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An Aligned Assessment Item Authoring Environment based on Interoperability Standards

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Abstract **—** Standard representations support sharing assessment items and learning objects among learning environments. Different standards have been developed to provide interoperability-based descriptions for all learning aspects. Designing assessment items or questions using standard representations became a key point in learning/teaching domain. This paper proposes an environment for authoring assessment items using a combination of standards linked together to align the produced questions. The environment consists of a set of tools. The first tool is dedicated for building question body using IMS (Innovation, Adoption, and Learning) QTI (Question and Test Interoperability) standards. An extension to IMS QTI was designed to represent question Intended Learning Outcomes (ILOs), difficulty degree, assessed concepts, and target groups. The second tool manipulates competency definitions bank which is used in representing assessment item ILOs. The third tool deals with target groups to whom question will be delivered.

Index Terms — IMS QTI, ILOs, Assessment, Interoperability.

I. INTRODUCTION

At this electronic era, eAssessment is deemed to be a milestone in any educational or training system whether it is an e-learning or classic face-to-face environment. Assessment became a strong complementary or even an alternative for the traditional paper and pencil test systems. This trend provides valuable features which attracted educational and training organizations to use and promote e-learning in their progress and growth.

Designing reliable, tested, revised, and domain-conformable question is not an easy task. Sharing questions among learning environments reduces test construction challenges in both cost and quality level. With small effort, assessment items shareabilty and reusability in stand-alone form allow examiners to build exams by just picking out and organizing appropriate ones.

Compliance of standards facilitated assessment items reusability, since all of assessment repositories which populate items have the same representation schema so they can be interpreted and rendered by assessment tools using the same mechanism. Current standards provide a set of predefined templates vary according to question type to be filled by question generators. These templates specify the structure of question content as well as mechanisms of feedback and scoring.

A current research line, in the CAA field, works on the creation of tools compliant with assessment specifications or standards [1]. Assessment systems should use standard representations to have the capability of interoperability which became a key point that allow them to exchange and share pieces of assessment, learners' feedback[2] and scores. Question specification should incorporate information about how to use it and in what context it should be employed.

The rest of this paper is organized as follows: Section II deals with some background. Section III describes the previous and related works. Section VI briefly reports the proposed system architecture. Finally, conclusions and future work derived from the contribution introduced in this paper are presented in Section IV.

II. BACKGROUND

Different standards have been developed to provide interoperability descriptions for all learning aspects. The following subsections will investigate the two main standards used for designing and aligning assessment items: QTI [3] standards, and IEEE Reusable Competency Definitions (IEEE RCD) [4].

A. Aligning assessment items

Effective assessment is inseparable from good teaching and learning. Assessment design should be related not only to curriculum content but also to learning and teaching methodology in an outcome oriented educational framework. Assessment items should be selected according to criteria appropriate for the underlying learning program objectives to assess learning outcomes in various domains – professional knowledge, generic skills, and attitudes, etc.

Practically speaking, constructing an assessment test specific to some learning objectives requires describing

assessment items with metadata related to ILOs, difficulty level, concept to be assessed and target group. Metadata will make it easy to select a set of assessment items to formulate a specific test according to their criteria.

Well expressed statements of intended learning outcomes help both tutors and students. They provide a clear explanation of what is required to complete successfully a module in a programme of study providing there are strong links between the learning outcomes, the assessment criteria and the assessment methods [5].

B. IMS QTI description and application

IMS GLC (Global Learning Consortium) [6] presented a unified specification named QTI for e-assessment in 1999. It has been considered as a de facto standard for reusable components. It is based on Question Markup Language (QML), a structured language proposed by Question Mark Computing Ltd [7] in 1997. It depends on the XML to organize and specify the assessment content which could be easily shared and reused [8]. It uses ASI model (Assessment-Section-Item) to define reusable tests [9]. QTI was enhanced [3], [6], [1], and [8] to provide specifications for building, processing and sharing all items of assessment information and reporting test results.

IMS QTI deals with questions (i.e. *assessmentItems*) and tests (i.e. *assessmentTests*). More specifically, it proposes a software architecture consisting of a repository (i.e. *itemBank*) managed by the itemBankManager that stores the *assesmentItems* that can be included and reused in different *assesmentTests* in a given *learningSystem*. There is also an *authoringTool* for the authors to manage *assessmentItems* and a *testConstructionTool* for the *testConstructors* to build *assessmentTests*. The tutors configure the materials in the *learningSystem* for the candidates, who can answer *assessmentTest* through an *assessmentDeliverySystem*, maybe under the vigilance of a proctor [10]. Figure 1 illustrates these main concepts and architecture of IMS QTI.

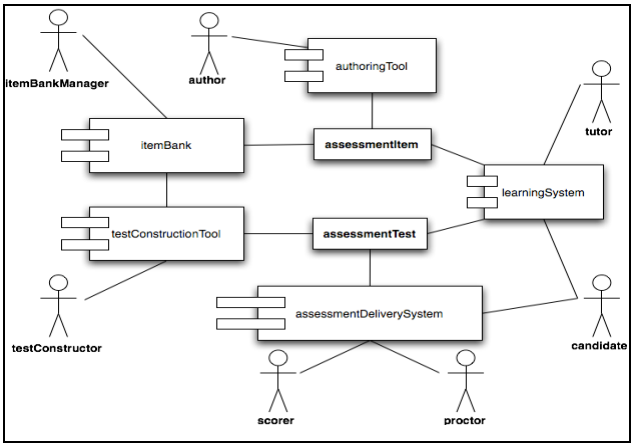

Figure 1. IMS QTI architecture and Role of Assessment Tests and Assessment Items [3]

C. Deficiencies of IMS QTI

As to online assessment management systems, the use of IMS QTI specification only limits in a few countries and still only a few organizations adopt it [11].

- The semantic and terminologies of the specification has some difficulties to be understood by instructors. Testers need to spend a lot of time to get familiar with its complex and specific concepts.
- It does not support a reference representation for Aims, learning objectives and ILOs for assessment items.
- There's no any link information between assessment items and the concept or subject being assessed
- The difficulty level of the assessment items is absent.
- Optional and redundant attributes in assessment items need special concentration during software developing.
- The existence of different versions is a huge obstacle for interoperability. The amount of possible scenarios to consider when writing an import module derived from the specification rules it too complex [12], [8].

D. IEEE RCD description and application

It is based on IMS RDCEO (Reusable Definition of Competency or Educational Objective) [13]. It defines a data model for describing, referencing, and sharing competency definitions, primarily in the context of online and distributed learning. This Standard provides a way to represent formally the key characteristics of a competency, independently of its use in any particular context. It enables interoperability among learning systems that deal with competency information by providing a means for them to refer to common definitions with common meanings.

IEEE RCD is the only widely accepted standard for describing generic learning outcomes [14]. Its structure is very simple and consists of four elements most of them are text. Figure 2 illustrates RCD elements.

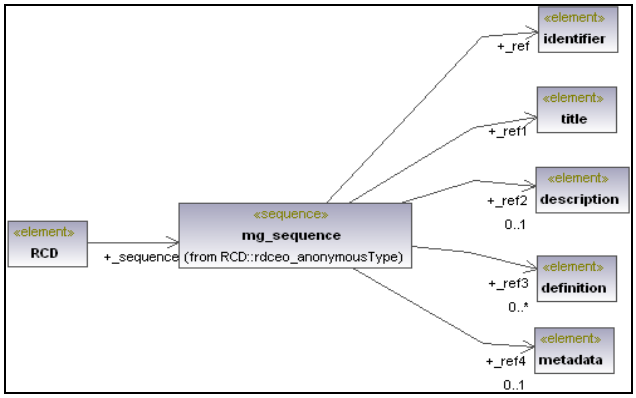

Figure 2. Reusable Competency Definition (RCD) Model

III. RELATED WORK

Researchers added some modifications to QTI specifications to allow it to support some valuable and missing criteria. Also, an enormous number of tools

have been created to facilitate the creation and manipulation of QTI-compliant assessments. The next two sub-sections will deal these two points.

A. IMS QTI model extensions

Table I lists a set of architectures which were presented as extension to QTI model. First column (Architecture) specifies the name of architecture. Second column (level) deals with the QTI model portion in which the modifications were took place. Level may be Item (Question, a part of assessment), Test (Whole assessment), or QTI model (All components of QTI). Third column (Supplemented Features) introduces the set of added criteria.

TABLE I. IMS QTI EXTENSIONS

Architecture	Level	Supplemented Features
AQT[15]	Item	• Accumulative assessment • Accumulative feedback • Visualization declaration
QTI Mobile assessment [16]	Test	• Automatically generating self-contained Flash-Lite assessments from QTI packages
Collage IMS LD [17]	QTI Model	• Use of educational patterns • Enable integration of Web 2.0-like services
QTI-Rubrics [2]	QTI Model	• Integrate IMS Rubric with QTI • Enables automatic formative feedback for learners
LEARN-SQL [10]	QTI Model	• Automates the role of scorer • Enables automatic Rating and grading
CompositeText Interaction [18]	Item	• Assembles two interactions: hottext and textEntry • Allows to find wrong instructions and correct the identified error

B. QTI-based systems

QTI specification is chosen by a set of e-learning systems for representing different components of assessments to be used in importing and exporting assessment documents at different levels. Table II briefly reports the most recent set of these systems. First column (System) lists the names of these systems. Second column (Type) specifies system type which may be learning management system (LMS), Learning Content Management System (LCMS), Virtual Learning Environment (VLE) or Assessment Tool (AT). Third column mentions the QTI level at which is the same as Table II. Fourth column (Version) highlights the QTI version which is used in exporting/importing assessment documents from/into these systems. Finally, fifth column presents the system home site at which system details can be located.

VI. PROPOSED SYSTEM

The proposed system is presenting an environment called *ESI* consisting of three tools (i.e. Competency, Target Groups, and Assessment Item Authoring tools) for constructing questions based on standards. The employed standards are IMS QTI and IEEE RCD. An extension to IMS QTI was designed to represent assessment item ILOs, difficulty level, concepts to be assessed, and target groups. Beside ESI features, next sub-sections will describe IMS QTI extended model [19] and the three tools.

A. Features of ESI

ESI introduces the following features:

- Facilitates teachers the utilization of good techniques of building assessment contents compliant with standard specifications without have a deep technical background or knowledge about it.
- Minimizes time: since building efficient questions consumes a lot of time and need especial skills. ESI helps learning participants to construct questions in an easy-to-use manner.
- Can be integrated and plugged in any learning environment since it is composed as java package
- Supports valuable criteria added in the QTI extended model such as ILOs, difficulty level and learnt concept.
- Compatible with QTI-based system even after adding new features. Systems that do not support this addition will not process it.

TABLE II. IMS QTI BASED SYSTEMS

System	Type	Level	Version	Homepage
Angel	LMS	Test	2.1	www.angellearning.com
AQuRate	AT	Item	2.1	http://aqurate.kingston.ac.uk
ASDEL	AT	Item	2.1	www.asdel.ecs.soton.ac.uk
ATutor	LCM	Test	2.1	www.atutor.ca
Blackboard	LMS & VLE	Item	1.2	www.blackboard.com
Clix	LMS	Item	1.2	www.im-c.com
Cognero	AT	Item	2.1	www.cognero.com/
COMBA [20]	AT	Test	2.1	http://ecs.soton.ac.uk
Content-e	AT	Item	2.0	http://eng.content-e.nl
DB Primary	LMS	Item	2.0	www.getprimary.com
Desire2Learn	LMS	Item	1.2	www.desire2learn.com
Diploma	AT	Test	2.1	www.brownstone.ne
Dokeos	LCMS	Item	2.0	www.dokeos.com
Elques	AT	Item	2.1	http://elques.bps-system.de/
ILIAS	LMS	Item	1.2	www.ilias.de
LRN	VLE	Item	1.2	http://dotlrn.org
Mathqurate	AT	Item	2.1	www.qtitools.org
Moodle	LMS	Item	2.0	http://moodle.org
OLAT [21]	LMS	Test	1.2	www.olat.org
Q Writer Publisher	AT	Item	1.2	www.questionwriter.com
QMark Perception	AT	Test	1.2	www.questionmark.com
Respondus	AT	Test	1.2	www.respondus.com
Sakai	LMS	Item	1.2	www.sakaiproject.org
Studywiz	VLE	Item	1.2	www.europe.studywiz.com

The QTI v2.1 was chosen because its interoperability and the easy management of its elements [1]. Also, its

increasing complexity of XML tags in QTI makes it more flexible [16], [22].

B. IMS QTI extended model

The proposed extension of QTI model integrates *extension Declaration* [19] object with *variable Declaration* object associated with *assessment Item* object. Figure 6 illustrates this integration.

Extension Declaration supplemented features include four elements:

- ILOs (*intended Learning Outcomes*): represent the kinds of outcomes aimed to appraise and on which the assessment test is adapted and aligned. Assessment item may involve more than one ILO. ILO can refer to an entry for a competency in RCD repository.
- Difficulty level (*difficulty Declaration*): describes the degree of difficulty the assessment item fall in. The selection of assessment questions is performed on the basis of their difficulty level (i.e. some questions are dedicated to excellent students; others are assigned for ordinary ones and so on).
- Assessed concepts (*concepts Declaration*): highlights the concepts to which the question is applied.
- Target group (*target Groups Declaration*): qualifies groups in the community selected as being the most appropriate for answering the specified assessment item. It can be learners of a certain education license, age, gender and expertise time and level.

Attributes of *intended Learning Outcome*, *difficulty Declaration*, concept Declaration, and *target Group Declaration* are clarified in tables III, IV, V, and VI respectively.

TABLE III. DESCRIPTION OF INTENDEDLEARNINGOUTCOME ATTRIBUTES

Attribute	Description
Identifier	Uniquely identifies its ILO instance
refID	Refers to some ILO description in external repository related to the identified one
Type	Specifies to which category of ILOs the assessment item related. This category may be knowledge and understanding, intellectual skills, professional and practical skills, or general and transferable skills.
Value	Assigned to the literal description of ILO itself.

TABLE IV. DESCRIPTION OF DIFFICULTYDECLARATION ATTRIBUTES

Attribute	Description
identifier	The same as table III
Grade	A symbol specifies difficulty level (i.e. A, B, C,etc)
Value	A number specifies difficulty level may (i.e. 0.3, 0.5, 0.7... etc).
Range	Specifies the symbols used in grade attribute
From	Holds the start of number range for value attribute
To	Holds the end limit of number range for value attribute

TABLE V. DESCRIPTION OF CONCEPTDECLARATION ATTRIBUTES

Attribute	Description
Identifier	The same as table III
refID	The same as table III
Parented	A reference identifier for the learning concept or unit which contains the current concept
Type	It's specified by the concept generator. Assessed concept may be a unit, lesson, section, theory or term
From	Holds the start of number range for value attribute
Title	A description or name of the concept being assessed

TABLE VI. DESCRIPTION OF TARGETGROUPDECLARATION ATTRIBUTES

Attribute	Description
identifier	The same as table III
Domain	The area of knowledge on which the question applied (i.e. medicine, computer science, agriculture, …)
Gender	Takes value of male or female
description	Detailed statement about the specified target group
Extra	Additional information may be supplied dependent on the tool applying this ontology

B. Competency Tool (CT)

CT is a tiny tool dedicated for building and manipulating competency repositories. The word competency is used in a very general sense that includes skills, knowledge, tasks, and learning outcomes. The generated competencies structure is RCD-conformable. Competencies can be used to describe ILOs and can be referenced by *extensionDeclaration* as *intendedLearningOutcomes*. CT architecture, a sample of generated competencies, and GUI are shown in figures 3, 4, 5 respectively. CT puts JAXB (Java Architecture for XML Binding) [23] and DOM (Document Object Model) [24] technologies into service to manage competencies repository. Also, CT employs *Ekit* [25] which is a free open source Java HTML editor applet and application. Some modifications have been supplemented to Ekit to view competency objects.

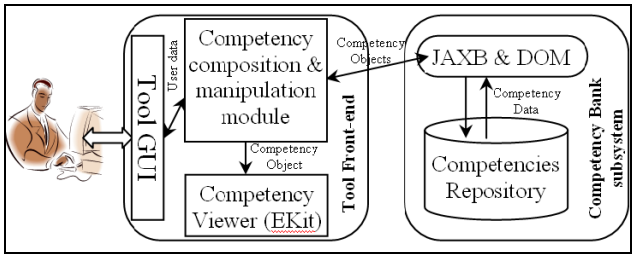

Figure 3. Competency Tool (CT) Architecture

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<competencies xmlns:ns2="http://www.imsglobal.org/xsd/imsrdceo_rootv1p0">
   <rdceo> <identifier>ID_1292588087468</identifier>
      <title>
         <langstring xml:lang="en-us">Recognize the basic components of programs written in high level
         languages.</langstring></title>
      <description>
         <langstring xml:lang="en-us">The first Knowledge and Understanding ILO related to Programming
         (1) course. Computer Science Department. Faculty of Computers and Information. Cairo
         University.</langstring></description>
      <definition> <model>Default Model</model>
         <statement statementname="Intended Learning Outcome" statementid="ST_ID_1292588191078">
         <statementtext>
                  <langstring xml:lang="en-us">Knowledge and Understanding</langstring>
         </statementtext></statement> </definition>
</rdceo>
   . . .
```

Figure 4. Competency Sample generated by CT

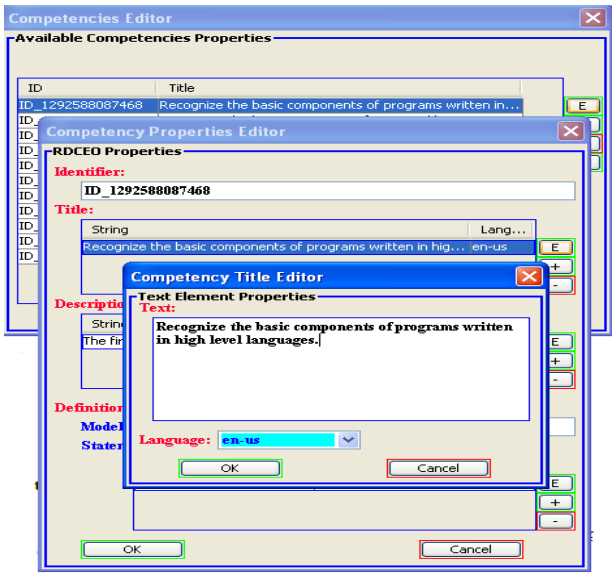

Figure 5. Competency Tool GUI

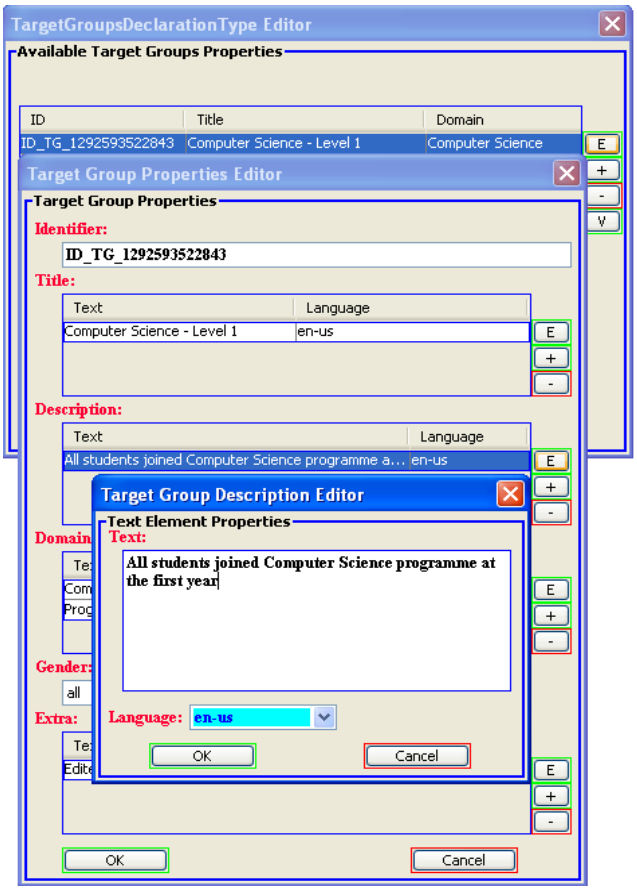

Figure 7. Target Group Tool GUI

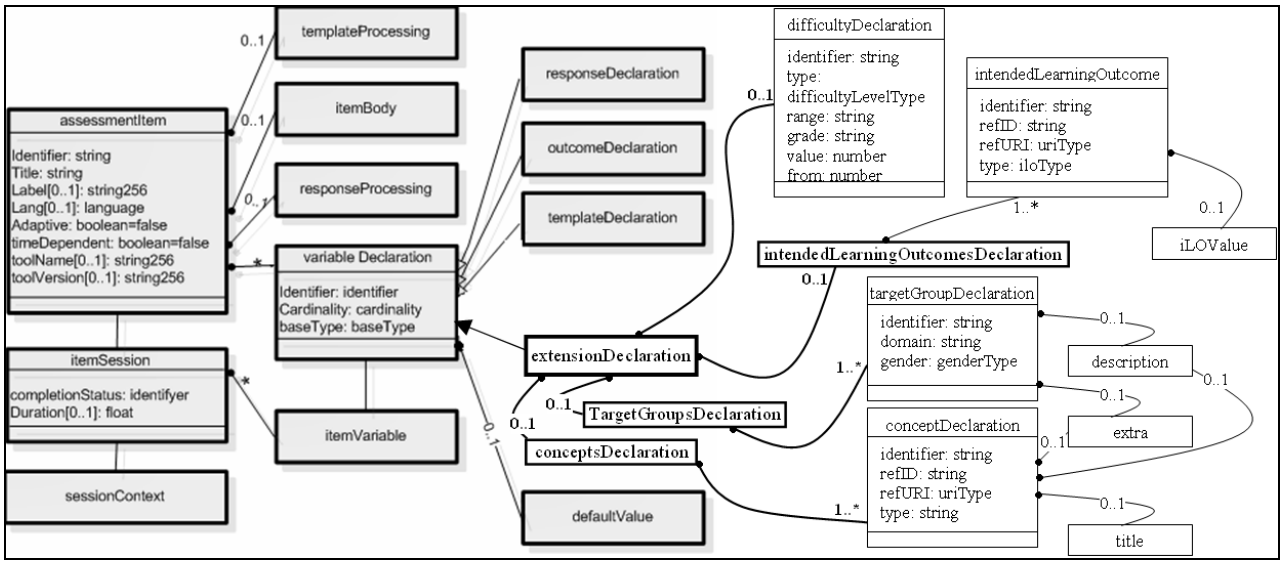

Figure 6. IMS QTI assessment item object model [15] and extentionDeclaration [19] added to it

C. Target Group Tool (TGT)

TGT is a small tool intended to simplify and facilitate managing repositories of target group definitions. The produced target group structure matches *targetGroupsDeclaration* definition. TGT architecture is closely similar to CT but instead of generating competencies, TGT generates target groups. TGT GUI and sample of the generated target groups are demonstrated in figure 7 and 8.


```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
 <targetGroupsDeclaration xmlns:ns2="http://www.targetGroups.org">
  <targetGroupDeclaration identifier="ID_TG_1292593522843">
   <title>
    <langstring xml:lang="en-us">Computer Science - Level 1</langstring></title>
  <description>
    <langstring xml:lang="en-us">All students joined Computer Science programme at the first year
    </langstring></description>
  <domain>
    <langstring xml:lang="en-us">Computer Science</langstring>
   <langstring xml:lang="en-us">Programming</langstring></domain>
  <gender>all</gender>
  <extra><langstring xml:lang="en-us">Edited by CS staff at Faculty of Computers and Information</langstring>
  </extra> </targetGroupDeclaration>
  ...
```

Figure 8. Target group sample generated by TGT

D. Assessment Item Authoring Tool (AIAT)

AIAT designed to create assessment items based on the proposed QTI extended model. AIAT can manage any QTI Question Bank. Also, it has the capability to operate with competency, target group, and LOM (Learning Object Metadata) [26] concept banks to fill question aligning data according to QTI extension. AIAT architecture is shown in figure 10.

Enhanced AQuRate tool (figure 9) displays QTI-based question for editing. It is based on AQuRate with new functionalities added such as editing new types of QTI questions and displaying/saving questions from/to strings not files only.

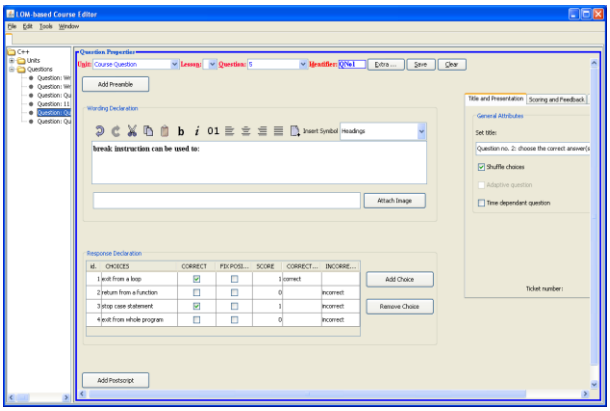

Figure 9. Assessment Item Authoring Tool GUI

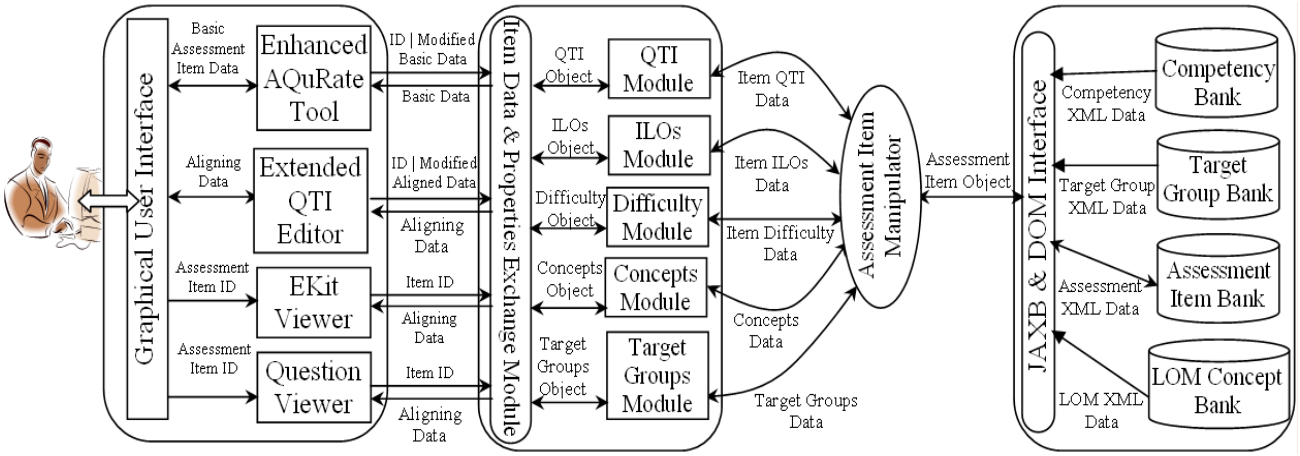

Figure 10. Assessment Item Authoring Tool Architecture

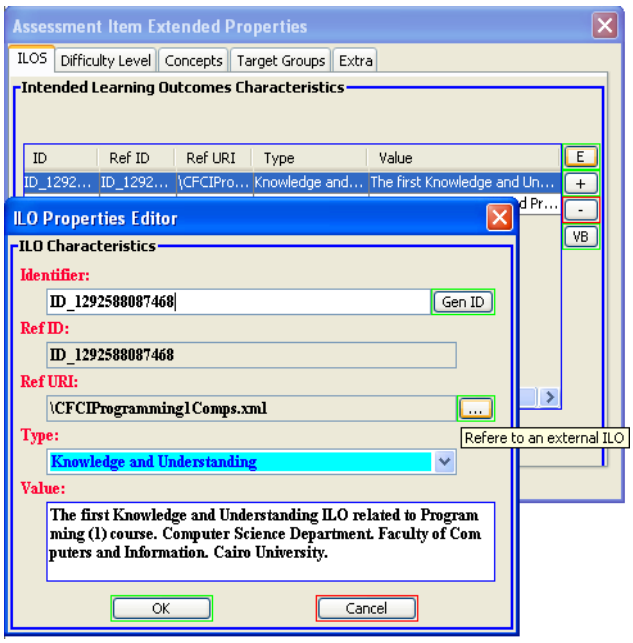

Figure 11. QTI Extension Editor

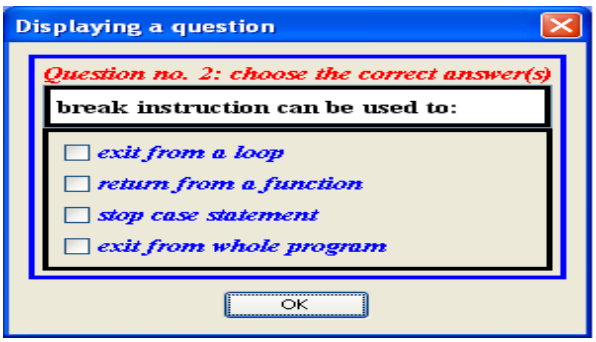

Figure 12. Question Viewer (displays QTI question in fig 13)

Question aligning data can be edited through Extended QTI Editor (figure 11). A question can be displayed in its final ready-to-be-answered form using Question Viewer (figure 12). The generated items are simply saved in QTI assessment item bank in XML format. Sample of these items is shown in figure 13. Ekit viewer is dedicated to view user-readable HTML form of question ILOs and target groups. Some competency

target group used to align question shown in figure 13 are displayed using Ekit in figures 14 and 15.

```
<assessmentItem adaptive="false" identifier="QNo1" label="mylabel" timeDependent="false" title="Question
no. 2: choose the correct answer(s)" xmlns="http://www.imsglobal.org/xsd/imsqti_v2p1"
...
xsi:schemaLocation="http://www.imsglobal.org/xsd/imsqti_v2p1 imsqti_v2p1.xsd">
<responseDeclaration baseType="integer" cardinality="multiple" identifier="RESPONSE">
    <correctResponse>
      <value>ID0</value>
      <value>ID2</value></correctResponse>
    <mapping defaultValue="0.0">
      <mapEntry mapKey="ID0" mappedValue="1.0" />
      <mapEntry mapKey="ID2" mappedValue="1.0" />
        </mapping></responseDeclaration>
<outcomeDeclaration baseType="integer" cardinality="single" identifier="SCORE" />
<outcomeDeclaration baseType="identifier" cardinality="single" identifier="FEEDBACK" />
<itemBody><choiceInteraction maxChoices="0" responseIdentifier="RESPONSE" shuffle="true">
    <prompt>
      <b>break instruction can be used to:</b> </prompt>
    <simpleChoice fixed="false" identifier="ID0"> exit from a loop
      <feedbackInline identifier="ID0" outcomeIdentifier="FEEDBACK"
        showHide="show">correct</feedbackInline>
      <feedbackInline identifier="ID0" outcomeIdentifier="FEEDBACK" showHide="hide" /> </simpleChoice>
    <simpleChoice fixed="false" identifier="ID1"> return from a function
      <feedbackInline identifier="ID1" outcomeIdentifier="FEEDBACK" showHide="show" />
      <feedbackInline identifier="ID1" outcomeIdentifier="FEEDBACK"
        showHide="hide">incorrect</feedbackInline>  </simpleChoice>
    <simpleChoice fixed="false" identifier="ID2"> stop case statement
      <feedbackInline identifier="ID2" outcomeIdentifier="FEEDBACK" showHide="show" />
      <feedbackInline identifier="ID2" outcomeIdentifier="FEEDBACK"
        showHide="hide">incorrect</feedbackInline> </simpleChoice>
    <simpleChoice fixed="false" identifier="ID3"> exit from whole program
      <feedbackInline identifier="ID3" outcomeIdentifier="FEEDBACK" showHide="show" />
      <feedbackInline identifier="ID3" outcomeIdentifier="FEEDBACK"
        showHide="hide">incorrect</feedbackInline></simpleChoice> </choiceInteraction></itemBody>
<responseProcessing
    template="http://www.imsglobal.org/question/qti_v2p0/rptemplates/map_response" />
<extensionDeclaration cardinality="record" identifier="ID_1292662121609"
    xmlns:ns6="http://www.targetGroups.org" . . . >
    <intendedLearningOutcomesDeclaration>
      <intendedLearningOutcomeDeclaration identifier="ID_1292588087468" refID="ID_1292588087468"
        refURI="\CFCIProgramming1Comps.xml" type="Knowledge and Understanding">
        <iLOValue>The first Knowledge and Understanding ILO related to Programming (1) course.
        Computer Science Department. Faculty of Computers and Information. Cairo
        University.</iLOValue></intendedLearningOutcomeDeclaration>
      <intendedLearningOutcomeDeclaration identifier="ID_1292593150296" refID="ID_1292593150296"
        refURI="C:\CFCIProgramming1Comps.xml" type="Professional and Practical Skills">
        <iLOValue>The first Professional and Practical ILO related to Programming (1) course.
        Computer Science Department. Faculty of Computers and Information. Cairo
        University.</iLOValue></intendedLearningOutcomeDeclaration>
    </intendedLearningOutcomesDeclaration>
    <difficultyDeclaration grade="B" identifier="ID_1292662078843" range="A;B;C;D;E" type="Symbol" />
    <targetGroupsDeclaration>
        <targetGroupDeclaration identifier="ID_TG_1292605812578">
          <refID>ID_TG_1292593522843</refID>
          <refURI>\TargetGroups.xml</refURI></targetGroupDeclaration>
        <targetGroupDeclaration identifier="ID_TG_1292605826218">
          <refID>ID_TG_1292593716421</refID><refURI>C:\TargetGroups.xml</refURI>
            </targetGroupDeclaration>
    </targetGroupsDeclaration>
    <extra>Course Object Oriented Programming </extra>
</extensionDeclaration>
</assessmentItem>
...
```

Figure 13. QTI Assessment Item Sample with extension generated by AIAT

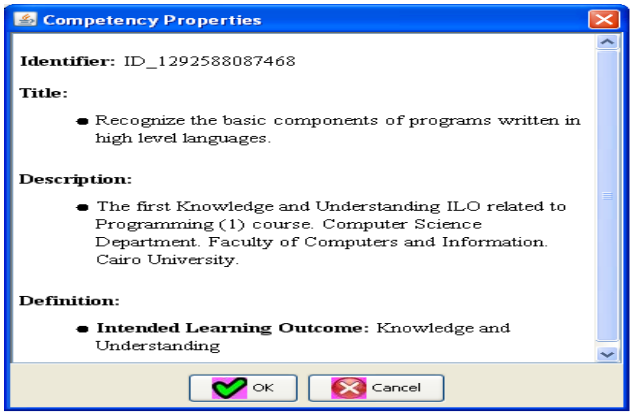

Figure 14. Ekit displays some competency

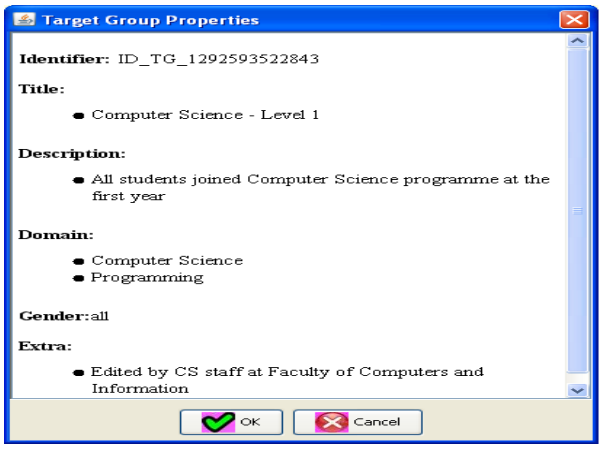

Figure 15. Ekit displays some target group

IV. CONCLUSION AND FUTURE WORK

The work proposed in this paper represents a preliminary approach towards an extension of the QTI data model. The added features are necessary for aligning QTI questions and describing their ILOs, difficulty level and assessed concepts. Different extensions were developed for IMS QTI to overcome some deficiencies. Although, QTI specifications are under discuss and it seems to be promising and different shortages were addressed. An authoring environment called ESI was presented. ESI main objective is to manage and align QTI assessment items to be used in tests and exams according to their criteria.

As IMS formats continue to improve in future, we will keep track adapting our environment to the new features. Future work may include adding some features needed by the e-assessment community. Also, it's highly required to test redundancy, similarity and dependency founded in the generated assessment items.

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