoke, 2007)

The IMS-QTI standard allow the packaging (encapsulation) of course sections or teaching points («

learning objets ») into small XML (« eXtensible Markup Language») modules as shown in figure 2.

Many E-learning formal standards are now in use: Dublin Core/DCMI[11], IEEE LTSC LOM[15], IMS-QTI[16], AICC/CMI[2], and ADL/SCORM[1]

Dublin Core, SCORM, LOM and CMI standards are especially designed to automate and model course material (learning objects). These standards don't include formalism and item modeling parameters for testing (learning evaluation).

The IMS-QTI standard doesn't actually allow online adaptive testing based on item response theory (IRT).

To solve this problem, this project wants to improve the IMS-QTI standard with the formal implementation of two sub standards: characterization of the interfaces and characterization of the item parameters according to the item response theory.

## 4.5 Objectives

This project reaches four fields of the learning domain: evaluation, individualization, adaptation and methods. The RATH application focuses on adaptive learning. Other testing application like QTIEDitor, CosyQTI and PersonFIT are using the IMS-QTI format. SIETTE and PersonFIT applications have been developed for adaptive testing using item response theory. Finally, the PersonFIT application is using the IMS-QTI standard in adaptive testing context. Unfortunately, these applications are not part in any academic cursus and are not the object of learning methods.

These applications also don't have a user interface parameter characterization for self adaptability. In this project, we will work to improve learning methods in adaptive testing. We want also to increase user interface adaptability.

## 4.6 Research questions

The research question could be « How to optimize learning methods and user interfaces in a computerized adaptive testing context? »

## 4.7 Hypothesis

The hypothesis stated is «By the implementation of learning methods supporting E-Learning applications using adaptive testing in academic cursus ».

## 5. Method

This project will have three phases, the first is the development of an E-Learning application with adaptive testing capabilities, the second is to implement QTI-IMS sub standards for item and user interface parameters modeling and the final phase will be to establish learning methods with formative evaluation capabilities.

The E-Learning application will be tested on different subjects that will be students of the Québec province's schools and members of the Canadian Army. The results will be collected by interviewing the students using the E-learning application.

## 6. Results

This project is in its first stages and some preliminary results are the development of the E-Learning application with adaptive testing capabilities in Macromedia Flash.

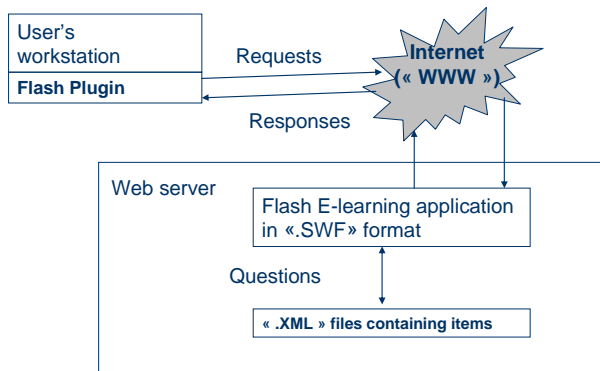


Fig. 3. Software architecture of CAMRI Laboratory's Flash adaptive testing application for reading and writing XML IMS-QTI standard files on local or user workstation mode. (Lesage, Raïche, Riopel, Sodoke, 2007)

The application is based on a client/server architecture. The user access the application with his Web browser (ex.: Internet explorer). The application is a Web site on a server. It can be used for question data entry and have a question display engine for adaptive testing in accordance with item response theory. The inputted questions are converted in assessment item coded in QTI-IMS XML format and stored in the server database as shown in figure 3.

The question data entry interface is shown in figure 4. The actual stage of development only allows the system the data entry of multiple choice questions.

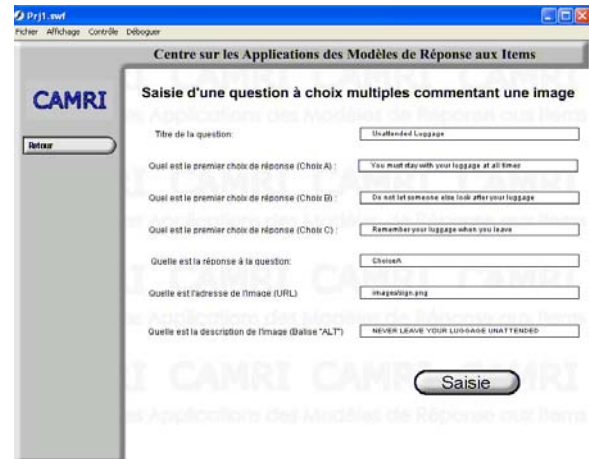


Fig. 4. Item (Question) data entry interface of CAMRI Laboratory's Flash adaptive testing application (Lesage, Raïche, Riopel, Sodoke, 2007)

The application is able to generate items in IMS-QTI format and to store the items in its database. The system is also able to do the reverse operation and to retrieve items from its database, parse the XML and display the question as shown in figure 5.

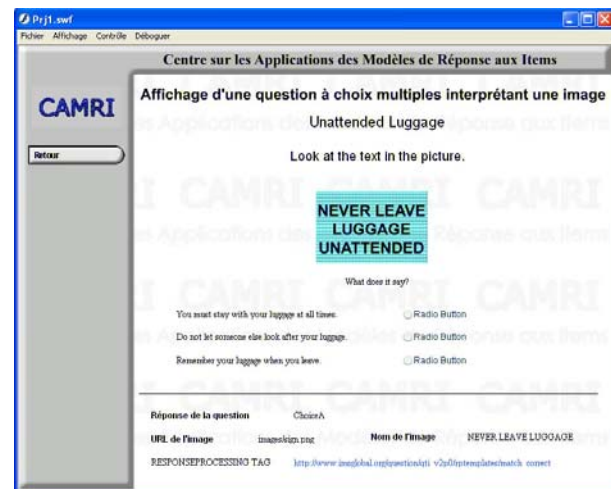


Fig. 5. IMS-QTI item displayed in the flash application.

## 7. Future work

The main part of the project is still to realize and consists of the completion of the E-Learning application, the implementation of IMS-QTI sub-standards and the accompanying learning methods.

## 7.1 IMS-QTI sub standard for interface parameters

Some example of a QTI-IMS sub-standard characterization for interface parameters are shown:

- Menus

```
<MenuParameter positionX="100" positionY="200" type="DropDown" />
```

- Backgrounds

```
<BackGroundParameter src="bckdir/bck.png" positionX="100" positionY="200" Animated="No" />
```

- Buttons

```
<Button positionX="100" positionY="200" type="Rectangle" caption="E-mail" Animated="Yes">
```

- Graphics animations

```
<graphicsAnimation positionX="100" positionY="200" src="anim/anim1.jpg"/>
```

## 7.2 IMS-QTI sub standard for item parameters

The project will study in details the E-learning standard IMS-QTI because it already contains questions banks and item modeling parameters. Our goal is to enhance the IMS-QTI standard by developing a sub-standard for item parameter modeling.

Item Response Theory (IRT) is a collection of mathematical models allowing a mathematical representation of items characteristics using statistics to determine ability level or latency parameters for a student writing a test (Sodoke, Nkambou, Raïche, Riopel, and Lesage, 2007).

Those three item parameters are the discrimination (a), the difficulty (b) and the pseudo-guessing (c). The later represents the chance for a low level examinee to find by guessing the correct response to the item. The conditional probability for a person with an ability  $\theta$  to get a correct response to an item  $i$  ( $a_i$ ,  $b_i$  and  $c_i$ ) is:

$$p_i(\theta) = c_i + \frac{(1 - c_i)}{1 + e^{-Da_i(\theta - b_i)}}$$

where D is a constant which value is 1.701.

IRT provides strategies for:

- Estimating the learner ability  $\theta$  (Baker, F. 2001) and the standard error (S $\theta$ ) of the estimated ability.

- Estimating the item parameters from data (Baker, F. 2004).

- Ascertaining how well the data fits a model, for instance the Lz misfit indices.

- Investigating the psychometric properties of assessments.

If  $P_i = .11$ ,  $\theta = .25$ ,  $a = .3$ ,  $b = .4$  and  $c = .5$ , the CAMRI laboratory QTI-IMS modeling for item parameters are:

```
<ItemParameter P="0.11" Theta = "0.25 a="0.3" b="0.4" c="0.5"/>
```

Or when all the parameters are in multiple XML structures:

```
<PItemParameter>0.11</PItemParameter>
<ThetaItemParameter>0.25</ThetaItemParameter>
<AItemParameter>0.3</AItemParameter>
<BItemParameter>0.4</BItemParameter>
<CItemParameter>0.5</CItemParameter>
```

## 7.3 Learning methods for E-testing applications

An important part of this project will be the implementation of learning methods for E-Learning applications with adaptive testing functionalities in a constructivist formative evaluation context. One of the main goals of the methods will be the student preparation for the use of an E-testing software to overcome his resistance to change. Another important issue will be the summative aspect of the evaluation with pass/fail criterion.

## 8. Conclusion

A lot of E-Learning applications using computerized adaptive testing have been developed and many are similar as this project by the inclusion of a question and data entry module in databases or knowledge bases. These applications also have a question (item) display engine using item response theory. The most similar applications to this project are SIETTE (Conejo, Guzmán, Millán, Trella, Pérez-De-La-Cruz, J.L., & Rios, 2004) and PersonFIT (Sodoke, Kkambou, Raïche, Riopel & Lesage, 2007).

A major innovation of this project is the implementation of two IMS-QTI sub standards for item and interface parameters modeling that will facilitate exchange of items among teachers and learning institutions. The constructivist approach of learning using E-Testing applications will create new

learning methods that will be stated in further publications.

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