Supporting the Process of Developing and Managing LOM Application Profiles: The ASK-LOM-AP Tool

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Abstract—A number of international initiatives, such as the Open Educational Resources initiative, have recognized the potential value of sharing and reusing digital resources among educational communities. As a result, organizing, offering, and accessing these resources over the web have been key issues for both the research and the educational community. Within this framework, a popular way for describing digital educational resources is the IEEE Learning Object Metadata (LOM) Standard. On the other hand, it has been also recognized that it is not possible for a generic standard such as IEEE LOM to fully meet the specific requirements and accommodate the particular needs of different educational communities. Therefore, the practice of generating Application Profiles (APs) of the IEEE LOM has emerged and a number of different APs have been developed worldwide. However, despite the widespread development of APs it seems that only a limited number of software tools exist, to support the process of LOM Application Profiling. Within this context, in this paper we target addressing this problem by introducing a new web-based tool (ASK-LOM-AP) that aims to overcome the identified limitations of existing tools and facilitate its users to easily develop and manage LOM APs for different educational communities.

Index Terms—Authoring tools, e-learning standards, learning objects

1 INTRODUCTION

Over the past years several initiatives have been emerged worldwide toward the provision of open access to Educational Resources, in the form of Learning Objects (LOs) such as “video and audio lectures (podcasts), references and readings, workbooks and textbooks, multimedia animations, simulations, experiments and demonstrations, as well as teachers’ guides and lesson plans” [1]. UNESCO [2] has defined Open Educational Resources (OERs) as the “technologically-enabled, open provision of educational resources for consultation, use, and adaptation by a community of users for noncommercial purposes.” The Open Educational Resources initiative is defined as: “a technology-empowered initiative that aims to create and share educational resources that are freely available online for everyone at a global level” [3]. The main objective of such initiatives is to support the process of organizing, classifying, and storing digital educational resources and their associated metadata in web-based repositories which are called Learning Object Repositories (LORs). McGreal [4] has defined LORs as systems that “enable users to locate, evaluate, and manage learning objects through the use of ‘metadata,’” namely descriptors or tags that systematically describe many aspects of a given learning object, from its technical to its pedagogical characteristics.”

Within this context, a number of international efforts have led to the development of the IEEE Learning Object Metadata (LOM) standard as a commonly accepted way for describing educational resources with metadata [5]. Many of the existing LORs that have been developed worldwide adopt the IEEE LOM standard for describing their educational resources aiming to facilitate their interoperability with other LORs [1]. More specifically, a survey [6] about 59 well-known LORs indicated that 54 percent of them are using IEEE LOM compatible metadata and each one of these specific LORs are including more than 10,000 LOs characterized with LOM compatible metadata. However, it was recognized early enough that it is not possible for a generic standard such as IEEE LOM to fully meet specific requirements and thoroughly accommodate the particular needs of different educational communities requiring local extensions or modifications to the IEEE LOM [7]. As a result, a common practice of generating Application Profiles (APs) of the IEEE LOM standard has emerged as a means of addressing this problem [7], [8], [9], [10] and several educational communities have developed a number of APs, so as to adapt IEEE LOM to their specific requirements and needs.

An AP is a metadata scheme, which consists of metadata elements selected from one or more standard metadata schemes and it is created for allowing a given application to meet its functional requirements [11]. LOM APs are developed for addressing common needs of educational communities, such as the simplification of the metadata authoring process [12]. This can be achieved by generating LOM APs as small subsets of IEEE LOM Standard.

Despite this increased interest for LOM Application Profiling, only a limited number of software tools have been...
developed, so as to facilitate educational communities in the process of developing and managing their own LOM APs. These tools on the one hand are addressing users who are familiar with the metadata elements and the structure of IEEE LOM Standard, namely e-Learning Experts (as defined in [13]) and on the other hand, users with a profound knowledge of XML structure and its syntax, namely technical developers. This means that the process of LOM Application Profiling needs to be a collaborative task between e-Learning experts, who undertake the task of translating the needs of an educational community to appropriate IEEE LOM modifications, and technical developers, who undertake the task to use an existing tool, so as to produce the desired LOM AP. Therefore, e-Learning experts without a profound knowledge of XML structure and its syntax are not able to create LOM APs and they continuously need assistance from technical developers for developing or modifying LOM APs making the process more costly. Beyond that, existing tools have a number of limitations that can be summarized, as follows:

- The produced LOM APs cannot be exported and reused by other software tools and systems. This means that the produced LOM APs remain “locked” in the software tool and cannot be edited and reused by other similar software tools.
- They do not support the process of educational metadata authoring based on the produced LOM APs. This means that an educational community has two options:
  - use existing educational metadata authoring tools along with the produced AP, to author educational metadata instances based on it. However, this is a difficult process, since existing educational metadata authoring tools incorporate existing built-in LOM APs, which can be modified only from their source-code,
  - develop from the scratch a customized educational metadata authoring tool based on their desired LOM AP.

In most of the cases, LOM APs are produced by technical developers without the use of an existing LOM Application Profiling Tool, but with the use of simple XML editors. Although this approach tackles the first limitation identified above (since the produced AP can be exported as XML Schema, which is an interoperable format), the second limitation is not tackled.

To this end, in this paper we target to address all the above-mentioned limitations by introducing a new web-based tool, namely ASK-LOM-AP. ASK-LOM-AP aims to overcome the identified limitations and facilitate its users, namely e-Learning experts, as well as technical developers to easily develop and manage LOM APs for different educational communities.

The paper is structured as follows: Following this introduction, Section 2 presents the concept of AP, the main reasons for their development and describes the key steps that are suggested to be followed for the development of a LOM AP according to international organizations such as IMS Global Learning Consortium (IMS GLC) and European Committee for Standardization (CEN/ISSS). Moreover, existing LOM APs are presented and compared, so as to identify the most common modification types that are applied to existing LOM APs. Section 3 provides an overview of existing tools used for developing and managing LOM APs and identifies their weaknesses according to the requirements that an IEEE LOM Application Profiling Tool should meet, which are derived from

1. an analysis of the guidelines proposed by IMS GLC and CEN/ISSS,
2. interoperability issues,
3. widespread availability issues and
4. lack of XML programming competences of its end users.

In Section 4, we present the architectural components, the fundamental functionalities of the ASK-LOM-AP Tool, as well as scenarios of its use. In Section 5, we present users’ satisfaction results from the use of ASK-LOM-AP and we compare them with results from the use of other relevant tools. Finally, we discuss our findings and we present our conclusions and suggestions for future work.

2 Background

2.1 Guidelines for Developing Application Profiles

The European Committee for Standardization [14] defines an AP as: “an assemblage of metadata elements selected from one or more metadata schemas and combined in a compound schema. Application profiles provide the means to express principles of modularity and extensibility. The purpose of an Application Profile is to adapt or combine existing schemas into a package that is tailored to the functional requirements of a particular application, while retaining interoperability with the original base schemas.”

According to IMS Global Learning Consortium, the main reasons for the development of an AP can be summarized below [15]:

- To meet technical and other requirements and preferences specific to a project, a community, a domain, and/or a region.
- To address ambiguity and generality in a specification or standard.
- To foster semantic interoperability, e.g., through the use of commonly understood vocabularies.
- To facilitate testing for conformance and successful interoperability.

However, it is important in the process of Application Profiling to support the communities, which are interesting in developing APs, with a consistent practice that will facilitate them during this process. The IMS Global Learning Consortium recognizes a number of benefits in doing this, namely [16]:

- A set of rules for constructing an AP will confine the changes that can be made, thus ensuring greater interoperability across conformant APs.
- The consistent documentation of APs will enable vendors to build products and services that reach out multiple communities with simple configuration settings for localization.
The growing number of publicly documented APs will allow subsequent adopting communities to select and reuse elements of existing APs, rather than develop them from the scratch. Machine readable definitions of APs will facilitate data exchange and interoperability across different communities.

International Organizations such as IMS GLC and European Committee for Standardization have published guidelines for the development of APs with specific focus on the IEEE LOM Standard. These guidelines include the following steps [14], [16], [17]:

- **Step 1—Selection of data elements.** During this step the data elements that the new AP will be built on are selected.
- **Step 2—Size and smallest permitted maximum.** This step includes the definition of the size that a data element is allowed to have at a metadata instance. More specifically, the size can be equal to one (when the data element can have only one value at the metadata instance) or more than one (when the data element can have multiple values at the metadata instance). In the second case, a smallest permitted maximum is defined, which is the smallest number of occurrences of a data element in a metadata instance. However, it should be noted that the new AP can reduce the size of a data element or keep it equal to the value of the IEEE LOM Standard but it cannot increase the size of a data element.
- **Step 3—Data elements from multiple namespaces.** This step aims at the definition of data elements from different namespaces, which are part of different metadata schemas. For example, the IEEE LOM Standard itself illustrate this by integrating the vCard schema (which is a schema for describing electronic business cards) to describe people and organizations.
- **Step 4—Adding local data elements.** During this step new local data elements, which are not contained to the initial metadata schema, are added to the new AP.
- **Step 5—Obligation of data elements.** This step aims at the definition of mandatory data elements (that is, the value for these data elements shall always be present), the conditional (that is, the value for the data element shall be present only if a certain condition is satisfied), the recommended (some APs recommend including values for specific metadata elements).
- **Step 6—Value space.** During this step the value space of the data elements is defined. The value space defines the set of values that the data element shall derive its value from. In IEEE LOM Standard, a value space is defined though
  - a vocabulary (where the values are enumerated) and
  - a reference to another standard or specification.

As a result, the new AP can restrict an IEEE LOM vocabulary to a subset of this vocabulary or it can replace the reference for the value space of an IEEE LOM value space to another standard or specification.

- **Step 7—Relationship and dependency.** This step includes the definition of interrelationships and dependencies between data elements.
- **Step 8—Data type profiling.** This step aims at data type profiling of the metadata elements of the new AP. In the IEEE LOM Standard applicable data type values are:
  - Langstring,
  - DateTime,
  - Duration,
  - Vocabulary,
  - CharacterString and
  - Undefined.

Therefore, data type in IEEE LOM Standard is a metadata schema in its own right and all rules defined for LOM APs can be applicable to data types.

- **Step 9—Application profile binding.** The final step includes the production of the AP binding, which is the conceptual data schema of the AP and should be represented in XML schema or RDF format.

2.2 Examples of Existing Application Profiles

As a result, during the past years a number of IEEE LOM Application Profiles have been developed worldwide. Next, we present examples of well-known LOM APs, which have been adopted by large LORs (including more than 10,000 LOs) for characterizing their LOs with educational metadata [6]:

- The UK-LOM Core Application Profile [20] and its evolution, namely, the JORUM Application Profile [21] developed by a JISC-funded Service for Development in United Kingdom Further and Higher Education and adopted by the JORUM Web Repository (http://www.jorum.ac.uk).
- The VET Metadata Application Profile (Vetadata) [22] developed by the Australian Flexible Learning Framework and adopted by the LORN Web Repository (http://lorn.flexiblelearning.net.au).
- The DET Learning Resource Metadata Application Profile [24] developed by the Department of Education and Training of New South Wales in...
TABLE 1
Modification Types of Existing LOM APs

<table>
<thead>
<tr>
<th>Modification Types</th>
<th>CELEBRATE</th>
<th>LRE</th>
<th>UK-LOM Core</th>
<th>JO-RUM</th>
<th>VETADATA</th>
<th>ANZ-LOM</th>
<th>DET-LOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Selection of data elements</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2. Size &amp; smallest permitted maximum</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3. Data elements from multiple namespaces</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>4. Adding local data elements</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>5. Obligation of data elements</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>6. Value space</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>7. Relationship &amp; dependency</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>8. Data type profiling</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>9. Application profile binding</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

On the other hand, none of the examined LOM APs define data elements from multiple namespaces (step 3) nor new data types for specific metadata elements (step 8). Additionally, only two of them (namely, CELEBRATE and LRE) define new local data elements which are not included at the IEEE LOM Standard. The analysis of the modification types of existing LOM APs and their comparison demonstrates that a LOM Application Profiling tool should be able to support with its functionalities at least seven out of nine modification types, so as to facilitate the production of existing LOM APs (Table 1).

3 EXISTING TOOLS FOR DEVELOPMENT AND MANAGEMENT OF IEEE LOM APPLICATION PROFILES

During the last years, despite the widespread development of LOM APs only a limited number of software tools facilitating the process of LOM Application Profiling have been developed. This is due to the fact that the LOM AP development task is often assigned to technical developers, who do not use special software tools but simple XML editors, so as to accomplish this task. Nevertheless, LOM Application Profiling tools bare the potential to facilitate their users in developing a LOM AP following the steps of IMS GLC and CEN/ISSS. Such existing tools are the IMS SchemaProf [25] and the eMAP [26].

eMAP Tool [26] is an open source stand alone tool targeting non-XML experienced users. Its main functionalities include: 1) the production of new LOM APs partially following the steps of IMS GLC and CEN/ISSS (namely, only four out of nine steps are followed) and 2) editing of LOM APs (produced by the tool) by visualizing the metadata elements in a tree structure and grouping them according to the IEEE LOM Standard categories.

IMS SchemaProf Tool [25] is a stand-alone tool developed in the framework of the Project TELCERT (http://www.opengroup.org/telcert). It is included in a suite of tools that support the process of application profiling in learning technologies. IMS SchemaProf is targeting XML experienced users and its main functionalities include: 1) the production of new LOM APs following all steps of IMS GLC and CEN/ISSS (namely, only four out of nine steps are followed) and 2) editing of LOM APs (produced by the tool) by visualizing the metadata elements in a tree structure and applying modifications, and 3) the exportation of a LOM AP as an XML Schema (xsd file), which means that the produced LOM AP can be edited and reused by the other similar tools or simple XML editors.

In order to be able to compare the existing tools for developing and managing LOM APs, we define a comparison grid, which is based on specific requirements that such a tool should meet. The first set of requirements that a LOM Application Profiling Tool should meet is derived directly from the guidelines that IMS GLC and CEN/ISSS have proposed. As we mentioned in Section 2.2, a LOM Application Profiling Tool should support at least seven out of nine guidelines, so as to facilitate the production of the existing widely used LOM APs (Table 1). However, it is important to support also the remaining two guidelines, so as to be compatible with the full set of guidelines proposed.
by IMS GLC and CEN/ISSS. To this end the first set of requirements (corresponding to the nine steps of the IMS GLC and the CEN/ISSS Guidelines, presented in Section 2.1) can be summarized below:

- **Requirement 1.** Capability to select the IEEE LOM metadata elements which will be used for the development of a new AP (addressing Step 1).
- **Requirement 2.** Capability to define the minimum and maximum occurrence of the selected IEEE LOM metadata elements in the IEEE LOM metadata instance of the developed AP (addressing Step 2).
- **Requirement 3.** Capability to select metadata elements from other metadata schemas (not only IEEE LOM) and to include them to a new AP (addressing Step 3).
- **Requirement 4.** Capability to include to a new AP, metadata elements which are not included at the IEEE LOM metadata schema (addressing Step 4).
- **Requirement 5.** Capability to define to a new AP the mandatory, the recommended, and the optional metadata elements (addressing Step 5).
- **Requirement 6.** Capability to define the set of values that a metadata element of a new AP shall derive its values from (addressing Step 6).
- **Requirement 7.** Capability to define relationships, as well as, dependencies between the metadata elements of a new AP (addressing Step 7).
- **Requirement 8.** Capability to define the data types of the metadata elements of a new AP (addressing Step 8).
- **Requirement 9.** Capability to produce and export the AP binding using the XML language (in the form of an XML Schema) (addressing Step 9).

The second set of requirements that a LOM Application Profiling Tool should meet is derived from 1) interoperability issues, 2) widespread availability issues, and 3) lack of XML programming competences of its end users. The second set of requirements is summarized below:

- **Requirement 10.** Capability to produce new LOM APs, which can be interoperable with other tools such as educational metadata editors. This is very important because the produced LOM APs should not be isolated from those tools.
- **Requirement 11.** Capability to author educational metadata instances based on the produced LOM APs. This is also an important requirement because the user of the LOM Application Profiling Tool should not be needed to use a separate educational metadata editor, so as to author educational metadata instances based on the various LOM Application Profiles developed.
- **Requirement 12.** Capability to be used by non-XML experienced users. This requirement is making the LOM Application Profiling process accessible to users without XML programming competences.
- **Requirement 13.** Capability to be accessible via a web browser. This requirement maximizes the potential of sharing and reusing LOM APs between different users and different communities of users.

Table 2 compares existing LOM Application Profiling tools according to the requirements that these tools should meet. The requirements are divided into two main categories, in accordance with the requirements’ categories previously described.

As we can notice from Table 2, it is clear that the eMAP Tool fails to meet most of the requirements derived by IMS GLC and CEN/ISSS Guidelines, whereas the IMS SchemaProf Tool fully supports these Guidelines. On the other hand, the eMAP Tool does not require from its users to be experienced in XML language, whereas the IMS SchemaProf Tool requires from its users adequate knowledge of XML language. Moreover, it should be noted that the eMAP Tool provides the capability to its users to author metadata instances of a LOM AP, whereas the IMS SchemaProf Tool does not offer this capability. Finally, both tools are stand alone and they are not accessible via a web browser.

It is evident that existing tools come short into meeting all the anticipated requirements of a LOM Application Profiling tool. Therefore, in this paper we propose a new tool namely, ASK-LOM-AP, which is web based and fully supports the above-mentioned requirements.
ASK-LOM-AP is an open source web-based tool fully supporting the process of developing and managing LOM APs. It also incorporates the ability of educational metadata authoring based on a produced LOM AP. The ASK-LOM-AP Tool is addressing non-XML experienced users, who are familiar with the metadata elements and the structure of IEEE LOM Standard but they might have limited knowledge about the standard process (proposed by IMS GLC and CEN/ISSS) for developing LOM APs. The ASK-LOM-AP Tool provides its users with appropriate step-by-step wizards, which facilitate them in the process of LOM Application Profiling, as well as in the process of educational metadata authoring based on the developed LOM APs. Fig. 1 presents an overview of ASK-LOM-AP modules.

As shown in Fig. 1, the lowest level includes XML Native Databases, which implement the Registry of LOM APs and the various repositories of metadata instances that are produced based on the developed LOM APs. The lower level module (namely, the Repositories Manager) provides access to the XML databases and includes all the necessary procedures for reading and writing to them. The next level includes the following modules: 1) the LOM Application Profile Authoring Engine, which includes all functionalities relating to storage, search, and retrieval of LOM APs, as well as the functionality for the creation of the Application Profile Binding (that is the XML Schema of the produced LOM AP), 2) the Metadata Authoring Engine, which includes all the functionalities for authoring educational metadata instances based on different LOM APs. Finally, the top level of the system is the web Interface Manager Module, which is responsible for the visualization of LOM APs and the interface with the end user.

The main functionalities of ASK-LOM-AP can be summarized as follows:

- **Create New LOM Application Profile.** The user has the capability to use a step-by-step wizard following the IMS GLC and CEN/ISSS Guidelines for the development of LOM APs and built his/her LOM AP customized to his/her specific needs and requirements. This functionality guides non-XML experienced users (through the use of the step-by-step wizard) to create easily LOM APs.

- **Browse and Edit Existing LOM Application Profiles.** The user has the capability to browse LOM APs that has been developed by other users of the tool and edit them by applying changes to the metadata elements and value space of the elements. Moreover, the modified LOM AP can be saved to the LOM APs Registry of the tool for future use. This functionality facilitates collaborative development of LOM APs from the various users of the tool.

- **Export the XML Schema of a Developed LOM Application Profile.** The user has the capability to export the XML Schema of a LOM AP with all the modifications, in comparison with the base schema of the IEEE LOM Standard and import it to other educational metadata authoring tools. This functionality enables the interoperability of the tool with other software tools that can import LOM APs such as IMS SchemaProf.

- **Author Educational Metadata based on Existing LOM Application Profile.** The user has the capability to use a step-by-step wizard and author educational metadata instances of a LOM AP stored in the tool. Moreover, the educational metadata instances could be exported in XML format and imported to web-based Repositories of Learning Objects Metadata. This functionality facilitates the interoperability of the tool with web-based repositories or software tools that are compatible with IEEE LOM Standard.

Next, we present two scenarios of ASK-LOM-AP use, so as to demonstrate how ASK-LOM-AP meets the requirements identified in Section 3.

### 4.1 Scenario 1: Develop a New LOM Application Profile

The scope of this scenario of use is to present the process of developing a new application profile of the IEEE LOM Standard toward meeting Requirements 1 to 10, as well as Requirements 12 to 13.

ASK-LOM-AP starts from a web browser (meeting requirement 13) and the process of developing a new LOM AP consists of a five steps wizard, which guides the end user to develop the new LOM AP (meeting requirement 12). More specifically, during the first step the user can select the metadata elements that will be included in the new LOM AP (meeting requirements 1, 3, and 4). Fig. 2 presents the first step of the wizard.

During the second step the user can define the obligation (mandatory, optional, and recommended elements) and the

multiplicity of the selected metadata elements of the new LOM AP (meeting requirements 2 and 5). Fig. 3 presents the second step of the wizard.

During the third step the user can define the text length and the predefined value for a metadata element, as well as relationships and dependencies between the metadata elements of the new LOM AP (meeting requirements 7 and 8). Figs. 4 and 5 present the third step of the wizard.

During the fourth step the user can define the set of values that a metadata element of the new LOM AP shall derive its values from (meeting requirement 6). Fig. 6 presents the fourth step of the wizard.

During the final step the user can save the new LOM AP to the Application Profiles Registry of the tool with an appropriate title and description. Additionally, the user can export the new LOM AP as an XML Schema (xsd file) conformant with the XML Schema of the IEEE LOM Standard (meeting requirement 9). Fig. 7 depicts the developed LOM AP in XML Schema format.

4.2 Scenario 2: Author an Educational Metadata Record Based on the LOM Application Profile Developed in Scenario 1

The scope of this scenario of use is to present the process of authoring an educational metadata record based on a LOM Application Profile that has been previously developed with the ASK-LOM-AP Tool toward meeting Requirements 11 to 13.

In this scenario of use, the user can select a LOM AP from those that are stored in the Application Profile Registry of the tool and initiate the process of authoring educational metadata based on the selected LOM AP (meeting requirement 11). Fig. 8 depicts the available LOM APs that are stored in the tool and they can be selected by the user for authoring educational metadata. More
precisely, the user can see the list of LOM APs that are stored in the LOM AP registry of the tool and select a LOM AP based on its available description.

Next, the user is presented with a step-by-step wizard, to support authoring of educational metadata based on the selected LOM AP (meeting requirement 13). The steps of the wizard correspond to the metadata elements categories of the IEEE LOM Standard, which are included in the selected LOM AP. Additionally, the text boxes of the form of the Wizard have different colors that correspond to the obligation of each metadata element of the LOM AP. More specifically, the green frame of the text boxes indicates optional metadata elements, the orange frame indicates mandatory metadata elements, and the yellow frame indicates recommended metadata elements. Fig. 9 presents the wizard for educational metadata authoring.

4.3 Technical Validation

In order to validate the LOM APs produced by the ASK-LOM-AP (Scenario of Use 1), we exported them as XML Schemas and we checked their validity with a well-established XML Editor such as XML Spy (http://www.altova.com/xmlspy.html). The XML Schemas of all the developed LOM APs were syntactically correct and conformant with the XML Schema of the IEEE LOM Standard. More specifically, LOM APs with extended metadata elements, modifications to the LOM vocabularies or data types were validated against LOM loose XML Schema, whereas all other LOM APs were validated against LOM Strict XML Schema. Additionally, we checked the interoperability of the produced LOM AP with other LOM Application Profiling Tools and more specifically with the IMS SchemaProf (described in Section 3). The XML Schemas of the LOM APs were imported successfully to the IMS SchemaProf Tool (meeting requirement 10). The same process was repeated also with the XML metadata records produced by the ASK-LOM-AP (Scenario of Use 2) and the results were also successful.

5 Evaluation

In this section, we present an experiment of using ASK-LOM-AP for the development of a LOM Application Profile. The main objective that we aim to address through this experiment is to measure the difference in user satisfaction between ASK-LOM-AP and other tools for developing LOM Application Profiles following the standard process described in Section 2.1. The evaluation method we have used is the method of survey [28]. Surveys are appropriate evaluation methods for measuring the attitudes and the opinions of users [29]. Thus, we consider this evaluation method suitable for our evaluation objective.

5.1 Participants

The study was conducted with 42 MSc students during their third semester of studies as a workshop which was presented in the MSc Course on e-Learning at the Department of Digital Systems of the University of Piraeus, Greece. The students participated in two different workshops that lasted three hours each.
During the first workshop the participants were asked to develop a predefined LOM Application Profile (namely, the Learning Resource Exchange Application Profile [14], which was described in Section 2.2) by using IMS SchemaProf Tool.

During the second workshop participants were asked to develop the same LOM Application Profile (as in the previous workshop) by using ASK-LOM-AP Tool. It should be also mentioned that the other existing tool for developing and managing LOM APs, namely the eMAP Tool, was not included in this experiment, since it does not fully meet the requirements derived by IMS GLC and CEN/ISSS Guidelines and consequently participants would have not been able to apply all the modifications needed for the development of the predefined LOM AP.

All participants were familiar with the concept of educational metadata, the structure, and the metadata elements of the IEEE LOM Standard, as well as with the concept of a LOM Application Profile from the previous MSc Courses. However, none of them had previous experience with an LOM Application Profiling Tool.

Another important element of participants' background profile that is worth to mention is their experience related with the XML structure and its syntax. Table 3 presents the distribution of the participants based on their previous knowledge related with XML structure and its syntax.

As we can notice from Table 3 the majority of the participants were non-XML experienced users, that is, three out of five participants had no previous experience with XML language.

5.2 Workshop Setup

The two evaluation workshops followed a similar procedure, their only difference was related with the software tools introduced and used. For the first workshop, IMS SchemaProf was used and for the second workshop, ASK-LOM-AP was used.

LOM Application Profiling Tool Introduction. Each workshop started with a demonstration of the LOM Application Profiling Tool to be used by the participants. The main objective of the demonstration was to familiarize participants with the functionalities of both tools, and to provide guidance for the subsequent hands-on LOM AP development task. The demonstration took the form of a 45-minute presentation supported with slides including 1) a brief introduction of each tool’s functionalities and guidelines for using them during the LOM AP development task and 2) an example of developing a LOM AP.

LOM AP Development Task. Next, each participant was assigned the task of developing the predefined LOM AP using the corresponding software tool and without any further assistance. The predefined LOM AP that was given to the participants was the LRE Application Profile [14] (participants were already familiar with this LOM AP from previous MSc Courses) and it was selected as one with many modification types applied to the IEEE LOM Standard compared with other LOM APs (discussed in Section 2.2). Our intention was to ask the participants to develop a rather complex LOM AP, so as to ensure that the participants had to perform more than a simple transfer of identical actions from the example to the task. The LRE Application Profile was handed to the participants as a document describing in details the modification types that must be applied to the IEEE LOM Standard, in order to produce the LRE Application Profile. During the development of the given LOM AP, the participants followed the nine (9) steps proposed by IMS GLC and CEN/ISSS for the development of LOM APs, as described in Section 2.1.

Post Task Questionnaire. After the LOM AP development task was completed, it was assessed how many participants were able to successfully complete the IEEE LOM development task by using each tool and we recorded it according to their previous knowledge about XML language. Table 4 presents the distribution of the participants that managed to complete successfully the LOM Application Profile Development Task.
complete successfully the LOM Application Profile development task.

As we can notice from Table 4, all participants that were XML experienced were able to successfully complete the LOM Application Profile development task with both tools. This was expected since IMS SchemaProf is targeting XML experienced users and ASK-LOM-AP is targeting non-XML experienced users. On the other hand, only five out of 25 (20 percent) non-XML experienced participants were able to successfully complete the LOM development task with IMS SchemaProf, whereas all non-XML experienced participants were able to successfully complete the LOM AP development task with ASK-LOM-AP. The results from the use of IMS SchemaProf were expected since IMS SchemaProf is targeting XML experienced users and it is quite difficult to be used by non-XML experience users. On the other hand, the results from the use of ASK-LOM-AP provided us with solid indications that ASK-LOM-AP can clearly facilitate the process of LOM Application Profiling for non-XML experienced users.

Next, for these participants that completed successfully the Application Profile development task we assessed their satisfaction for each tool for different categories. These categories were selected from the different requirements that a LOM Application Profiling Tool should meet, as described in Section 3.

As we can notice from Table 5 and Fig. 10, the users’ satisfaction mean related with ASK-LOM-AP is higher than users’ satisfaction mean related with IMS SchemaProf for all applicable satisfaction categories. Moreover, the ASK-LOM-AP standard deviation (Table 5) indicates that the individual users’ responses are close to the users’ satisfaction mean proving its validity for each category of the questionnaire. This clearly indicates a comparative advantage of ASK-LOM-AP in the process of developing LOM APs against other existing tools.

Apart from the results presented in Table 5, Table 6 presents users’ satisfaction results for XML experienced participants, that is 17 participants in total. The aim of this further analysis was to exclude non-XML experienced users, who might be negative biased with the level of difficulty of IMS SchemaProf and focus only on XML-experienced users, who did not face difficulties in completing the LOM Application Profile development task with both tools.

As we can notice from Table 6 and Fig. 11, there were only slight variations to the users’ satisfaction mean for ASK-LOM-AP. On the other hand, there was a slight increase of users’ satisfaction mean for IMS SchemaProf. This increment

<table>
<thead>
<tr>
<th>Nr</th>
<th>Categories</th>
<th>IMS SchemaProf - Mean (N=22)</th>
<th>IMS SchemaProf - Standard Deviation (N=22)</th>
<th>ASK-LOM-AP - Mean (N=42)</th>
<th>ASK-LOM-AP - Standard Deviation (N=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy to select metadata data elements</td>
<td>3.42</td>
<td>0.86</td>
<td>4.43</td>
<td>0.28</td>
</tr>
<tr>
<td>2</td>
<td>Easy to define size and smallest permitted maximum</td>
<td>3.35</td>
<td>1.09</td>
<td>4.48</td>
<td>0.29</td>
</tr>
<tr>
<td>3</td>
<td>Easy to select metadata elements from multiple namespaces</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>Easy to add local metadata elements</td>
<td>1.91</td>
<td>0.67</td>
<td>4.61</td>
<td>0.27</td>
</tr>
<tr>
<td>5</td>
<td>Easy to define obligation of metadata elements</td>
<td>3.57</td>
<td>0.92</td>
<td>4.53</td>
<td>0.30</td>
</tr>
<tr>
<td>6</td>
<td>Easy to define the value space of metadata elements</td>
<td>3.42</td>
<td>1.14</td>
<td>4.60</td>
<td>0.30</td>
</tr>
<tr>
<td>7</td>
<td>Easy to define relationship and dependency</td>
<td>3.47</td>
<td>1.11</td>
<td>4.52</td>
<td>0.27</td>
</tr>
<tr>
<td>8</td>
<td>Easy to define data types of the metadata elements</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>Easy to produce and export the AP binding</td>
<td>3.45</td>
<td>1.07</td>
<td>4.47</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Fig. 10. Representation of users’ satisfaction between IMS SchemaProf and ASK-LOM-AP.
did not affect the overall difference of users’ satisfaction between ASK-LOM-AP and IMS SchemaProf, providing us with an indication that ASK-LOM-AP can facilitate the process of LOM Application Profiling for XML experienced users, too. This is enhanced also by the ASK-LOM-AP standard deviation, which indicates the validity of users’ satisfaction mean for each category of the questionnaire.

### 6 Conclusions—Future Work

Despite the widespread use of LOM Application Profiles by various educational communities, it appears that limited attempts exist in the available literature for the development of technological tools that support the process of LOM Application Profiling. Nevertheless, such technological efforts are much needed in order to make the process of developing and managing LOM APs for different educational communities more accessible to either technical or nontechnical users such as e-Learning experts. In this paper, we presented ASK-LOM-AP, a web-based tool fully supporting the process of developing and IEEE LOM Application Profiles following the IMS GLC and CEN/ISSS Guidelines and addressing non-XML experienced users.

Evaluation results from the use of ASK-LOM-AP and its comparison with other LOM Application Profiling Tools provided us solid indications that ASK-LOM-AP:

- Has a comparative advantage on users’ satisfaction against other existing tools for developing LOM APs.
- Can facilitate the process of LOM Application Profiling and make them more accessible to users without XML programming competences, as well as to XML-experienced users.

Finally, it should be mentioned that ASK-LOM-AP has been used in the framework of the MW-TELL Project (http://www.mobile2learn.eu) enabling the development of LOM Application Profile for characterizing educational resources suitable for mobile assisted language learning, as well as in the framework of the OpenScienceResources Project (http://www.osrportal.eu) enabling the project community to develop a LOM Application Profile for characterizing educational resources suitable for informal science education. More than 10,000 LOM metadata records have been developed based on the aforementioned LOM APs and they have been validated successfully against the LOM loose XML schema. This process has provided us additional evidences about the validity of the LOM APs developed by ASK-LOM-AP.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Categories</th>
<th>IMS SchemaProf – Mean (N=17)</th>
<th>IMS SchemaProf – Standard Deviation (N=17)</th>
<th>ASK-LOM-AP – Mean (N=17)</th>
<th>ASK-LOM-AP – Standard Deviation (N=17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Easy to select metadata data elements</td>
<td>3.71</td>
<td>0.72</td>
<td>4.39</td>
<td>0.27</td>
</tr>
<tr>
<td>2</td>
<td>Easy to define size and smallest permitted maximum</td>
<td>3.74</td>
<td>0.86</td>
<td>4.47</td>
<td>0.25</td>
</tr>
<tr>
<td>3</td>
<td>Easy to select metadata elements from multiple namespaces</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>4</td>
<td>Easy to add local metadata elements</td>
<td>2.15</td>
<td>0.56</td>
<td>4.61</td>
<td>0.28</td>
</tr>
<tr>
<td>5</td>
<td>Easy to define obligation of metadata elements</td>
<td>3.92</td>
<td>0.69</td>
<td>4.55</td>
<td>0.32</td>
</tr>
<tr>
<td>6</td>
<td>Easy to define the value space of metadata elements</td>
<td>3.84</td>
<td>0.91</td>
<td>4.64</td>
<td>0.29</td>
</tr>
<tr>
<td>7</td>
<td>Easy to define relationship and dependency</td>
<td>3.86</td>
<td>0.86</td>
<td>4.51</td>
<td>0.30</td>
</tr>
<tr>
<td>8</td>
<td>Easy to define data types of the metadata elements</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>9</td>
<td>Easy to produce and export the AP binding</td>
<td>3.93</td>
<td>0.62</td>
<td>4.52</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Fig. 11. Representation of users; Satisfaction between IMS SchemaProf and ASK-LOM-AP for XML experienced users.
Future work includes: 1) the development of new functionalities that will enable the users of the tool to build communities around the different Application Profiles developed with ASK-LOM-AP offering their comments and experiences regarding the usage of each Application Profile, 2) the development of new functionalities that will facilitate collaboration and consensus building among the members of educational communities and e-learning experts for translating conceptual APIs into concrete representations and bindings. Finally, we aim to use the proposed tool in the framework of other projects for developing LOM APIs for different contexts of use. This process will enable us to collect more data about its usage, so as improve and enhance its current functionalities for developing LOM APs.

ACKNOWLEDGMENTS

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REFERENCES


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