2003

Customizable Learning Objects Metadata Authoring

Elena Valentina Malaxa
CUSTOMIZABLE
LEARNING OBJECTS METADATA AUTHORING

By

ELENA VALENTINA MALAXA

A Thesis submitted to the
Department of Computer Science
in partial fulfillment of
the requirements for the degree of
Master of Science

Degree Awarded:
Spring Semester, 2003
The members of the Committee approve the thesis of Elena Valentina Malaxa defended on April 29\textsuperscript{th}, 2003:

Ian Douglas  
Professor Directing Thesis

Robert C. Lacher  
Committee Member

Alec Yasinsac  
Committee Member

The Office of Graduate Studies has verified and approved the above named committee members.
To
my parents
Ion and Elena
whose love, support and sacrifices made my American dream possible
ACKNOWLEDGMENTS

First of all, I would like to thank Dr. Ian Douglas for giving me the opportunity to work at the Learning Systems Institute, and for facilitating my attendance at several international conferences. The knowledge I acquired from working there and from attending the conferences contributed to the final outcome of my studies. I also thank him for his support, guidance and confidence during this research. Thank you!

I would like to thank the members of my committee, Dr. Alec Yasinsac and Dr. Chris Lacher, for their intellectual contributions to my development as a scientist. I also thank Dr. Yasinsac for the open discussions we had several times. I also thank Dr. Lacher for teaching me real object-oriented programming and for his positive feedback. Thank you!

I would like to thank Dr. Hawkes for bringing the Women in Computer Science in the light. I also thank her for her care, understanding, and support. Thank you!

I would like to thank all those from Learning Systems Institute who generously donated their time and expertise to the case study portion of this thesis. Thank you!

I would like to thank Robert Norton for his hospitality and support during the writing of this thesis. Thank you!
TABLE OF CONTENTS

LIST OF TABLES ................................................................................................................... vii

LIST OF FIGURES ................................................................................................................ viii

LIST OF ABBREVIATIONS .................................................................................................... ix

ABSTRACT ............................................................................................................................. x

1. INTRODUCTION .............................................................................................................. 1
   1.1. Learning Objects and Metadata .............................................................................. 1
   1.2. Scope of the Study .................................................................................................... 2
   1.3. Background and Motivation ................................................................................... 3
   1.4. Research Process ..................................................................................................... 5

2. METADATA THEORY AND TOOLS ............................................................................. 6
   2.1. Learning Objects Metadata Standards ................................................................... 6
   2.2. Metadata Authoring Tools ..................................................................................... 7

3. FRAMEWORK FOR CUSTOMIZABLE METADATA AUTHORING ........................... 15
   3.1. How the Framework was reached ........................................................................ 15
   3.2. Metadata Challenges .............................................................................................. 19
   3.3. Elements of the Framework .................................................................................. 20

4. CLOMAT PROTOTYPE .................................................................................................. 23
   4.1. Prototype Overview ............................................................................................... 23
   4.2. CLOMAT Design Issues ....................................................................................... 24
   4.3. CLOMAT Features ............................................................................................... 33
   4.4. CLOMAT Evaluation ............................................................................................. 41

5. CONCLUSIONS .............................................................................................................. 47

6. FUTURE WORK ............................................................................................................. 49

APPENDICES ...................................................................................................................... 50
# LIST OF TABLES

Table 1: Metadata Authoring Tools Comparison ................................................................. 14
Table 2: Three-Layer Architecture ..................................................................................... 27
Table 3: Example of elements from the SCORM (SCORM, 2001) ........................................ 51
LIST OF FIGURES

Figure 1. Sun Microsystems’ Meta-data Developers Toolkit ....................................................... 8
Figure 2. ADL’s SCORM Meta-Data Generator Version 1.1 ....................................................... 10
Figure 3. LOM Editor .................................................................................................................. 11
Figure 4. Reggie Metadata Editor ............................................................................................. 12
Figure 5. Dublin Core MetaBrowser ........................................................................................ 13
Figure 6. Main elements in the design of CLOMAT ................................................................. 24
Figure 7. Hierarchical view of metadata elements ..................................................................... 25
Figure 8. CLOMAT Meta-metadata model ................................................................................ 28
Figure 9. Algorithm to generate a new metadata model ........................................................... 29
Figure 10. vCard entity and its relationships ........................................................................... 31
Figure 11. vCard class .............................................................................................................. 32
Figure 12. Editing of a metadata element of type vCard .......................................................... 33
Figure 13. CLOMAT metadata model flexibility ...................................................................... 34
Figure 14. Metadata Models ..................................................................................................... 34
Figure 15. CLOMAT User Log In ............................................................................................ 35
Figure 16. CLOMAT Metadata Tree View Structure ............................................................... 36
Figure 17. CLOMAT External Standards Support ................................................................. 37
Figure 18. CLOMAT Multi-language Support ......................................................................... 38
Figure 19. CLOMAT View Accessibility .................................................................................. 39
Figure 20. CLOMAT Template-Driven Editing ....................................................................... 40
Figure 21. Copy of Informed Consent Form ............................................................................ 54
Figure 22. Copy of Human Subjects Approval Letter .............................................................. 55
# LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADL</td>
<td>Advanced Distributed Learning</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>ARIADNE</td>
<td>Alliance of Remote Instructional Authoring and Distribution Networks for Europe</td>
</tr>
<tr>
<td>ATM</td>
<td>Automatic Teller Machine</td>
</tr>
<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CETIS</td>
<td>Centre for Educational Technology Interoperability Standards</td>
</tr>
<tr>
<td>CLOMAT</td>
<td>Customizable Learning Objects Metadata Authoring Tool</td>
</tr>
<tr>
<td>DC</td>
<td>Dublin Core</td>
</tr>
<tr>
<td>FSU</td>
<td>Florida State University</td>
</tr>
<tr>
<td>HTML</td>
<td>HyperText Markup Language</td>
</tr>
<tr>
<td>IBM</td>
<td>International Business Machines</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>IMS</td>
<td>Instructional Management Systems</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>LMS</td>
<td>Learning Management System</td>
</tr>
<tr>
<td>LOM</td>
<td>Learning Object Metadata</td>
</tr>
<tr>
<td>LTSC</td>
<td>Learning Technology Standards Committee</td>
</tr>
<tr>
<td>MIME</td>
<td>Multipurpose Internet Mail Extensions</td>
</tr>
<tr>
<td>SCO</td>
<td>Sharable Content Object</td>
</tr>
<tr>
<td>SCORM</td>
<td>Sharable Content Object Reference Model</td>
</tr>
<tr>
<td>URI</td>
<td>Universal Resource Identifier</td>
</tr>
<tr>
<td>URL</td>
<td>Universal Resource Locator</td>
</tr>
<tr>
<td>XML</td>
<td>Extensible Markup Language</td>
</tr>
</tbody>
</table>
ABSTRACT

Metadata is an important aspect in learning resource discovery, reuse of learning resources, within-collection organization of learning resources, retrieval of non-textual media, and interoperability among learning resources. This paper presents an analysis of the challenges in metadata creation field and defines a framework for customizable metadata authoring. Also it presents the CLOMAT prototype (Customizable Learning Objects Metadata Authoring Tool) which was build as a proof-of-concept for the framework presented in this paper. The research concludes with the evaluation results of the prototype. In particular, the paper explores issues associated with the application of standards, the properties of the learning objects, the needs of the users involved in the creation of metadata, the problems that arise in practice. These issues help to characterize the problem space of metadata creation and to explore the possibilities for improvement. As research integrating different technology aspects of metadata management is still in its infancy, I consider this and similar work as early framework for learning object metadata creation and management. These frameworks form the basis for more detailed approaches to follow.
1. INTRODUCTION

1.1. Learning Objects and Metadata

This research has its roots in learning objects and learning objects metadata theory. The following paragraphs represent a short introduction to these issues and set the stage for the definition of the scope of this research. In-depth discussions on the topics of learning objects and metadata come along in the subsequent chapters.

“There is a growing need for new kind of learning and teaching as the technology advances rapidly and the skills and competencies required in the working life become more demanding and increasingly dynamic”. (Poyry, Pelto-Aho, & Puustjarvi, 2002) In the recent years the idea of e-learning has been becoming more and more popular in many countries all over the world as an answer to the on-demand learning problem. E-learning technology based on learning objects currently leads the technology in the next generation of delivery of learning content due to its generality, adaptability, and flexibility.

The most widely used definition of learning objects is given by IEEE-Learning Technology Standards Committee: “any entity, digital or non-digital, which can be used, re-used or referenced during technology-supported learning.” (IEEE-LTSC, 2003)

Also, by their definition, learning objects:

- are self-contained - each learning object can be used independently,
- are reusable - a single learning object may be used in multiple contexts for multiple purposes,
- can be aggregated - learning objects can be grouped into larger collections of content, including traditional course structures, and
- are tagged with metadata - every learning object has descriptive information allowing it to be easily found by a search.

Metadata is an emerging technology that will enable the sharing and exchange of learning objects across any technology-supported systems, including Web browsers, cell phones, and personal digital assistants. Metadata, generally defined as structured data about data, is necessary for efficient learning object discovery and reuse. In the context of learning objects, metadata describes to the outside world the purpose the learning object serves, the way to access and activate the object across the internet, and the way to use it in the context of the desired knowledge.
1.2. Scope of the Study

Learning resource discovery, use-based retrieval and reuse of learning resources, within-collection organization of learning resources, retrieval of non-textual media, and interoperability among learning resources all benefit from the availability of human-created metadata such as keywords, description, educational aspects, classifications as opposed to automatically-generated metadata such as date of creation or size of the resource. Within the challenges to human-created metadata noted in the literature are the potentially high cost of production in terms of human effort, time, money and the challenges related to errors and inconsistency in metadata assigned to resources. (Geisler, Giersch, McArthur, & McClelland, 2002; Marshall, 1998)

The main emphasis of this thesis is on creation, and management of human-created metadata for learning objects, which along this thesis is referred as metadata. This work analyzes the relevant aspects of metadata creation starting from the premises that the learning objects metadata sphere is an evolving field and organizations should be able to customize their metadata creation according to ever changing standards and their internal needs; “What is proposed today often becomes a standard tomorrow and what is a standard today often becomes defunct tomorrow”.

At a more detailed level, the thesis presents and discusses some of the learning objects metadata standards and process-related challenges that are likely to appear within the metadata creation and management process. The work also aims to set a framework for potential solutions to these challenges. In addition, this work aims to be a proof-of-concept and motivator for the idea that efficient and customized metadata creation has economic and technological justification, and that can be an integral part of the future of learning organizations. As research integrating different technology aspects of metadata management is still in its infancy, I consider this and similar work as early framework for learning object metadata creation and management. These frameworks form the basis for more detailed approaches to follow.

My personal goal was to concentrate on the big picture and raise the focal point from implementing a metadata standard into an authoring tool to the broader objective of assisting users with the metadata creation process by addressing the challenges they come across in their metadata development.

This study is based on my experience as a research assistant at FSU Learning Systems Institute, discussions, interviews, existing literature, case studies, prototype development and evaluation, analogies, and observations as the basis for understanding and explaining issues related to metadata creation.
1.3. Background and Motivation

Knowledge Age

There have been two decades of research that focused exclusively on data processing followed by two decades focused on information technology (IT). Data processing deals with the entities from the realities in which the data processing appears, whereas data are the attributes of those entities. Data represent, record, store, and maintain those attributes. Information is the result of analyzing, interpreting and reporting the data.

Information Technology does not in itself create knowledge or guarantees knowledge generation. Davenport and Prusak (Davenport & Prusak, 1997) describe the result of a study which showed that the introduction of Lotus Notes into an organization did not, by itself, produce change of information sharing and communication patterns. “Our fascination with technology has made us forget the key purpose of information: to inform people” (Davenport & Prusak, 1997). Recently, the IT world has been evolving from the Information to the Knowledge Age. There was a paradigm shift from data repositories to knowledge repositories, from processing data into meaningful patterns (thus, generating information) to facilitating the use of that information (thus, creating value-added information: knowledge). As cited by Spiegler, “knowledge – we know it when we use it”. (Spiegler, 2000) The emphasis on knowledge management recognizes the importance of knowing-that (data, information) along with knowing-how (skills, practices, processes, norms).

There were many business-related motivations behind the shift from the information perspective to the knowledge perspective. One of the most significant, the one that made the growth of the knowledge structures possible, was the need for skilled workers. It is a reality that need for skills is intensifying: 63% of employers think most of their employees have the skills needed to perform their jobs successfully today; 22% of employers think most of their employees have the skills needed for new initiatives today; only 9% of employers think their employees will have the skills needed to their jobs successfully for the next three years (Bloom, 2000). “Business is going to change more in the next ten years that it has in the last fifty” (Gates & Hemingway, 1999). An IBM white paper estimates that by 2005, 85% of all jobs in the United States will require skilled workers compared to only 20% of the jobs in 1950. In addition, 70% of today’s CEOs say that finding and retaining skilled workers is a serious problem (IBM, 2001).

Although technology cannot replace the skills and judgment of an experienced human worker, it can assist in the creation and transfer of knowledge by providing new methods, processes and tools of knowledge collection, exchange, storage and distribution. One way that organizations all around the world envisioned the creation and the transfer of knowledge is technology-enhanced learning. Studies show that 91% of employers believe that learning technologies are effective in developing employees’ skills and closing the skills gap (Bloom, 2000).
On-demand Society, On-demand Learning

We live in an on-demand society in which people feel the need to have more control over their time. “Sociologists in several countries have found that increasing education brings a sense of tension about time. We believe that we possess too little of it: that is a myth we live by now” (Gleick, 1999). Technology provides us with numerous opportunities for on-demand services and products in different aspects of our complex civilization: online shopping services, self-service and self-payment gas stations, ATM and Internet banking services. In this context, learning technologies are gravitating towards those solutions in which the learners are in control. Learners want to learn on the fly, just-in-time, when it is needed. Thus, new ways of enabling learning are evolving and new learning tools are being developed to meet the need for on-demand learning.

The Internet had a central influence on the learning environment, driving learning increasingly toward the online arena. The opportunities that the Internet offers for anywhere, anytime access are allowing for the creation of entirely new models for effective learning. The predictions reveal that the online creation and distribution of learning will grow at 83% a year over the next three years (IBM, 2001).

The new approaches to on-demand learning such as the Department of Defense Advanced Distributed Learning (ADL) Initiative’s Sharable Content Object Reference Model (SCORM) grow around the ideas of:

- **Reusability** - enhance reuse of learning resources for multiple purposes;
- **Accessibility** - make it easier to access learning;
- **Interoperability** - make it easier for learning resources to be used on different delivery systems and enables those systems to work together;
- **Durability** - make learning resources last longer as the underlying systems change.

Learning Objects

The **learning objects** technology (LTSC, 2003) currently leads the technology in the next generation of instructional design, development, and delivery of learning content due to its generality, adaptability, and scalability. SCORM describes “the creation of learning knowledge repositories where learning objects may be accumulated and cataloged for broad distribution and use. Once sharable learning objects exist and are commonly available, they can be assembled in real time, on demand, and then delivered to the learner as needed” (SCORM, 2001). These new learning technologies based on learning objects are more cost effective than traditional techniques, such as web-based training, due to flexibility and adaptability.

Learning objects let you have learning that is:

- just enough - if you need only part of a course, you can use just the learning objects you need,
- just in time - because learning objects are searchable, you can instantly find and take the content you need, and
• just for you - learning objects allow for easy customization of courses for a whole organization or even for each individual.

To facilitate the widespread adoption of the learning objects approach, the Learning Technology Standards Committee (LTSC) of the Institute of Electrical and Electronics Engineers (IEEE) formed in 1996 to develop and promote learning technology standards (IEEE-LTSC, 2003). Without such standards, universities, corporations, and other organizations around the world would have no way of assuring the interoperability of their learning technologies, specifically their learning objects. A similar project called the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) had already started with the financial support of the European Union Commission (ARIADNE, 2003). At the same time, another venture called the Instructional Management Systems (IMS) Project was just beginning in the United States (IMS, 2003). Each of these and other organizations (e.g., Advanced Distributed Learning (ADL, 2003)) began developing technical standards to support the broad deployment of learning objects.

The Dublin Core Metadata (DC, 2003) was the first internationally established online metadata model that supported a broad range of purposes and business models due to its simplicity, extensibility, and modularity. The first accepted metadata standard for learning objects was IEEE Learning Object Metadata (LOM, 2002) based on IMS Metadata and ARIADNE Metadata. The purpose of this standard is to facilitate search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors. The purpose is also to facilitate the sharing and exchange of learning objects, by enabling the development of catalogs and inventories while taking into account the diversity of cultural and lingual contexts in which the learning objects and their metadata will be exploited (LOM, 2002).

Many organizations began developing specifications based on LOM standard (e.g., SCORM already uses the IEEE’s standard for Learning Object Metadata) to support the broad deployment of learning objects. “With this broad industrial, governmental, and educational support, it would appear that learning objects may become the technology of choice in the emerging area of on-demand learning” (Wiley, 2000).

1.4. Research Process

This research began with the analysis of the present learning objects metadata standards and with a survey of the current state-of-the-practice metadata authoring tools. The challenges discovered in the metadata authoring process were taken into consideration in the definition of the theoretical framework for the CLOMAT (Customizable Learning Object Metadata Authoring Tool) prototype developed as a proof-of-concept of this research. Finally, this research evaluated whether or not CLOMAT addressed the challenges identified in a practical and economical manner.
2. METADATA THEORY AND TOOLS

2.1. Learning Objects Metadata Standards

The Greek term “meta”, literally translated to mean “about”, leads to the interpretation of “metadata” as “data about data”. But metadata is more than that; it is designed to deal critically with data at a more comprehensive level. Metadata is one of the biggest critical success factors to sharing, reusing and storing information cost-effectively.

In the context of on-demand learning based on learning objects, metadata is used by content creators, instructional designers, learners, tools and applications, search mechanisms and repositories in different ways and various purposes. As mentioned above in the introduction, one of the first and most common metadata schemes is Dublin Core Metadata (DC, 2003). Since Dublin Core is designed as metadata for describing any kind of resource, it doesn’t respond to the specific needs we encounter in describing learning objects. The Learning Objects Metadata Standard (LOM, 2002) by the Learning Technology Standards Committee (LTSC) of the IEEE was established as an extension of Dublin Core. Each learning object can now be described using a set of 80 metadata elements divided into nine categories responsible for general, life cycle, meta-metadata, educational, technical, educational, rights, relation, annotation, and classification aspects of the learning object. All these categories were necessary in order to address all anticipated requirements that learning objects metadata may have.

As it is stated in LOM specifications “the purpose of this multi-part metadata standard is to facilitate search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors or automated software processes. This multi-part standard also facilitates the sharing and exchange of learning objects, by enabling the development of catalogs and inventories while taking into account the diversity of cultural and lingual contexts in which the learning objects and their metadata are reused.” (LOM, 2002)

While the LOM standard defines the structure of a metadata instance for a learning object, it does not define how a learning management system will represent or use a metadata instance for a learning object.

A great amount of work in that area has been done by the IMS Global Learning Consortium, which has developed a XML binding of LOM (IMS, 2003). XML is well suited for the interchange of data, since XML documents are structured, self-describing, easily parsed and
can represent complex data. The IMS XML Binding defines an exchange format for metadata, focusing on the transfer of the metadata instances. The metadata might be contained in a database allowing an XML representation to be generated on demand for export to other tools and environments. Thus, an XML metadata record is a self-contained entity with a well-defined structure.

The newest and the most comprehensive initiative in the on-demand learning field is ADL’s Sharable Content Object Reference Model (SCORM). SCORM is a framework for on-demand learning incorporating different aspects of these emerging standards into one content model. By incorporating leading standards such as IEEE LOM standard and IMS XML binding, SCORM gained widespread acceptance and implementation among government, commercial, and academic circles. One of the main reasons SCORM has been so readily embraced is that nearly all of the guidelines have been adopted from the various industry segments it serves. There are 80 metadata elements in total and examples of them can be found in Appendix A at the end of this document.

The SCORM Metadata Model is also used for the present work. This thesis regards the SCORM Metadata Model as a reference model for the representation of learning objects metadata and a basis for discussion of the relevant aspects related to metadata since it seems to be the most mature model available. However, the prototype developed to support this study, is designed to be flexible and able to use different kinds of metadata models.

### 2.2. Metadata Authoring Tools

Standards are developed as means to ends. The end for learning metadata standards is being able to store, find, retrieve, exchange, use, and reuse learning content. Given that metadata is important and standards have been developed for it, what do we have to do now? What's the next step?

Robby Robson, the president of Eduworks Corporation, a consulting company specializing in e-learning products and standards, outlines his ideas about the next step in an article from e-Learning Magazine: “If you are producing content, it is your responsibility to describe it with metadata. If content is worth creating, then surely it is worth describing so it can be found. This means you need to at least understand the basics of metadata. But, equally important, you should insist on having tools that allow you to create and manage metadata with a minimum of effort on your part” (Robson, 2002).

Selecting and using a learning object metadata authoring tool is not a trivial task. During informal discussions I had with FSU Learning Systems Institute employees working with metadata editors, they confessed that they tried to use different implementations of metadata authoring tools but they ended up creating their own metadata editor that answered their needs for that particular project.
Starting with this observation I did my own research of metadata authoring tools to understand better the state of available tools and the problems they raise. The metadata authoring tools presented in this paper are a representative sample of currently available metadata editors and do not represent a comprehensive survey of all of them.

Sun Microsystems’ Developers Toolkit for creating IMS Learning Resource Compatible Metadata was released with big fanfare in October 1999. “The creation of this fully-functional toolkit demonstrates our commitment to supporting IMS's 'Open Standards' approach to platform independent interoperability of educational tools”, said Kim Jones, vice president, Global Education and Research, Sun Microsystems.

“This toolkit will help the educational community reap the benefits of Web top access to learning by allowing developers to create interoperable content using Java technology.”(Sun-Toolkit, 1999). The toolkit was advertised as a tool which simplifies and increases the speed at which developers can provide content that complies with the IMS Metadata Specification. The Java toolkit consists of an API, with code examples, and a Java servlet that generates an XML document that conforms to the IMS Metadata. The XML is based on data input by the user through the HTML form (Figure 1.)

![Figure 1. Sun Microsystems’ Meta-data Developers Toolkit](image-url)
Although this toolkit is free of charge and has valuable code and functionality behind it that can be used by other software developers to build on new or better tools, it remains useless for the community of learning designers and content creators due to the lack of upfront features that are believed to be important for everyday use of a tool:

- Easy to use interface;
- documentation or on-line help;
- reuse of metadata elements;
- vocabulary metadata management;
- standards enforcement.

So far, there have been no known efforts to further enhance or deploy the toolkit.

**ADL’s SCORM Compliant Metadata Generator (SCORM-Generator, 2000)** provides a web-based graphical user interface that allows the user to create SCORM metadata XML documents without having a working knowledge of XML. “The software is being provided to simplify and accelerate the process of writing ADL SCORM Version 1.0 conformant XML meta-data records” (SCORM-Generator, 2000). Although the generator has value due to its in-depth implementation of the SCORM Metadata Information Model, it loses some of its appeal upon a closer examination of technical and user-oriented issues. (Figure 2)

The technical limitations and problems of this metadata generator include:

- Not configurable;
- no flexible metadata schema;
- no attribute management;
- no vocabulary and standard formats management.

The user-oriented limitations of this metadata generator include: No reuse of metadata elements; instructions for editing metadata confusing to first-time users; no explanation for some restricted vocabularies and standard formats; inconsistency in presenting the information; confusing separators for multi-entry attributes; poor layout and organization of the forms; poor error and exception handling; limited help; inadequate feedback.

Despite the need for a good metadata authoring tool conformant to SCORM standards, in order to concentrate on the evolution of the SCORM, a decision has been made by ADL to indefinitely discontinue the development and maintenance of the Meta-data Generator, thus leaving the user community in a continuous search for a good tool.

Real-world examples of what users want from a SCORM compliant metadata editor are presented in detail in “3.1 How the framework was reached”.

9
LOM Editor (LOM-Editor, 2001) developed by Darmstadt University of Technology - Germany, and written in Java, is a standalone desktop application which includes superior abilities for editing metadata, such as: Tabular presentation of metadata categories; vocabulary management; multiple-language values management; metadata template generation to avoid the necessity to repeatedly enter the same data in multiple fields. (Figure 3)
Some of the drawbacks of this metadata authoring tool include: No help or documentation; omission of specific details of LOM Model (e.g. multiple-language values support for metadata elements); some standards like vCard (vCard, 1996) and ISO 8601 DateTime standard (ISO8601, 1998) are not supported in the representation of the metadata elements; storage of the metadata record is done in a database and there is no export option for the XML document.

In an article about learning objects in the field of Operations Research and Management Science (OR/MS) published by IEEE Learning Technology Journal, some of the features mentioned above about the LOM editor of the Technical University of Darmstadt are demonstrated in their project and also, to be able to exchange metadata with other applications, they included an XML-based import/export functionality as part of the LOM editor.(Kassanke & Steinacker, 2000)

Reggie Metadata Editor (Reggie, 1998) developed by Distributed Systems Technology Centre, a joint venture supported by the Australian Government's Cooperative Research Centres Program, enables easy creation of various forms of metadata with the one flexible program.
providing means of choosing an already defined schema from a list or importing a new XML schema. If the resource to be described has a web page, Reggie Metadata Editor allows entering the URL of the page. It will extract the metadata tags from the page and attempt to add them to the most appropriate fields for the chosen schema. It also has support for multi-language values and on-line help. (Figure 4)

Reggie played an important role as a tool capable of extracting metadata from given Web resources being reviewed and mentioned in several technical papers. (Candan, Liu, & Suvarna, 2001; Grissom et al., 1998; Knox, 1998)

Some of the downsides of this editor include: No metadata template facility which would speed metadata record creation; in trying to achieve generality supporting multiple schemas, it looses some specific aspects of the LOM model such as standards and metadata vocabulary support; metadata elements are not organized in their corresponding categories or any other structure, thus creating a poor form layout.
Generic Dublin Core MetaBrowser (Metabrowser, 2001) developed by Metabrowser Systems, Australia is a cataloging tool that works either by communicating with Metabrowser Server, by embedding metadata into a web page, by copying metadata output to the clipboard, or by sending metadata to a custom metadata repository. Although this authoring tool is too specific (learning objects are more diverse and they are not limited to web pages) and it doesn’t support the metadata model taken as reference by this thesis, it has some high-quality features that are merit comment in this review of metadata authoring tools.

The Dublin Core MetaBrowser generates DC Metadata for web pages which can be incorporated into the header of the web pages or saved as MetaBrowser server record into a custom database allowing peer review of those records. The Web page and the metadata are displayed at the same time. This is a simple idea but makes a huge difference in being able to see the data you are cataloging. Metabrowser also supports the use of customizable templates for simplified entry of metadata records. Another laudable idea is the representation of metadata in a hierarchical structure, which is an expressive metaphor for metadata models and allows for easy user navigation (Figure 5).

Figure 5. Dublin Core MetaBrowser
Table 1 summarizes some of the important similarities and differences among the surveyed metadata authoring tools:

<table>
<thead>
<tr>
<th>Feature</th>
<th>Sun’s Toolkit</th>
<th>SCORM Generator</th>
<th>LOM Editor</th>
<th>Reggie</th>
<th>MetaBrowser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible metadata schema</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Metadata templates</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Vocabulary management</td>
<td>No</td>
<td>Some</td>
<td>Yes</td>
<td>No</td>
<td>Some</td>
</tr>
<tr>
<td>Standards enforcement</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Some</td>
</tr>
<tr>
<td>Multi-language support</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Interface organization and navigation</td>
<td>Poor</td>
<td>Poor form layout</td>
<td>Tabular organization and navigation of metadata categories</td>
<td>Poor form layout</td>
<td>Hierarchical organization and navigation of metadata categories</td>
</tr>
<tr>
<td>Consistency in presenting information</td>
<td>Inconsistent</td>
<td>Inconsistent</td>
<td>Consistent</td>
<td>Consistent</td>
<td>Consistent</td>
</tr>
<tr>
<td>Feedback while editing</td>
<td>None</td>
<td>Some at the end of editing</td>
<td>None</td>
<td>Some at the end of editing</td>
<td>Yes</td>
</tr>
<tr>
<td>Documentation/Help</td>
<td>None</td>
<td>On-line help</td>
<td>None</td>
<td>None</td>
<td>Documentation</td>
</tr>
</tbody>
</table>
3. FRAMEWORK FOR CUSTOMIZABLE METADATA
AUTHORING

3.1. How the Framework was reached

Each of the tools surveyed in the previous chapter were developed as part of different projects and, in consequence, they can provide functionality to meet specific metadata requirements. The way the metadata is created affects the discoverability, the use and reuse of learning objects. Thus, in order to achieve generality, in order to facilitate learning objects metadata creation we have to gain a better understanding of the characteristics of learning objects and their metadata and the environment they operate. The following research was done to understand the issues involved in metadata creation and to abstract a theoretical framework that will stand as the basis for the prototype development.

Discussion Forums

Let’s take a look at what metadata creators expect from the authoring tools.

After ADL discontinued the development and maintenance of the SCORM Meta-data Generator, it started a discussion forum SCORM – compliant authoring tools to be shared with members of the ADL Community. The collaboration forum, entitled SCORM 3rd Party Tools, has been created to facilitate dissemination and discussion of these tools and utilities. (SCORM-Forum, 2003) Some extracts from this forum outlines the problems users experience (sic):

“I am looking for a tool that is external to the LMS. I work with developers who use multiple development tools and load courseware on multiple LMSs. My goal is to provide them with a tool that they can use to build the SCO metadata files. One of the ADL’s Co-Labs had a tool linked to their site, but I was unable to get it to work.” (February 27, 2003)

“Yes, I agreed that, because all the meta-data tools I found (like Aloha, IMS Package Editor, ImseVimse, LOM editor, PackageIt, Metadata Generator Pro, Manifest_Gen_Pro, Sun LOM Editor) did not met my needs.” (February 27, 2003)

“I'm looking for a tool that is flexible enough for me to choose which meta-data elements I need. The tool should be user friendly and guide a user to fill in all the value appropriately (remember the instructional designer is normally not technical sound). The
tool also need to be robust and fast enough because I used some of the Java-based tools which always crash and required different Java RTE version (This why I don't like Java). Is there already having a tool (or part of the LMS), something like that or do I need to build my own? :)” (March 21, 2003)

“I am also looking for such tools.” (April 02, 2003)

These comments act as a problem statement in themselves for the current situation in the metadata authoring domain.

**Previous Research**

Research efforts from different corners of the world describe other problems users have encountered.

Research done at the Institute of Information Systems, Hanover, Germany, found that most editors or viewers for metadata learning resources that use the LOM standard concentrate only on this standard and lack flexible structure to adapt to new standards. Also, they believe that the LOM standard, regardless of the very useful work that has been done in developing it, still has space for improvement in specifying important educational aspects of learning resources. Therefore they advise for flexible learning object metadata tools and that are able to use future metadata models. (Kunze, Brase, & Nejdl, 2002)

In a project done at University of Paderborn, Germany, several important facts can be found in the researchers’ reflections: “When tagging the source material with the LOM editor, an interesting experience turned out: Most elements of a lesson to be described apply the same basic metadata information, such as the name of the author, the rights of the lesson, or the targeted user group. It would hence be very useful to use a set of templates to tag the material. Templates can avoid the necessity to fill a lot of fields again and again, for example the owner fields, the necessary browser requirements, and many more”. (Kassanke & Steinacker, 2000; Saddik, Ghavam, Fischer, & Steinmetz, 2000)

Research done at the Helsinki University of Technology, Finland, developed a system, CUBER – virtual university, that supports learners in searching higher education courses from European universities. Metadata played a central role in the system. As the result of the CUBER’s metadata work a new and innovative metadata schema was developed. “Expertise from different fields of science was needed in order to solve the multidisciplinary problems; the team consisted of researchers from educational science, software engineering and computer science.” (Poyry et al., 2002) The researchers understood from the start that the process of specifying the appropriate metadata elements is problematic: the elements should be thorough enough to allow a wide range of searches, and on the other hand, entering the metadata elements should not overly burden the provider. The goals of the CUBER system, like to make it possible to compare learning materials from different providers, have had direct consequences for the metadata, generating extensions to LOM standard, which was the reference model taken into consideration. (Poyry et al., 2002)
A project developed at the University of North Carolina at Chapel Hill, United States deals with virtual collections for digital repositories. These virtual collections are made possible by exploiting advantages the digital environment inherently provides: objects can exist in multiple collections, collections with the same objects grouped in different ways can co-exist, collections can be created dynamically and exist for varying amounts of time. A similar project was the one done at Xerox Research Center regarding metadata creation for a mixed physical-digital collection. Metadata was also a key element in these projects and was used to describe the resources at the collection-level. One challenge to creating collection-level metadata noted was the potentially high cost of production. Human-created metadata is time-consuming, error-prone, costly to create, and likely to be inconsistent. Inconsistencies in metadata assigned to resources can arise due to variations in a given cataloger’s judgment over time and because different catalogers may make varied judgments in cataloging resources. Another challenge was that metadata standards often required adjustments based on the particular collection and its use. (Geisler et al., 2002; Marshall, 1998)

In a paper presented at the 2000 Australasian Conference in Computing Education, named “Metadata for smart multimedia learning objects”, the researchers outline that the current metadata standards for learning objects don’t take into consideration the dynamic aspect of certain learning objects such as animations, simulations, multimedia presentations which are named “smart learning objects”. From their perspective, the usage of dynamic learning objects, such as animations, requires a new sort of metadata, which must be dynamic in order to facilitate the I/O behavior of a dynamic learning object. For example, some interactive visualization can be used to illustrate different scenarios or different parts of an algorithm, depending on the parameters passed to them. The same learning object can hence be re-used in a different learning context, according to the way it is configured by parameters. They had to develop an extension of IEEE’s Learning Objects Metadata. The scheme of dynamic metadata followed the generic format of <property, values, value type>. They tagged the learning objects with a modified version of the LOM Editor, described in the previous chapter. (Saddik et al., 2000)

Also, a modified version of Learning Object Metadata Standard was used in a project within the context of a course-sequencing (Fischer, 2001) or for the courseware modules for combined learning and knowledge management environments(Grützner, Angkasaputra, & Pfahl, 2002). Different other efforts were done in the area of MPEG-7 metadata authoring and video metadata authoring and they shape the problems in that specific domain; raw video and image do not possess the same user-level information as text and thus are not directly searchable, reusable in the same way. Thus, different hierarchies of metadata were developed. (Ryu, Sohn, & Kim, 2002; Yao & Jin, 2001)

As one can see from all these previous research, the efforts for creating metadata were divergent but not opposite. There is a need for integrating different perspectives into one that will allow the creation of metadata for different purposes. Also the idea that entering complex metadata efficiently, accurately, and consistently can be confusing, time consuming and error-prone (Greer, 2002; Grissom et al., 1998; Kunze et al., 2002; Marshall, 1998) transpire from most of the papers.
Surveys and Case Studies

The Centre for Educational Technology Interoperability Standards (CETIS) for metadata and digital repositories from the United Kingdom has conducted a survey of learning resource metadata usage in the UK. (CETIS, 2002) The survey gives useful insights into how metadata is used and how the tools which generate metadata can be improved:

- The average number of tagged learning objects is high. It is in the range 100-9999 as opposed to the range 10-100 or >10000.
- Most of the people use metadata to describe single files (e.g. single image, webpage or simulation) or single lessons as opposed to more files or lessons at a time.
- Most of them make reference to the IMS / LOM / SCORM standard and they give reasons for doing so. E.g., promoting the reuse of learning content across multiple environments; desire to benefit from work which had been put into these initiatives instead of re-inventing the wheel.
- The proportion of schema used by content authors, shows that most of the projects don’t need all the elements: 25% of people use less than 25% of the metadata schema and 33% of people use between 25-50%, as opposed to 8% who use 50%-75% of the schema and 8% who use 75-99%.
- For the importance of categories of metadata elements to a particular project, most of the subjects felt that they can not make a judgment. Leaving out the majority of “don’t know” answers, the General category scored as essential and Educational and Technical categories scored as very important, while the Meta-metadata category scored as fairly important and the Annotation category scored as not important.

In order to provide more depth to the information about the experience while implementing metadata standards, some case studies were developed by the CETIS, UK. The aim of producing these case studies was to raise awareness of how and why people are implementing educational metadata specifications, and to provide some reflection on what problems were encountered and what worked well. (Barker & Ryan, 2003)

- The first case study was on a catalogue of electronic learning materials for engineering, with a resource description schema which mapped to the LOM model. There were approximately 500 learning resources from simple simulations lasting 10 minutes to multimedia course packs lasting several hours. They decided which fields would be necessary based on what the end user would require, and then mapped the elements similar to those in LOM model. The interface was custom designed and built so that data could be entered online. 37 metadata elements out of the 80 LOM elements were used to describe the learning objects metadata. Much work was done creating vocabularies that fitted their needs.

“There were several elements that caused some difficulties, especially since the cataloguers were neither the creators nor the target users of the resources: technical requirements - it is difficult to say what systems software will work with so there is a chance that people could be put off a resource which may work on their system; educational description – it requires specialist knowledge and is
difficult for cataloguers to be consistent; end user – sometimes it is difficult to classify a resource in terms of end user as it requires thinking about how it might be used. A lot of users considered main URL and general description to be completely sufficient for their purposes. Furthermore educational descriptions were considered to be subjective and maybe not so useful. The project team, however, doubt whether such a minimal approach would provide sufficient routes for resource discovery.”(Barker & Ryan, 2003)

The second case study built a repository of online learning material to support the delivery of learning content in the broad subject areas of engineering/manufacturing. There were approximately 2500 learning resources ranging from single images to complete documents. 25 metadata elements out of the 80 LOM elements were used to describe the learning objects’ metadata. The vocabularies for some metadata elements were changed to reflect the project requirements. The people who produce the learning resources were also responsible for tagging it with metadata. This gave them the opportunity to classify the resource themselves using guidelines provided.

“The difficulty with this process was making sure that the authors understand the purpose of the metadata and the methodology used to enter it. A balance had to be struck between getting high quality metadata and not going above the skill level of those entering the metadata. There were not enough best practice guidelines. The elements with definite values such as educational difficulty were considered to be more useful than descriptive elements, which were thought to be too subjective. The project team considers obtaining consistent metadata content to be a major difficulty.”(Barker & Ryan, 2003)

3.2. Metadata Challenges

Summarizing the challenges in metadata authoring field from all these reviews, research, case studies, and forum discussions, we have:

- **Evolving standards**

  According Darin Hartley, author of “On-Demand Learning”, learning solutions should change with standards: “Does your learning solution have to be in place for ages? If not, don’t build it for the ages. It can really change the way you design learning solutions in a positive way.”(Hartley & Cone, 2000)

- **Diversity of learning objects**
If the past the majority of learning objects were web pages or textual documents, the new trend is towards smart, dynamic learning objects such as video simulations, animations that require new metadata models.

- **Retaining higher discoverability for the learning objects**

  The value of the learning object goes up as its associated metadata increase in richness and completeness. But the greater amount of metadata and the higher discoverability of learning objects, the higher the cost of producing that metadata. (South & Monson, 2000)

- **Creating metadata for significantly higher numbers of learning objects**

  For example, a recently developed physical science online course, while consisting of only 34 lessons and approximately 350 web pages, contains over 1300 media objects, ranging from simulations to charts and diagrams. When tracking so many learning objects, the cost of creating high quality metadata for each object as well as the cost of storing and managing them becomes a significant issue. (South & Monson, 2000)

- **Accommodating the needs of content creators who are not metadata experts**

  Due to the large number of learning objects that have to be tagged with metadata, we’ll see more and more people who are not metadata experts involved in the metadata authoring process. Those people also have to be provided with the exact information, just-in-time, when it is needed.

- **Providing an interface that will allow users to efficiently meet their goals**

  Regardless of the skill level of metadata creators, whether experts or not, the interface plays an important role in any computer related endeavor. Great functionality with a poor designed interface will remain unusable and unreachable.
  “If it is not compelling to the masses based on its obvious and high practical value (relevant), and if it is not easy for them to use, then do not expect it to catch on.”(Hodgins, 2000)

### 3.3. Elements of the Framework

The range of possible solutions to the above challenges is vast, extending far beyond the scope of this thesis and involving strategies from different research areas such as instructional design and domain modeling. My approach to metadata authoring comes from the technical side
of these challenges. While alone it cannot resolve all of the problems, it can have a significant impact on them.

The principle that guided my approach was to **meet existing needs while accommodating future changes**:

- **Flexible metadata schema**

  The possibility for a flexible metadata schema incorporated into a metadata authoring tool which would be extensible and flexible, a tool which would not be limited to a certain metadata standard or schema, but be open for arbitrary future developments. Ideas and resulting schemas would answer the challenge of evolving standards and diversity of learning objects.

- **Metadata schema views**

  The possibility for multiple views of the same metadata schema would allow users to select and display only those metadata elements necessary for the description of the learning objects for their particular context or project. Thus, they don’t have to be bounded to a strictly defined schema and they don’t have to “reinvent the wheel” by building a metadata schema from scratch.

- **Metadata templates**

  Metadata templates represent a great possible solution for the challenge of creating metadata for significantly higher numbers of learning objects. Users can use templates to store personal profile information (e.g. name, type of contribution), or specific information related to the learning objects (e.g. keywords, medium type, level of granularity, etc). Thus users do not have to reenter the same information for each learning object. Creating a template with \( m \) metadata elements already edited for a group of \( n \) learning objects reduces the cost of editing the metadata for those learning objects by \( m^*(n-1) \) times. If the grouping of the learning objects is optimal and \( m \) approaches the total number of metadata elements that schema has, the time for editing \( n \) learning objects approaches the time for editing one learning object.

- **Collaborative metadata editing**

  An editor which allows editing content online from anywhere in the world without additional client software, plug-ins or configuration represents a possibility for reducing the workload for metadata creators. For example, the design specification for a new learning object can be provided by the subject matter expert, the instructional designer can edit those metadata elements related to educational aspects of the learning objects, while the technical staff can take care of technical details such as the software needed to access the learning
resource or the size in bytes of the resource. In this way, the metadata can reach a higher level of richness, completeness, and accuracy.

- **On-the-fly, dynamic, contextual help**

Novice users often face many difficulties in mastering current highly interactive systems. Providing means for contextual help would allow users with different levels of proficiency in the metadata authoring process to be part of metadata creation and to produce accurate metadata. The contextual help allows the process and the concepts to be explained while the user carries the tasks. The contextual help follows-up the user activity and acts according to what they perform, thus permitting a better assimilation of the concepts or processes from the application they use. (Garcia, 2000)

- **Effective, well-organized interface**

Visual representations of metadata schemas, drop-down lists, controlled vocabularies, fill-in-the-blank fields have to be part of the effective interface that will allow the management of all kinds of metadata elements (e.g., simple, composed, range, multi-entry) in an organized way. The design techniques have to be based on global usability principles and guidelines (e.g. learnability, flexibility, familiarity, consistency, predictability, recoverability, etc.). For example, a poor layout and design of a form (one big form) can be avoided by breaking up the form into digestible, self-explanatory segments of information, which will provide the user with the adequate feedback for the state of the system while the task is gradually being accomplished.
4. CLOMAT PROTOTYPE

4.1. Prototype Overview

As it was stated in its scope, this thesis, besides outlining the learning objects metadata-related challenges and possibilities from a theoretical point of view, also proposes to provide a proof of concept for learning objects metadata construction as a critical factor for the next generation of learning and knowledge creation by integrating the new ideas of metadata management that take shape from the theoretical framework.

The present proof-of-concept prototype, Customizable Learning Objects Metadata Authoring Tool (CLOMAT) is a browser-based metadata editor which uses standard (e.g. SCORM model) and self-defined metadata schemas to represent the structure and meta-information of different learning objects. It is implemented in ASP.NET and C# and uses the .NET framework. It is connected to a SQL Database Server through web services which is used to store the metadata schemas and metadata elements' values. The metadata values can be exported to a XML file that can be stored in learning object repositories.

The CLOMAT prototype:
- demonstrates several techniques to overcome some of the main difficulties of authoring in this domain;
- points a user-centered way to a future in which everyone can be as comfortable editing metadata as they are today editing text;
- makes use of the latest standards that have a scalable architecture and permit integration with future tools.
- intends to make metadata editing easier, complete and accurate;

The design of the CLOMAT prototype is based on the framework described in the previous chapter and it has been affected by three main elements: metadata standards, user needs, and environment. (Figure 6) Metadata standards represent the present and future learning objects metadata standards in which the tool has to perform. User needs represent issues related to what users want, what characteristics are important to them in the context of editing learning objects metadata and in the context of their project. The environment represents the changes, the dynamics that might influence the metadata standards and the user needs such as the evolution of different types of learning objects or different business rules that apply to collections of learning objects. The Environment must be recognized as a factor in the management of metadata that must be reflected in design decisions.
Following is an in-depth description of the design issues and decisions that shaped the CLOMAT prototype.

### 4.2. CLOMAT Design Issues

#### The Tree Structure of Metadata

Humans intuitively use hierarchies to navigate through a multitude of elements. The family tree structure (grandparents, parents, and children) is a basic metaphor underlying many of the logical structures we use to structure information. (Walton & Vukovic, 2003) Concepts organized into hierarchies allow for different levels of detail. Hierarchies help to create summarizations of the more detailed concepts and to group concepts based on their relation to others. The use of a hierarchical decomposition of a classification problem allows for efficiencies in both learning and representation because each sub-problem is smaller than the original problem. (Dumais & Chen, 2000)

Most of the metadata model definitions, such as SCORM, are hierarchies. (Figure 7) At the top of the hierarchy is the "root" element. The root element contains many categories. A category contains metadata elements that refer to the same property of the learning objects such as: lifecycle, meta-metadata, technical, educational. A full description of these categories as they apply to SCORM can be found in Appendix A.
A category is itself a metadata element and contains additional metadata elements. A metadata element which contains additional elements is called “container”. Elements that do not contain any sub-elements are called "leaves."

Since hierarchical models are convenient for representing metadata consisting of many elements and sub elements and they also are very useful to navigate such collections of elements, the design decision to represent metadata models in a tree view structure was made. This was considered to simplify the mental models users have to build in order to understand the metadata conceptual model.

The meta-metadata model

Meta-metadata is an abstraction of metadata as metadata is an abstraction of the data. The meta-metadata model is seen in the present paper as a framework for modeling and extensibility of the metadata model.

As we could see from the discussion in the previous chapters, standards are developed as means to ends and metadata standards cannot work very well without a great deal of flexibility. One size cannot possibly fit all, and the developers of the metadata standards recognize this. The elements in the standards may determine what you can say about learning objects, but you get to decide how, how often, and in how many different ways you say it. For example, you can specify an English title, a French title, and a Chinese title for the same learning content; you can add your own lists of keywords for classifying instructional material; and you can refine an element like contributor so that you can better differentiate among types of contributors, e.g., primary versus secondary contributors.

To date, various standards bodies have been concerned primarily with the metadata elements and this is why we have today large standards with 80 metadata elements.
There has not been as much emphasis placed on **meta-metadata models as means of standardizing the types of metadata used and tracked by distinct functions that those metadata elements serve.**

In SCORM model, the meta-metadata model contains the following necessary pieces of information as they are used to describe the metadata model’s elements.

- **Number:** Hierarchical number within the metadata model.
- **Name:** Element name
- **Explanation:** Detailed description of the element
- **Multiplicity:** How many instances of the element are allowed within the immediate parent element. Possible values are: one and only one; one or more; zero or one; zero or more.
- **Data Type:** Whether the element’s value is textual, numerical or a date; and any constraints on its size and format. There are four general-purpose types used in the SCORM information model: **String Type**, **LangString Type**, **Date Type** and **Vocabulary Type**. A **string** represents string of characters. A **langstring** represents a string of characters which has associated a human language. **LangStrings** are a good way to support multi language environments. A **date** represents a date or time expressed as per ISO 8601 standard and a description of the date/time. A **vocabulary** represents a source for **langstring** items. For those elements that have a data type of a Vocabulary Type, additional information is provided on whether or not the vocabulary is a Restricted or Best Practice Vocabulary. Restricted indicates that the metadata element is restricted to the vocabulary entries listed. Best Practice indicates that the SCORM recommends, as best practice, to use the vocabulary entries listed.

Are these pieces of information sufficient to describe a meta-metadata model that will allow a flexible metadata schema? Studying in detail the type of metadata elements that are part of a metadata model, in particular SCORM, it is very easy to find generalizations due to the general-purpose types that restrict the model. For example, the entity element that is used to describe information about the people and organization is defined as being of **String Type** but there is a note saying that this element should be a vCard (vCard, 1996). The implications of such a definition of an element are reflected into the flexibility of the model and the tool that implements the model. Since the element is defined as being of **String Type**, the element has associated the behavior of that particular type. The extra behavior that is associated with a vCard has to be added through code within the tool for that particular element. Coding the behavior for each element of a model means that we hard code the model within the tool. But this is what we try to avoid. We want to represent different models within the same tool.

The idea of dynamic tools that represent flexible models has to be backed up by well-defined meta-metadata model. The CLOMAT prototype reflects this philosophy. Rather than starting with the individual metadata elements from the SCORM model and trying to represent them within the tool design started from the types of metadata elements and their behavior. Thus CLOMAT addresses specific functions for different types of metadata and establishes generic types as means of regulating the metadata types that should be tracked throughout these functions, regardless of the metadata elements defined as being of those types. The metadata
elements will be just instances of those metadata types inheriting their behavior. Table 2 represents the three-layer architecture of CLOMAT.

Table 2. Three-Layer Architecture

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M3 Meta-metadata model</td>
<td>Contains the structure (represented in the database), rules and specifications (represented in coded algorithm) for appropriate definitions for compliant metadata models. The meta-metadata model allows for representation of different models through the definition of individual elements of the metadata model along with the hierarchical structure within the elements that links the elements together.</td>
</tr>
<tr>
<td>M2 Metadata model</td>
<td>Is an instance of meta-metadata model. It contains the metadata elements and their behavior according with their types. The behavior comes from the rules and specifications defined in meta-metadata model.</td>
</tr>
<tr>
<td>M1 Data model</td>
<td>Is an instance of metadata model. It represents the user data from learning objects templates and records where the valid structure of such data is defined at the M2 level.</td>
</tr>
</tbody>
</table>

Thus, the meta-metadata model provides a rigorous infrastructure at a higher level of abstraction and furnishes an architectural basis for extension of metadata models. Figure 8 shows the meta-metadata model structure of CLOMAT as retrieved from SQL Server Database.

The algorithm that coded the generation of the new metadata models according with the meta-metadata model structure corresponding to the meta-metadata model structure Figure X. The algorithm ensures that any such a metadata model is a rooted tree.
Figure 8. CLOMAT Meta-metadata model
Figure 9. Algorithm to generate a new metadata model
The metadata types designed in CLOMAT are intended to be a proof-of-concept of how changing the focus from creating metadata models with many elements to creating meta-metadata models can provide a better design data that provides superior interaction with the development tools in order to provide flexible applications. The metadata types described by CLOMAT are those already defined by SCORM plus some extra metadata types which although, look like strings, but don’t behave like strings due to extra functionality such as:

- vCard Type – Virtual Electronic Business Card (vCard, 1996) defines the entities, people or organizations, that interact with the learning object or its metadata.
- MIME Type - Multipurpose Internet Mail Extension (MIME, 1996) defines the type of application associated with the learning object.
- URI Type - Uniform Resource Identifier (URI, 1993) define the syntax and semantics of formalized information for location and access of the learning resource.
- Language Type (ISO639) – String restricted to represent a human language. The Language Type permits linguistic diversity of both learning objects and the metadata instances that describe them.

As one can see, all four of these metadata types are standards in themselves and they have associated certain behavior. Treating them like strings means sacrificing some of their functionality. Who would like to type a vCard by hand, following its standard, while defining the metadata for a learning object? If we already have standards and there are also tools out there dealing with those standards, let’s make use of them.

The CLOMAT prototype design acknowledges that metadata standards must not ignore external standards, or those created by external organizations for the purposes of interoperable data exchange. Also, describing types of metadata that implement a certain behavior rather than instances of metadata facilitates processing the metadata elements at run-time. The better full-featured applications that manage the metadata types are built, the more flexible the metadata schemas that can be implemented.

The behavior of metadata types like the ones mentioned above along with the multiplicity types such as: “one and only one”, “zero or more”, zero or one”, “one or more” is also enclose in the meta-metadata model and defined as generic classes with certain functionality. When a metadata element is processed at run-time, the corresponding functionality is extracted and associated with the particular element, thus we don’t restrict the metadata models that one can define as long as they are in concordance with the meta-metadata model.

For example, in figure 10 is a database snapshot of vCard entity and its relationships with in the user entity and the metadata elements of type vCard that can use any vCard as user data.
Figure 10. vCard entity and its relationships
The functionality associated with vCard Type is represented in figure 11.

<table>
<thead>
<tr>
<th>vCard</th>
</tr>
</thead>
<tbody>
<tr>
<td>vCardName</td>
</tr>
<tr>
<td>vCardContent</td>
</tr>
<tr>
<td>vCardDescription</td>
</tr>
<tr>
<td>vCardVisibility</td>
</tr>
<tr>
<td>vCardFileName</td>
</tr>
<tr>
<td>+ImportVcard()</td>
</tr>
<tr>
<td>+OpenVcard()</td>
</tr>
<tr>
<td>+SelectVcard()</td>
</tr>
<tr>
<td>+AddVcardToCollection()</td>
</tr>
<tr>
<td>+RemoveVcardFromCollection()</td>
</tr>
<tr>
<td>+AddVcardToMetadataElementValues()</td>
</tr>
</tbody>
</table>

**Figure 11. vCard class**

When an element from the metadata model is declared of being of type vCard, all the functionality associated with vCard and its database structure becomes available to the application through an event-based engine that parses the events related to metadata elements (e.g. metadata type, multiplicity type) at run-time to allow their processing, display, and editing.

Figure 12 is a screenshot of the interface that allows use of the vCards while editing metadata elements.

Metadata type controlled processing has been with us a long time:

- File management systems are metadata intensive.
- Opening a file involves using a file system to invoke a file access method on a specific file type.
- While file objects are often able to invoke programs that can access them, much of the document’s content is unavailable to the operating systems’ file management system.
- Data in the files is made available to the application program that launches it.

This kind of behavior is well suited for metadata elements too.

The next subchapter introduces the features of the CLOMAT prototype that was designed to answer the challenges encountered in the metadata area. The CLOMAT prototype follows closely the framework defined in the previous chapter.
4.3. CLOMAT Features

The future audience for this metadata authoring tool is not intended to be an exclusive audience such as librarians, instructional designers or information professionals familiar with SCORM metadata specifications, and other standards but a broad audience incorporating any metadata creator. The features outlined below are supported by an intuitive, informative, engaging, easy to navigate web interface. Relevancy and clarity of the information, adequate feedback, reduced workload and most important overall consistency and simplicity were the principles that drove the implementation of CLOMAT.

Based on the above designed issues and the theoretical framework created in the second chapter, the CLOMAT prototype brings together the following features:

- **Metadata Model Flexibility**
Due to the metadata type-driven design, CLOMAT provides the option of defining multiple metadata models and all of them are available at the same time for use. (Figure 13) Figure 14 represents the trees corresponding to the SCORM model and to My metadata model, which have been defined according to the meta-metadata model outlined before.

Figure 13. CLOMAT metadata model flexibility

Figure 14. Metadata Models
• **User management**

User profiles facilitate the automation of those metadata elements related to the content creator. They also allow for customization of the metadata model within each individual profile.

Metadata model views and metadata model templates provide a great degree of flexibility for users to personalize the metadata models according to their needs and expertise.

This version of the CLOMAT prototype doesn’t include a collaborative aspect of editing metadata as discussed above in “2. Framework for Customizable Metadata Authoring,” but it still includes some aspects of collaboration such as metadata model sharing, and vCards exchange. (Figure 15)

![Figure 15. CLOMAT User Log In](image-url)
• **Tree-based Representation**

A tree-based structure is used to represent the internal database structure and allows the users to navigate the metadata.

An event-based engine parses the events related to metadata elements once the user clicks the element in the tree structure and permits their processing at run-time. (Figure 16)

![Figure 16. CLOMAT Metadata Tree View Structure](image)
• **External Standards Support**

External Standards such as: vCard standard (vCard, 1996), MIME standard (MIME, 1996), URI standard (URI, 1993), ISO 369 standard (ISO639, 2002) for language codes are incorporated into the prototype in such a way that a non-metadata expert can make use of them. (Figure 17)

![Figure 17. CLOMAT External Standards Support](image)

• **Multiple language support**

Every element of type langstring has a language associated with it. You can set the default language and then assign it to each langstring element you edit.

Because you can duplicate langstrings within an element, you can provide the most important elements in several languages to reach a larger audience. If you do not specify a language, no language will be associated with the langstring elements. (Figure 18)
Custom View Accessibility

No one wants to look at the entire metadata information model in order to get to the few pieces of metadata that are of interests of him or her.

That is why CLOMAT offers the possibility of defining custom views of metadata models.

This feature can be enhanced by adding it to the collaboration between users in such a manner that various users are responsible for different parts of the metadata for the same learning object. (Figure 19)
• **Template-Driven Editing**

A metadata template is an aid to help users create metadata faster, by not editing the same information twice. The template-driven editing, along with the metadata model views was facilitated by the tree-layer architecture of the design model of CLOMAT. Both model templates and model views are instances of the meta-metadata model.

When an author starts working on a learning object metadata using a template, the record for that learning object is filled with the already existing data from the template.

In a collaborative environment a metadata template can be exchanged among users. CLOMAT enables users to have several templates and custom views at the same time.

Each template can be based on different metadata models or model views of models according to the needs of the users. (Figure 20)
• **On-the-fly, dynamic, contextual help**

The contextual help supports a better interaction between the CLOMAT prototype and the content creators through:

- immediate assistance without their having to leave the context in which they are working;
- information about a particular metadata attribute, its context and its corresponding vocabulary;
- answers to questions such as "What is this?" and "Why would I use it?".

The descriptive information can be also printed as a paper-based help guide. (Figure 19 and Figure 20)
4.4. CLOMAT Evaluation

Objective

The techniques used to accomplish the evaluation include expert evaluation and exploratory study on the use of CLOMAT. An example of the informed consent form and a copy of the human subjects’ research approval letter can be found in Appendix B.

The objective of the evaluation of CLOMAT was two fold:

• Expert evaluation
  
  It was the objective of the expert evaluation process to retrieve information from experts in the field of learning objects and metadata which may be useful in future design iterations of the CLOMAT. It was considered that the evaluation of the assumptions and the framework behind the prototype as long as the current prototype can help to determine unforeseen considerations, technical design problems.

• Exploratory study on the use of CLOMAT.
  
  It was the objective of the exploratory study to determine the extent to which the CLOMAT prototype can be used by users to achieve the specified goal: editing learning objects metadata records with effectiveness, efficiency and satisfaction.

Methodology

• Expert evaluation
  
  An individual interview process was considered to be the most appropriate method for the expert evaluation of the CLOMAT prototype as opposed to questionnaire or expert group meetings for the following reasons:

  • It does not require that the experts meet at a common place and time. Additionally, methods requiring group meetings introduce negative group dynamics such as they can influence each other’s ideas, lack of anonymity, and pressure to conform.
  • Questions which may be misinterpreted can be clarified by the interviewer.
  • The participant can be motivated by the interviewer with positive responses.
  • Speaking is a more natural form of communication than writing.
• Areas of interest not covered in the predetermined questions (introduced by the expert) can be explored further by the interviewer.

Open-ended questions as opposed to multiple choice answers were considered relevant to this type of interview since they permit the subject to introduce a unique response. This type of question allows the subject to explain his/her answer and offers a good format for identifying new ideas which is the objective of the expert interview.

The panel of discussion included:

• **Metadata standards**

  The following questions referred to current learning technology vendors which move to adopt standards when designing their products, and to consumers of these technologies which insist that the products they buy conform to these emerging standards.

  • What level of involvement do you have at this moment with the various standards activities?
  • What are the plans for conforming with the accredited standards and the specifications as they emerge?
  • How can your organization assist with the transition strategy if new standards make existing products obsolete?
  • Is there any need for developing a metadata model within your organization that will be used to ensure interoperability of different learning initiatives?

• **Human-created metadata challenges**

  The following questions referred to the purpose and usefulness of metadata

  • Do you reuse any of the content developed in previous projects?
  • Do you make use of learning objects?
  • Do you make use of metadata? Did you use a metadata authoring tool?
  • Did you use a metadata model like SCORM / LOM? How much of it?
  • How much of metadata do you find useful?

The experts were briefed with the metadata challenges outline by the present work and then asked the questions:

  • Did you experience any of these challenges?
  • Did you experience other challenges specific to your projects?

• **Possible solutions**
The experts were briefed with the possible solutions identified in the CLOMAT framework and then asked questions like:

- How can we achieve rich, complete, accurate and cost-effective metadata?
- Are these possibilities practical, realistic?
- Which do you think would create the biggest impact on the cost of metadata? Which do you think would create the biggest impact on the completeness of metadata?
- Are there any unnecessary features in the CLOMAT prototype?
- What other possibilities, if any, do you foresee?

Exploratory study on the use of CLOMAT

The evaluation of the prototype tested its functionality and usability according to predefined criteria and against the principles that led to its development. The prototype was tested to determine how much of the functionality described by this research and incorporated into the prototype is reachable and useful. The functionality was evaluated against user’s goals, requirements and expectations underlining those features that are considered important for daily use of the tool.

A variety of usability characteristics as they apply to the metadata editor include:

- how easy the tool is to learn – the set up for this characteristic was to introduce the CLOMAT prototype to the subjects, one day before the actual test and let them create their own accounts and make a contact with the interface;
- the degree to which the tool supports the tasks the user wishes to perform and in the way that the user understands them;
- whether a user would gradually find the tool adaptable to ones expertise;
- how much time is saved by using templates to create metadata for the learning objects;
- whether the tool provides an effective online help and how extensive it is;

These characteristics were considered as the criteria during evaluation and they were tested using the following scenarios. The subjects were chosen to match the expected user population for the tool. A number of five (5) participants with no previous experience in editing the metadata were considered for this test. They have been encouraged to speak aloud while performing the tasks. The tasks had different degrees of complexity. The participants have been encouraged to see themselves as collaborators in the evaluation and not simply as experimental subjects. Also they have been encouraged to criticize the system.

Scenario 1:

“Let’s take an image or a diagram that you developed as part of your work and let’s define as much metadata about it as possible.” This scenario tried to identify issues
related to the CLOMAT prototype and if the resulting metadata is complete and accurate. Also the time to edit a metadata record was recorded.

Scenario 2:
“Let’s take the document in which you found the diagram and let’s define the same information about it using CLOMAT and a different tool”. (LOM Editor and ADL Generator were considered). This scenario tried to identify the difference the interface can make in defining accurate metadata and also if the users can understand concepts like “relations between learning resources” and how hard is to define them using the tool.

Scenario 3:
“An expert created a template for you to use in defining this learning object that is part of a collection. The only elements you have to define are: title, description and keywords, and URL.” This scenario was developed from the study of metadata of nine learning objects already defined as part of a course. Samples of the metadata XML files taken into consideration can be found in APPENDIX D. The time to edit the reduced number of elements was recorded. This scenario was created to understand the cost savings that templates might introduce in the creation of metadata.

Results

- Expert Interview

The data from the interviews was analyzed for innovative ideas, identification of design deficiencies, and determination of opportunities which may serve to improve current deficiencies. Following is a summary of the results based on a transcript of expert answers. Sample answers from the transcript can be found in APPENDIX E.

- Opportunities
  - The need for extensible models that would allow for cataloging the resources from different perspectives: learning, human performance technology, etc.
  - The importance of human-created metadata for the discovery of the learning objects.

- Innovative ideas
  - A metadata model at the organization level that would provide a common framework would be useful if brings ROI.
  - People who search digital repositories for learning objects should be able to add their own metadata. Thus, we can add users’ experience in searching the learning objects. This might increase their discoverability and reuse.
  - Attaching a rationale to a metadata element that explains why it is important to edit that particular metadata element for different contexts.
- For the metadata elements that can cause ambiguity, a wizard would be helpful to walk through scenarios and help the user select the best answer.

  - Identification of the design deficiencies
    - Collaborative editing of metadata was seen as the most important feature in creating complete and accurate metadata records since metadata elements are asking for different expertise. This should be incorporated in the next iteration of CLOMAT.
    - The contextual help should also include examples which can explain the concepts better than the technical terminology.
    - The tree structure was found stronger in terms of representation of metadata model than the tabular structure, but from the user perspective, the tabular structure was preferred.

- **Exploratory study on the use of CLOMAT**

The exploratory study conducted to the following findings:

- The tool was found pretty easy to learn.

  The users, previously familiarized with the tool in a 15 minute session, two days before the actual test, didn’t have any problems to login and start performing the tasks they were been given at once.

- Cost savings by using metadata templates.

  The average time for editing a complete metadata record was 25 minutes and metadata quality had to suffer. The average time for editing the reduced number of metadata elements was 4 minutes. If we start with the assumption that the template was created by experts, so it can be considered complete and accurate, and we take into consideration the observation that the metadata elements the subjects were asked to edit didn’t create any problems, the resulting metadata was complete and accurate, the errors were minimized. The savings in terms of time were in average 20 minutes per learning object, which for a course with 2500 learning objects translates to 50,000 minutes (approx. 833 hours).

- The contextual help has capabilities in defining complete and precise metadata

  All of the subjects made use of the contextual help while defining the metadata. Since the terminology used was sometimes too technical and it did not clarify what the metadata element refers to, we can not quantify at this moment the impact that the contextual help can improve the quality of metadata. Examples should be incorporated also to facilitate a better understanding of the metadata elements.
• Tabular structure can be an alternative to tree structure

The tabular structure seemed to be understood by the user quicker than the tree structure. Also, the tree structure had sometimes too much information attached to it and it became confusing. (e.g. the user had to click on +/- to extend the nodes, the user had to click on the name of the element to display information about it; the user had to click on the checkbox attached to element to select/deselect the element).

• Advanced concepts require advanced methods of illustration

The relation between learning objects, an advanced concept that is very important for the reuse of learning objects, was not understood by users without detailed explanation. I believe that visual representations of such relations can facilitate a better understanding. Further investigation is necessary regarding this concept. This finding is supported by a study done at University of North Carolina that shows that users spent most of their time focused on only a few subtasks (defined as time spent harvesting and entering information for a specific element) and defining the relation between learning objects took 23% of their total time task.

• Metadata quality

The quality of metadata was influenced by the user’s interpretation of the metadata elements and their values. Since the users were encouraged to speak aloud, many of them expressed their thinking: “I have no idea”, “I have no clue”, “I don’t know if it is true or not”. These misinterpretations lead to meaningless metadata. Some users input the keyword one by one, while others input all the keywords in one element. This issue is important when it comes to searching the learning objects collections.
5. CONCLUSIONS

In the Knowledge Age, there is an obvious requirement for metadata as means for exchange and sharing of learning objects. This metadata is used by the applications, repositories, content creators, instructional designers, learners. In a learning environment in which courses have thousands of learning objects, the metadata must be cost-effective, accurate, and complete.

Just as instructional designers focus on making learning content instructionally rigorous, defining metadata standards that will take into consideration all the aspects of learning objects to make them fully reusable, software developers should focus on a complete set of metadata solutions as critical tools in developing and maintaining searchable and reusable knowledge repositories. The power of metadata starts from its authoring. The more complete, accurate metadata we have, the more useful in the discovery and the use of learning objects we have.

This thesis illustrates that learning objects metadata creation is a complex issue and developing a tool for a particular metadata standard doesn’t solve everything. There are other process-related challenges and organization specific requirements that metadata solution has to address. By identifying challenges related to users’ needs, metadata standards, and learning environment and by proposing solutions to these challenges, my work, far from being a complete solution, presents a starting framework for an efficient customizable metadata authoring.

The main elements of the framework are:
- Flexible metadata schema
- Metadata schema views
- Metadata templates
- Collaborative metadata editing
- On-the-fly, dynamic, contextual help
- Effective, well-organized interface

Describing a flexible schema was one of the main goals of the CLOMAT prototype built on top of the above framework. By outlining a meta-metadata model and by describing the behavior of the metadata types, CLOMAT facilitates the processing of the metadata elements, instances of the metadata types, at run-time. My belief is that the better full-featured applications that manage the metadata types are built, the more flexible and powerful the metadata schemas that can be implemented.

On the other hand, the users need better interfaces to support their goals. The CLOMAT prototype was proved to have economical value by reducing the time of editing metadata. It also has potential for increase the quality of metadata through its contextual help but additional elements have to be added such as examples, wizards, and visual representations.
The CLOMAT prototype:

- demonstrated several techniques to overcome some of the main difficulties of authoring in this domain such as: editing the metadata for large number of learning objects; or answering users needs of customization of metadata models and organization of the information presented but future research regarding the quality of metadata is necessary.

- pointed a user-centered way to a future in which everyone can be as comfortable editing metadata as they are today editing text making use of contextual help, and directions for future research were indicated such as: wizards and visualizations.

- made possible the representation of a large range of metadata models that permit integration with future tools ad applications.
6. FUTURE WORK

Future work should concentrate on validating and generalizing the presented results. Learning objects metadata authoring is still in its infancy and lacks detailed research methods. Although I gained quite a detailed understanding of the relevant challenges in the metadata authoring, my results are still based on particular examples and should be validated and generalized further.

During my research I have identified a number of important topics that remain open for future research:

- **Collaborative editing**

  During this research collaborative editing was identified as being one of the critical features in achieving quality metadata. Learning objects metadata with its different functions represents a good subject for collaborating editing. For example, the design specification for a new learning object can be provided by the subject matter expert, the instructional designer can edit those metadata elements related to educational aspects of the learning objects, while the technical staff can take care of technical details such as the software needed to access the learning resource or the size in bytes of the resource. In this way, the metadata can reach a higher level of richness, completeness, and accuracy.

- **Import/Export XML documents**

  To achieve interoperability to other tools, applications, and repositories, any metadata authoring tool should provide features of import/export XML documents that describe metadata of the learning objects. Frameworks are being developed to provide interoperability for digital libraries (Arms et al., 2002) with many using the protocol for metadata harvesting developed by the Open Archives Initiative (Lagoze & Sompel, 2001). Further investigation is necessary to understand the issues related to import/export of metadata XML files.

- **Effective Interfaces**

  Further research is needed to understand the conceptual models users apply to metadata in order to design better interfaces. If the hierarchical model is not the best representation of the metadata models for the users, then is the tabular representation a better one? In the present evaluation of CLOMAT two displays were used to eliminate context switching from editing the metadata to viewing the learning object. If the same display is used, how can we minimize the cost of content switching? Is the combination of metadata creation and content creation the answer? These questions remain open for future research.
APPENDIX A: 
THE SCORM METADATA INFORMATIONAL MODEL

The SCORM Metadata Information Model (SCORM, 2001) describes the metadata elements that are defined to build SCORM conformant metadata records. The SCORM Metadata Information Model contains nine categories:

1. The General category groups the general information that describes the resource as a whole.

2. The Lifecycle category groups the features related to the history and current state of this resource and those who have affected this resource during its evolution.

3. The Meta-metadata category groups information about the meta-data record itself (rather than the resource that the record describes).

4. The Technical category groups the technical requirements and characteristics of the resource.

5. The Educational category groups the educational and pedagogic characteristics of the resource.

6. The Rights category groups the intellectual property rights and conditions of use for the resource.

7. The Relation category groups features that define the relationship between this resource and other targeted resources.

8. The Annotation category provides comments on the educational use of the resource and information on when and by whom the comments were created.

9. The Classification category describes where this resource falls within a particular classification system.
Table 3: Example of elements from the SCORM (SCORM, 2001)

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Name</th>
<th>Explanation</th>
<th>Multiplicity</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General</td>
<td>This category groups the general information that describes the resource as a whole.</td>
<td>1 and only 1</td>
<td>Container</td>
</tr>
<tr>
<td></td>
<td>Identifier</td>
<td>A globally unique label that identifies the resource. This is reserved and shall not be used, as there is no uniformly accepted method for the creation and distribution of globally unique identifiers. This element can be transparent to the meta-data creator. It can be created by the meta-data management system.</td>
<td>RESERVED</td>
<td>String</td>
</tr>
<tr>
<td>1.2</td>
<td>Title</td>
<td>Name given to this resource. The title can be an already existing one or it may be created by the indexer ad hoc.</td>
<td>1 and only 1</td>
<td>LangString</td>
</tr>
<tr>
<td></td>
<td>Language</td>
<td>The primary human language used within this resource to communicate to the intended user. This language is the language used within the resource being described. “None” is an acceptable value. Must be expressed as per ISO 63923 &amp; ISO 316624 standards.</td>
<td>0 or More</td>
<td>String</td>
</tr>
</tbody>
</table>
| 1.8 | Structure | Underlying organizational structure of this resource. **IEEE LOM Vocabulary:**  
  • Collection  
  • Mixed  
  • Linear  
  • Hierarchical  
  • Networked  
  • Branched  
  • Parceled  
  • Atomic | 0 or 1         | Vocabulary (Restricted) |
<p>| ... |         |                                                                                                |                |                |</p>
<table>
<thead>
<tr>
<th>Nr.</th>
<th>Name</th>
<th>Explanation</th>
<th>Multiplicity</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Lifecycle</td>
<td>This category describes the history and current state of this resource and those who have affected this resource during its evolution.</td>
<td>0 or 1</td>
<td>Container</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>Contribute</td>
<td>This sub-category describes those people or organizations that have affected the state of this resource during its evolution (includes creation, edits and publication). Note: This sub-category is different from 3.3:MetaMetaData.Contribute.</td>
<td>0 or More</td>
<td>Container</td>
</tr>
</tbody>
</table>
| 2.3.1| Role      | Kind of contribution. Note: It is recommended that exactly one instance of Author exists. **IEEE LOM Vocabulary:**  
• Author  
• Publisher  
• Unknown  
• Initiator  
• Terminator  
• Validator  
• Editor  
• Graphical Designer  
• Technical Implementer  
• Content Provider  
• Technical Validator  
• Educational Validator  
• Script Writer  
• Instructional Designer | 0 or 1       | Vocabulary (Best Practice)                                                                                                                     |              |           |
<p>| 2.3.2| Entity    | The identification of and information about the people or organizations contributing to this resource, most relevant first. If 2.3.1:LifeCycle.Contribute.Role equals Author, then the entity should be a person. If 2.3.1:LifeCycle.Contribute.Role equals Publisher, then the entity should be an organization. Note: This is a vCard25 element. | 0 or More    | String    |</p>
<table>
<thead>
<tr>
<th>Nr.</th>
<th>Name</th>
<th>Explanation</th>
<th>Multiplicity</th>
<th>Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3.3</td>
<td>Date</td>
<td>This sub-category defines the date of the contribution. Must be bound as a DateType that may contain a datetime element expressed as per ISO 860126 standard and a description element.</td>
<td>0 or 1</td>
<td>DateType</td>
</tr>
</tbody>
</table>

Table 2 - continued
APPENDIX B: COPY OF INFORMED CONSENT FORM

Figure 21. Copy of Informed Consent Form
APPENDIX C: COPY OF HUMAN SUBJECTS APPROVAL LETTER

Office of the Vice President
For Research
Tallahassee, Florida 32306-2763
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM
Human Subjects Committee
Date: 2/28/2003

Elena Maiak
2620 N Berkeley Lake Rd #424
Duluth Ga 30096

Dept: Computer Science

From: David Quadango, Chair

Re: Use of Human Subjects in Research
Customizable Learning Objects Metadata Authoring Tool

The forms that you submitted to this office in regard to the use of human subjects in the proposal referenced above have been reviewed by the Secretary, the Chair, and two members of the Human Subjects Committee. Your project is determined to be exempt per 45 CFR § 46.101(b) 2 and has been approved by an accelerated review process.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals, which may be required.

If the project has not been completed by 2/27/2004 you must request renewed approval for continuation of the project.

You are advised that any change in protocol in this project must be approved by resubmission of the project to the Committee for approval. Also, the principal investigator must promptly report, in writing, any unexpected problems causing risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols of such investigations as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Protection from Research Risks. The Assurance Number is IRB00000448.

Cc: Dr. Ian Douglas
HSC No. 2003.083

Figure 22. Copy of Human Subjects Approval Letter
APPENDIX D: EXAMPLES OF METADATA XML RECORDS

Example 1

```xml
<?xml version="1.0" ?>
<lo m xmlns="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1"
    xmlns:xsl="http://www.w3.org/2001/XMLSchema-instance"
    xsl:schemaLocation="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1
    imsmd_rootv1p2p1.xsd">
    <general>
        <title>
            <langstring lang="en-US">Introduction</langstring>
        </title>
        <catalogentry>
            <catalog>
                x
            </catalog>
            <entry>
                <langstring lang="en-US">x</langstring>
            </entry>
        </catalogentry>
        <language>en-US</language>
        <description>
            <langstring lang="en-US">SINCGARS, Frequency Hopping, Introduction</langstring>
        </description>
        <keyword>
            <langstring lang="en-US">SINCGARS, FH, ANCD</langstring>
        </keyword>
        <lifecycle>
            <version>
                <langstring lang="en-US">1.0</langstring>
            </version>
            <status>
                <source xml:lang="x-none">LOMv1.0</source>
                <value xml:lang="x-none">Final</value>
            </status>
            <contribute>
                <role>
                    <source xml:lang="x-none">LOMv1.0</source>
                    <value xml:lang="x-none">Proponent</value>
                </role>
                <centity>
                    <vcard>United States Army Air Defense Artillery School</vcard>
                </centity>
            </contribute>
        </lifecycle>
    </general>
</lom>
```
Example 2

<?xml version="1.0" ?>
<lom xmlns="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1"
    xmlns:xsl="http://www.w3.org/2001/XMLSchema-instance"
    xsl:schemaLocation="http://www.imsglobal.org/xsd/imsmd_rootv1p2p1
                      imsmd_rootv1p2p1.xsd">
  <general>
    <title>< langstring >FH Data</ langstring >
    </title>
    <catalogentry>
      <catalog><x</catalog>
      <entry>< langstring >x</ langstring >
      </entry>
    </catalogentry>
    <language>en-US</language>
    <description>< langstring >SINCGARS, Frequency Hopping Data</ langstring >
    </description>
    <keyword>< langstring >sincgars, mode of communication, jamming resistant, transmit, receive, frequencies, man frequency, cold start net openings, hopsets, lockout sets, transmission security key, tsk, fh sync time, net id, pseudo-random frequency pattern</ langstring >
    </keyword>
  </general>
</lom>
<langstring xml:lang="x-none">no</langstring>
</value>
</cost>
</copyrightandotherrestrictions>
<source>
<langstring xml:lang="x-none">LOMv1.0</langstring>
</source>
<value>
<langstring xml:lang="x-none">no</langstring>
</value>
</copyrightandotherrestrictions>
</rights>
<classification>
<purpose>
<source>
<langstring xml:lang="x-none">LOMv1.0</langstring>
</source>
<value>
<langstring xml:lang="x-none">MOS/SC & Skill Level</langstring>
</value>
</purpose>
<description>
<langstring xml:lang="x-none">Air Defense Noncommissioned Officer Skill Level Three</langstring>
</description>
<keyword>
<langstring xml:lang="x-none">Army Air Defense Artillery Noncommissioned Officer</langstring>
</keyword>
<classification>
<purpose>
<source>
<langstring xml:lang="x-none">LOMv1.0</langstring>
</source>
<value>
<langstring xml:lang="x-none">Critical Task Taught/Supported</langstring>
</value>
</purpose>
<description>
<langstring xml:lang="x-none">SINCGARS, Frequency Hopping Data</langstring>
</description>
<keyword>
<langstring xml:lang="x-none">sincgars, mode of communication, jamming resistant, transmit, receive, frequencies, man frequency, cold start net openings, hopsets, lockout sets, transmission security key, tsk, fh sync time, net id, pseudo-random frequency pattern</langstring>
</keyword>
</classification>
<purpose>
<source>
<langstring xml:lang="x-none">LOMv1.0</langstring>
</source>
<value>
<langstring xml:lang="x-none">x</langstring>
</value>
</purpose>
<description>
<langstring xml:lang="x-none">x</langstring>
</description>
</classification>
</lom>
APPENDIX E: SAMPLE EXPERT ANSWERS

1. The Navy specifically requested that we use SCORM 1.1 and SCORM 1.2, and they required the minimum impose by SCORM to be SCORM compliant plus a couple of other things.

2. There is a gap between what SCORM is asking for from the learning perspective and what we are during in the Army project which is from HPT perspective. So we are going to have metadata that is not defined in SCORM.

3. I would add that SCORM is a very specific implementation of learning objects. That’s something people tend to forget.

4. Some of the categories can be automated.

5. Automatically-generated metadata is the one that can be easily generated, the human-created metadata is the one that people balking at.

6. The tool we used didn’t work with LMS that we used. We built a tool in the house, it was rough and dirty.

7. When we switch from SCORM 1.1 to 1.2 we lost the information that was not supported by the new version of SCORM.

8. Do you think your organization should have a metadata model that will help interoperability between projects, define a common framework for present and future projects. If you get a Return on Investment. Sometimes you don’t get enough of that to make worth the effort if a tool would make easy to do that would be more likely to use it.

9. The metadata fields are asking for different kinds of information from different expertise and if you are going to have someone filled out a learning taxonomy, the person who is handling the technical side of the project is not qualified to decide that, and in the same time, instructional designers, we have a very difficult time recording the sequencing of objects. It seems inevitable to me that certain people have to fill out certain parts of the metadata.

10. In our tool you were actually creating metadata while defining the learning object while some other metadata is defined later. It goes back to separation. Some metadata in the system was created by the people that we searching the learning objects through annotations. Thus we add some of the human elements in the searching for learning objects.

11. I would very careful about limited the options they have to change the metadata if some part of it is automated as is the case of templates.

12. I think it would make authoring more easier for people working on metadata collaboratively, definitely.

13. Examples would help in the contextual help for metadata elements because examples really do explain things better the technical terminology and SCORM is pretty technical.

14. And you also can put a Rationale; why is it important that you include this metadata element in the description of the learning object.
15. I think one of the huge things with metadata is making a good argument why people should go with the trouble of fit and anytime you put a rationale there and tell them “this is going to help you in the long run”. Rationale should be like a sales pitch on each one of it from the business perspective.

16. We should have a core metadata and ability to expand

17. Like Amazon has core elements like author, title, publisher but then you have reviews which people write which is optional and people use that in different ways. To me that like having this core staff here but also having the optional like the rationale for the element down here. That might be more useful for some organizations than the other ones.

18. Social navigation search of the learning objects – peer review

19. I like the tree structure (CLOMAT). It’s pretty clean. The way you allowed expansion and reduction of nodes I think that the tree structure is stronger that the tabular structure

20. I like the tabs

21. Import/Export – I’ve found it useful when we migrated with the system from SCORM 1.1 to 1.2 but I don’t see it used on a regular basis.

22. I think the contextual help displayed along with the editing has the potential to make it use it more often and more consistently

23. It would be good if the user support would be adaptive both for experts and novices

24. For elements that can cause ambiguity, you can have a wizard that walks you through scenarios and helps you choose the best answer.
REFERENCES


Elena Valentina Malaxa was born in Targoviste, Romania, a small town on the beautiful hills south of the Carpathian Mountains. She spent her childhood and adolescence in Galati, Romania on the banks of the Danube.

Valentina graduated in May 2000 with a Bachelor of Science in Economic Informatics from the Academy of Economic Studies, Bucharest, Romania. She joined the Department of Computer Science at Florida State University in August 2000 and the team of researchers at the Learning Systems Institute in January 2001. Valentina was a member of the Upsilon Pi Epsilon - Honor Society in the Computing Sciences, Florida State University Chapter, and Women in Computer Science at Florida State University. She graduated in May 2003 with the degree of Master of Science in Computer Science.