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Reusable Learning Object Metadata Adaptation for Higher Education Instructional Design

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ABSTRACT

Reusable learning objects have always been adapted in e-learning environments to serve different purposes in instructional design. This adaptation process is usually limited by varying metadata standards of reusable learning objects that in most cases do not conform to the standard structure of the learning objects for a given educational level. In this paper, we present an analysis of various learning object metadata standards and propose a new metadata structure for a higher education reusable learning object. We evaluate this new metadata structure by instantiating it with a learning object authoring tool that also supports adaptation of learning objects with multi-format assets. We use expert sampling technique to randomly select 8 experts in higher education instructional design (from three different universities) to evaluate the functionality, correctness and usability of the tool in authoring reusable learning objects with multi-format assets. This process is repeated with 10 experts in instructional design, randomly selected from 5 universities. The results from the two experiments show a strong positive correlation and this proves that the proposed metadata structure can be adopted by higher education institutions in instructional design process to create adaptable reusable learning objects.

KEYWORDS

Learning Object Reusability, Learning Object Adaptation, Learning Object Metadata Standards, Higher Education Instructional Design, E-learning Environments.

1 INTRODUCTION

1.1 Reusable Learning Objects

The definitions of the term Reusable Learning Object(RLO) provided by various scholars and educational standards organizations depend on "*how the concept has been used in instructional design*"[1]. For example,

i. Wiley[2] defines a RLO as *"any digital resource that can be reused to support earning"*.
ii. The standard for Learning Object Metadata[3] developed by the IEEE's Learning Technology Standards Committee (LTSC) defines a learning object as *"any entity - digital or non-digital - that may be used for learning, education or training"*.
iii. Robbins[4] defines a RLO as *"a chunk of distinct knowledge that can be kept as a resource for content designers within the Learning Content Management System (LCMS), or delivered as a stand-alone object"*.

In this paper, we define a reusable learning object as a unit of electronic instructional content that can be reused to achieve a single learning objective in instructional design. Reusability of a learning object in this case is "*the degree to which a learning object can work efficiently for different users in digital environments and in different educational contexts over time*"[5]

For purposes of scope, this paper focuses on reusable learning objects that have the following technical characteristics;

i. White-box transparent reusable learning objects[1] that can provide access to their internal implementation (source code) to support adaptation.
ii. Learning objects that can be delivered in a web-based environment.
iii. Learning objects made up of multi-format assets. An asset in this case is the smallest unit of content that can not individually be used to achieve a learning objective, such as an image, a source code snippet, a video or audio clip, among others.
iv. Learning objects that are decomposable into their assets to allow asset-level adaptation.
v. Learning objects with instructional content for higher education level, such as a university.

1.2 Reusable Learning Object Adaptation

Reusable learning object adaptation is the process of modifying an existing learning object in instructional design with the aim of achieving a new learning objective in the learning environment. The results of the mEducator project [6] showed that a learning object can be adapted into different contexts such as; the content it self, the language, the cultures, the pedagogical approaches, the educational levels, the disciplines or professions, the content types, the technology, and the people with different abilities.

The standard structure of a learning object makes it more reusable in various ways in instructional design. Usually, each standard learning object has two parts, the metadata and the instructional content[2]. The metadata is the data that defines the learning object so that it is easily discoverable in online learning object repositories. The instructional content part is the actual content that the author intends to use in achieving a learning objective. Thus, adaptation of the reusable learning object can be either at instructional content level or at metadata level.

At instructional content level, the instructional designer modifies existing instructional content of the learning object so as to reuse it in achieving a new learning objective in the learning environment. For example, a Java applet (as an example of a learning object) meant to teach the student how the *while loop in Java programming language* works (in form of a simulation) can be modified (if the source code is available) to teach the student how *the do while loop* works either in the same programming language or another programming language. The fact that this Java applet now achieves a new learning objective means that it has been adapted for reuse.

At metadata level, the instructional designer modifies the existing metadata structure of the learning object. This can be done by either adding new metadata elements or formulating a new metadata structure from existing metadata standards with the aim of improving reusability of the learning object.

For purposes of scope, this paper focuses on adaptation of the metadata structure of the learning object to improve reusability, specifically, learning objects that can be used for higher education instructional design.

1.3 Reusable Learning Object Metadata Standards

Various standard metadata models have been defined to support authoring of standard reusable learning objects. Such metadata standards include the Institute of Electrical and Electronic Engineers Learning Object Metadata(IEEE LOM) standard[3], DublinCore[7], Sharable Content Object Reference Model(SCORM)[8], the National Educational Technology Group(NETg) learning object model[9] and Cisco's reusable learning object content model[10,11]. A critical analysis of these learning object metadata standards shows that;

i. They have varying metadata sets, implying different learning objects structures from one standard to another. For example, the IEEE LOM standard has 9 metadata elements/attributes[3] while the DublinCore standard has 15 metadata elements[7].

ii. They are generic in a sense that they are not customized for a given educational level. For example, much as the IEEE LOM standard[3] provides *Educational* attribute among the 9 metadata attributes, this attribute focuses on the educational and pedagogical characteristics of the learning object but does not specifically state which educational level such a learning object is meant for. However, instructional design as a process requires articulation of instructional design requirements before the content is designed. Among these instructional design requirements is educational level requirements. It is common practice that the instructional content of one educational level has different attributes from that of another educational level. For example, the structure of high school instructional content does not necessary have to have the same structure as university level content.

Several attempts to extend existing learning object metadata standards have not helped much to produce a metadata structure for a higher education learning object that is easy to adapt, especially learning objects with multi-format assets. For example, the extension of the IEEE LOM[5] standard by the collaborative partners of Customized Learning Experience Online (CLEO) [12] was meant *"to align the metadata requirements of Cisco, Microsoft, IBM and Thomson NETg to provide a foundation for collaboration using shared content*"[13] but not for a particular educational level. Another significant effort to specify the metadata structure of a higher education learning object was by Sun and Williams[11], which was an extension of the Cisco Systems reusable learning object model[10]. In this study, we further extend the higher education learning object metadata structure proposed by Sun and Williams[11] with the aim of supporting adaptation of higher education reusable learning objects with multi-format assets.

The rest of this paper is organized as follows; Section 2 presents the current metadata structure of a higher education reusable learning object and the proposed metadata structure of a higher education learning object, section 3 presents the methodology used to evaluate the proposed metadata structure, section 4 presents evaluation results, section 5 presents the conclusion and future work.

2 METADATA STRUCTURE OF HIGHER EDUCATION REUSABLE LEARNING OBJECTS

2.1 Current Metadata Structure for Higher Education Learning Objects

In the context of this research, we consider a higher education level to be an education level after high school, such as a university. Sun and Williams[11] adopted and extended Cisco's[10] definition of a RLO in order to *"meet the educational requirements for higher education"*. Sun and Williams[11] present Cisco Systems Reusable Learning Object(RLO) model [10] as a module of a course in a higher educational institution that is made up of five major components, namely; Reusable Information Object (RIO), Practical object, Assessment object and Summary (see figure 1).

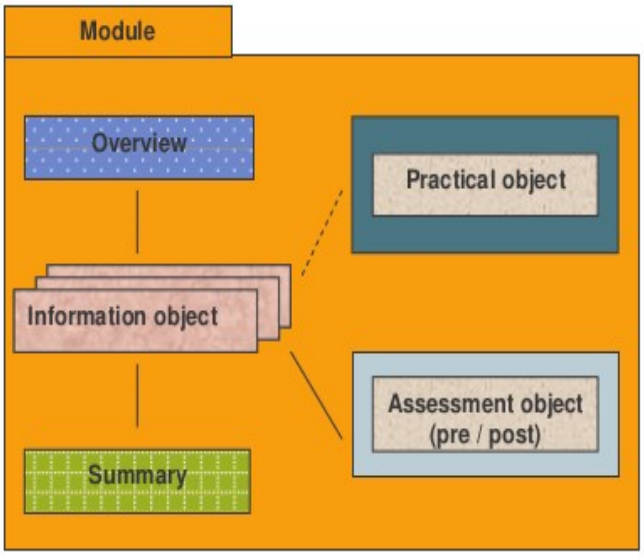

Fig. 1: Cisco Systems presentation for a Module as a Reusable Learning Object (Source: Sun and Williams [10]).

In figure 1 above, the *overview* of a module gives the general description of the module(such as the module code, the educational level, aim, learning outcomes, among others). The *information object* is the actual content to be delivered to the learner (these could be more than one depending on the size of the RLO). The *assessment object* uses a given assessment strategy (embodied in it by the instructional designer) to measure the level of understanding of the learner as far as the content in the RLO is concerned. The *practical object* in the RLO is optional and can be done offline depending on module requirements[11] and is mainly used to supplement the information objects to enable the learner to practically understand the content in the RIO. The *summary* is like the overview (in structure) but it is meant to conclude the RLO in form of a review.

In order to formulate the metadata set for a higher education RLO, we analyze the instructional content model by Sun and Williams [11] and we specifically look at the structure of each of the five components of the RLO presented in figure 1. We thus produce a schematic representation of a Higher Education RLO as shown in figure 2.

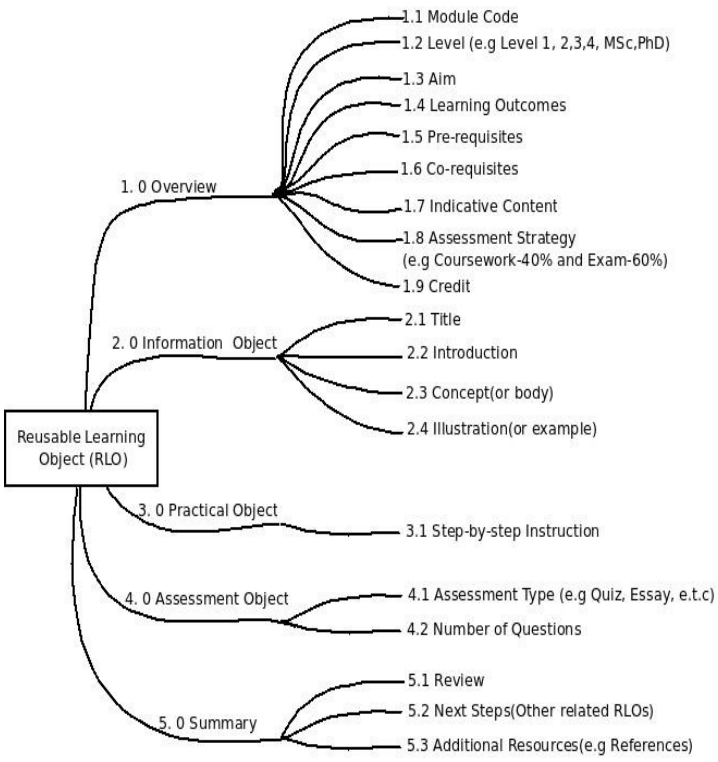

Fig. 2: A schematic representation of a RLO for higher education according to the instructional content model by Sun and Williams[11].

2.2 Proposed Metadata Structure for Higher Education Learning Objects

As far as the adoption of the definition of a RLO from Sun and Williams[11] by this research is concerned, the we further add new metadata elements in the schematic representation(see figure 3). For example, Sun and Williams[11] do not provide *identifier element* for RIOs yet they show that it is possible to have a RLO with many RIOs(see figure 1 above). It is also possible that a RIO has an external asset file (such as an image, an audio/video file or a code snippet) that is part of content in the RIO. We thus introduce another metadata element on the RIO called *asset file* that stores information about any external file which could be part of the content of the RIO. We also introduce three metadata elements on the practical object, namely; the *identifier* (since it is also possible to have many practical objects in one RLO), the *target RIO* (since each practical is meant for a particular RIO) and *the asset file*(since it is possible that the practical object also has external files like images and code snippets or Java applets). We further introduce four metadata elements on the assessment object, namely; *the identifier,* the *target RIO* since it is possible to have an assessment object per RIO, the *assessment question* which the learner should answer and also the *asset file* (since it is possible for an assessment to have an external file). In figure 3 below, the *dotted lines* indicate the new metadata elements that we are adding to the existing metadata structure in this research, as a way of adapting the higher education learning object metadata structure in Sun and Williams[11].

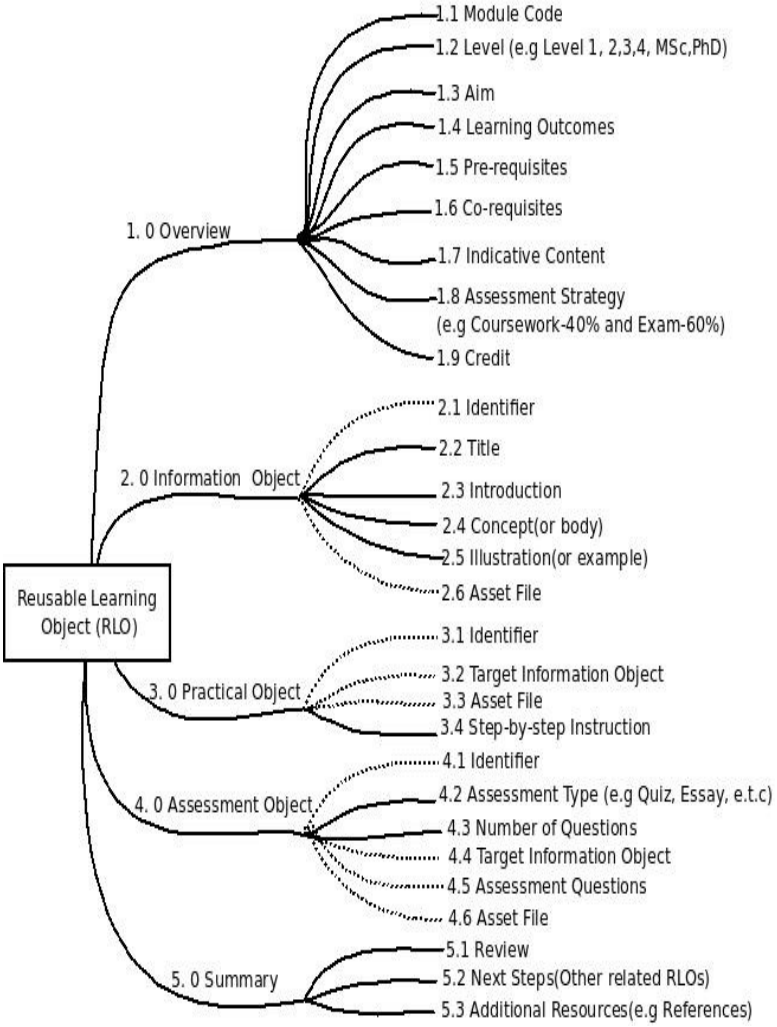

Fig. 3: A schematic representation of the proposed metadata structure for a higher education RLO with multi-format assets.

3 METHODOLOGY FOR EVALUATION OF THE PROPOSED METADATA STRUCTURE FOR HIGHER EDUCATION RLO

3.1 Choice of Methodology for Evaluation

To evaluate the proposed metadata structure of higher education RLOs with multi-format assets, we opted for an evaluation method that allows experimentation of this metadata structure in its prospective environment where the we could be passively involved. The justification for this choice was motivated by the need to get feedback from the prospective users who are practitioners in the field of instructional design for higher education course materials. This led us to choose field experimentation method [14] by using a prototype that instantiates the proposed metadata structure. Below we present how this prototype was developed and used in the evaluation process.

3.2 Development of the Tool for Evaluation

We developed a web based tool that can be used to author and adapt RLOs with a metadata structure presented in figure 3 above. This tool is called LOADAPTOR (short for Learning Object Adaptor) and it is currently hosted online as a web based application at www.loadaptor.com. This tool provides a number of functions to guide higher education instructional designers to create and adapt RLOs with multi-format assets. Figure 4 below presents a sample usecase for the different actors and their roles when using this tool and figure 5 presents a sample of a RLO under preview in LOADAPTOR tool.

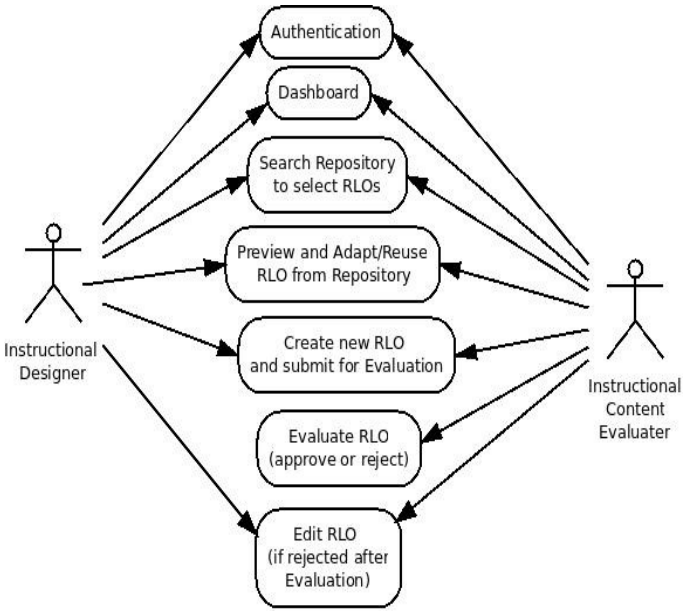

Fig. 4. Sample Use case showing actors and their roles when using the LOADAPTOR tool.

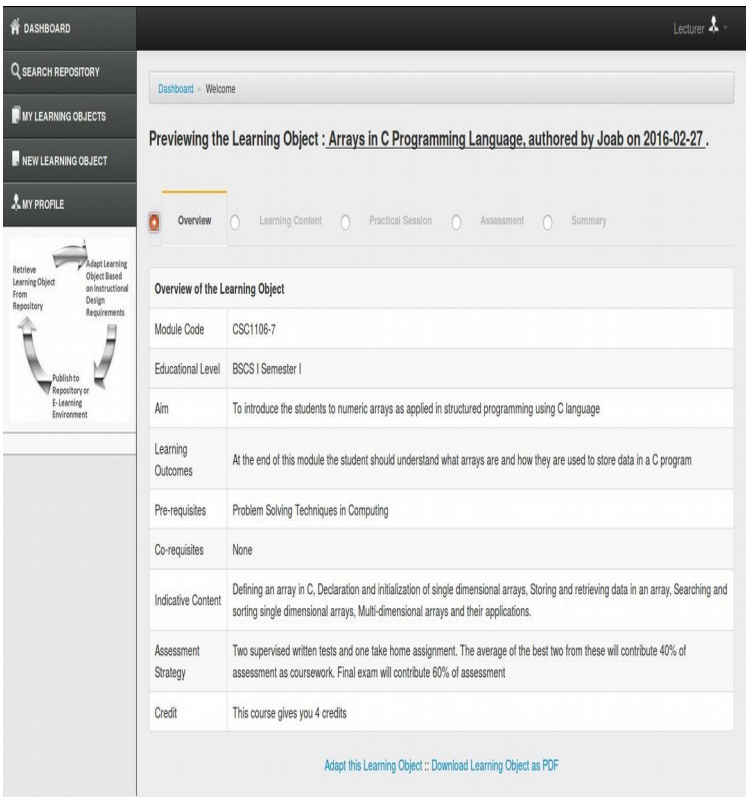

Fig.5. Sample of a RLO under preview in LOADAPTOR.

3.3 Evaluation of the Proposed RLO Metadata Structure using LOADAPTOR Tool

To evaluate the proposed metadata structure, we evaluated the functionality, the usability and correctness of the LOADAPTOR tool as far as authoring and adaptation of RLOs (that have the proposed metadata structure) in higher education instructional design is concerned. The choice of these three quality attributes to evaluate the tool was based on suggestions by Hevner *et al*[15].

We used expert sampling technique[16] to randomly select 8 experts in higher education instructional design from three different universities in Uganda. After analyzing the feedback obtained from these 8 experts, the evaluation process was repeated using a new different sample of 10 experts in instructional design who were randomly selected using the same sampling technique from 5 different universities in Uganda. The results from the two experiments are presented in next section.

4 RESULTS OF EVALUATION

4.1 Results of the First Experiment

Functionality of LOADAPTOR tool. Focus was put on how the tool supports the following functions in higher education instructional design process;

A. Author standard RLOs based on instructional design needs from various stakeholders.
B. Secure the instructional materials designed by the instructional designer through authentication and various access levels.
C. Search the online repository for existing RLOs and reuse such RLOs based on instructional design needs.
D. Create and publish quality instructional content to repositories by allowing public access to only RLOs that have been vetted and approved for publication by subject area experts and instructional design experts.
E. Publish the adapted RLOs to the repository or download them for e-learning environments.

Each of the above system functions (A to E) were rated by the 8 participants of this experiment on a Likert scale of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. Fig. 6 below presents a summary of responses from the participants of this evaluation process.

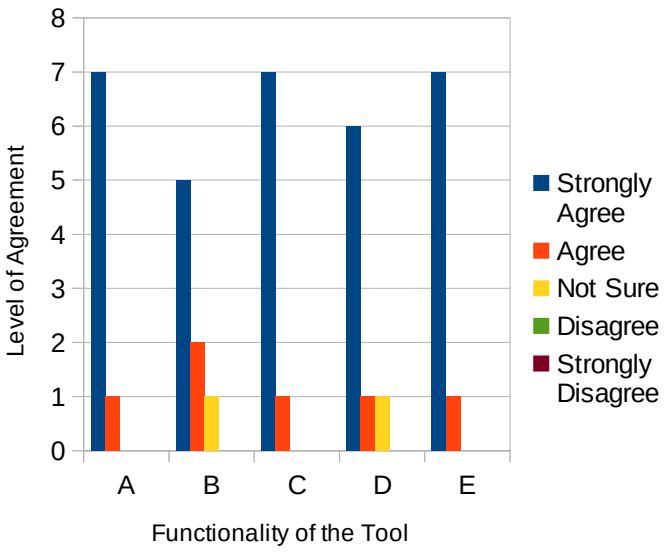

Fig.6. Summary of responses from the 8 experts about the functionality of the LOADAPTOR tool.

Usability of the tool. Focus here was on establishing how easily the tool enables the instructional designer to author, adapt and reuse RLOs in higher education instructional design process. To achieve this, the participants of the experiment were requested to rate their agreement with the statement that *"the tool is easy to use in authoring, adaptation and reuse of RLOs in higher education instructional design process"* based on the Likert scale of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. Out of the 8 experts, 7 (87.5%) strongly agreed to this question, and 1(12.5%) agreed. The rest of the values on this scale had no response.

Correctness of the tool. Focus here was on establishing how the tool correctly instantiates the process of authoring, adaptation and reuse of RLOs in higher education instructional design. This was rated by the participants of this experiment on a scale of Excellent, Very Good, Good, fair, Poor Very Poor and Does Nothing. Out of these 8 experts, 1 expert (12.5%) said that the tool was excellent, 4 experts(50%) said that it was very good, 2 experts(25%) said that it was good and 1 expert(12.5%) said that the tool was fair. The rest of the options under this question had no responses.

In addition, each of the 8 experts was requested to suggest how the tool can be improved and such suggestions were implemented to improve the tool.

4.2 Results of the Second Experiment

When this experiment was repeated with a new sample of 10 instructional designers from 5 different universities in Uganda, we organized a two hours workshop on higher education in instructional design for the 10 participants. They were requested to use the improved LOADAPTOR tool in authoring, adaptation and reuse of RLOs and after, each participant was requested to provide feedback about this tool. The approach used in the first experiment above was also used to get feedback from the participants in this second experiment. Figure 7 below presents a summary of the responses from the 10 instructional designers about the functionality of the tool.

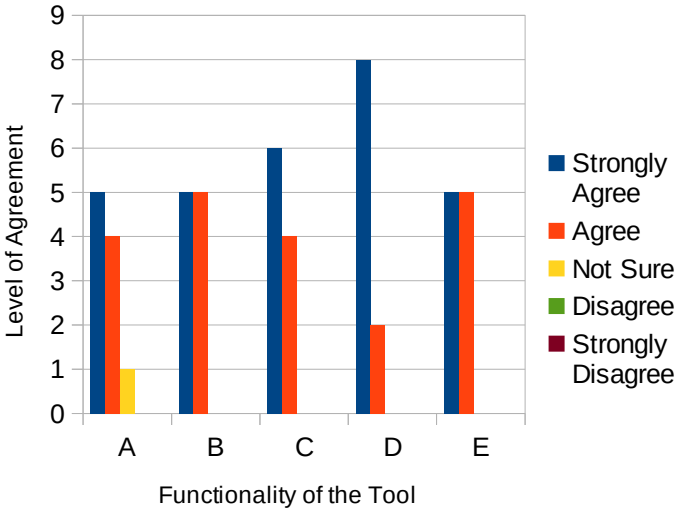

Fig.7. Summary of responses from the 10 instructional designers about the functionality of the LOADAPTOR tool.

Usability of the tool. As it was done in the first experiment, focus in second experiment was on establishing how easily the tool enables the instructional designer to author, adapt and reuse RLOs in higher education instructional design process. To achieve this, the 10 participants of this experiment were requested to rate their agreement with the statement that " *the tool is easy to use in authoring, adaptation and reuse of RLOs in higher education instructional design process"* based on a Likert scale of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. Out of the 10 participants of the

experiment, 4 participants(40%) strongly agreed to this statement, 5 participants(50%) agreed and 1 participant (10%) was not sure if the tool was easy to use. The rest of the values on this scale did not have responses.

Correctness of the tool. Still, as it was done in the first experiment, focus was on establishing how the tool correctly instantiates the process of adaptation and reuse of RLOs in higher education instructional design. This was rated by the participants of the experiment on a Likert scale of Excellent, Very Good, Good, fair, Poor Very Poor and Does Nothing. Out of the 10 participants in this experiment, 7 participants(70%) indicated that the prototype was very good while 3 participants(30%) indicated that the prototype was good as far as adaptation and reuse of RLOs in higher education instructional design process is concerned. The rest of the values on this scale did not have responses.

The results from the two experiments showed a strong positive correlation and this proved that the proposed RLO metadata structure can be adopted by higher education institutions in instructional design process to create RLOs for their e-learning environments. Using such an enhanced metadata structure helps to improve on the reusability of the RLOs developed.

5 CONCLUSION AND FUTURE WORK

This paper focused on proposing a metadata structure for a higher education RLO. This was achieved by adaptation of existing RLO metadata standards through extension of the metadata sets. The extensions that were added aimed at improving adaptability of such RLOs with multi-format assets. The two experiments done to evaluate the proposed metadata structure for higher education RLO showed a strong positive correlation which proved that the proposed RLO metadata structure can be used to author, adapt and reuse RLOs in higher education instructional design.

Future will focus on measuring the learnability of the instructional content created using RLOs with such a metadata structure in higher education institutions.

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