Design and Development of Metadata Management Tool for Learning Objects

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ABSTRACT

Learning objects (LO) reuse is one topical area in instructional design that is gaining popularity in the education economy. It hinges on high hopes and promises to transform how learning occurs in the information age. This study attempted to identify and interrogate the core characteristics of reusable learning objects and conceptualize them as innovations in the curriculum development process. The goal was to synthesize existing knowledge on learning objects, weave streams of literature and research to focus on core arising issues, and then develop an instructional design tool that can help learners easily and effectively find reusable learning objects. The learning objects could be categorized and deconstructed to the levels of their instructional design transformations with regard to macro and micro-level reusability. The researcher used combinatorial developmental research with integrative literature review methodologies to design and develop a metadata management tool. This study involved an in depth review of literature on learning objects, reusable learning objects and their associated metadata management schemes through the integrative literature review approach. Results and data from the integrative literature review were then utilized to design and develop a tool addressing meta-tagging schemes, metadata management, search, and access of learning objects. The researcher identified characteristics of learning objects within the reuse process and discussed best practices, reuse procedures and modeling, based on the analysis of existing cases such as the Open-Knowledge-Initiative (OKI) projects to aid in the tool development. Integrative analysis running concurrently with the development process allowed for rigorous identification and alignment of key factors in the learning objects reuse universe. If fully developed, the

metadata management tool could contribute to effective metadata management for learning objects often reused by learning designers, deliverers, and consumers.

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GENERAL AUDIENCE ABSTRACT

Learning Objects (LO) reuse is gaining popularity in the field of instructional design. This is because it could transform how learning occurs in today's information age. In this study, I outlined the important characteristics of reusable learning objects and set them up as creative and re-creative products in the curriculum development process. My goal was to combine and reproduce existing literature on LOs that would allow me to develop an instructional design tool to help learning content designers, deliverers, and consumers to easily tag, search, then find reusable learning objects. I reviewed literature on learning objects, reusable learning objects and their associated metadata management schemes then used this data to design and develop the tool addressing meta tagging schemes, metadata management, search, and accessibility of learning objects. The tool allows LO categorization and deconstruction to the largest and smallest granular levels of their instructional reusability. I combined a developmental research method with an integrative literature review method to design and develop the prototype of a tool known as metadata management tool (mmt) for reusable learning objects. If successful, the metadata management tool developed could contribute to an effective metadata management for learning objects often reused by learning designers, deliverers, and consumers.

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Chapter 1: Introduction

Access to learning resources in the form of responsive teaching, integrated with relevant content, information technology, and instructional design could go a long way in mitigating the skills gap that persists in today's workforce (Abagi, Nzomo, & Otieno, 2008; Chege, 2006; Ernest, 2014; Inter-University Council for East Africa, 2014; Maina, 2015). Although robust educational resources might play a significant role in addressing current skills gaps, these resources may not be available due to the expenses associated with their acquisition or the time required to produce those resources.

Learning objects are potentially an economically feasible means of acquiring these meaningful learning resources due to their standardization, interoperability, and heterogeneity with minimal to no cost for collection, storage, referencing, discovery, delivery, sharing, and reuse (Allen & Mugisa, 2010; Silveira, Omar, & Mustaro, 2007b). Learning objects can present flexible architectures allowing robust access to, and cheaper acquisition of, learning resources (Harsch, 2000; Wagner, 2000; Wiley, 2000a), thereby making it possible to minimize or eliminate many of the expenses and resources required to create a new learning resource compared to reusing existing ones (Cline & Luiz, 2011; Ernest, 2014; Manyika et al., 2013).

Learning objects with open source content have the potential to provide key learning resources in instructional development processes that are vital for educational success (Gustafson & Branch, 1997a, 1997b). Open source content as used in this study refers to content made available beyond the fair use clause at no, or minimal cost, but accompanied with licensing provisions such as the creative commons. This nature of openness allows foregoing costly royalty payments and legal strictures that often constrict access and widespread availability of quality educational material (Harsch, 2000; Littlejohn, 2003; Wagner, 2000; Wiley, 2000a).

Learning objects are one form of open source content. Barritt and Alderman (2004) define them as a collection of independent "content and media elements" including learning architecture, learning approaches, context, interactivity and associated metadata used to index, store, search, and then find the resources within a repository system (pp.7-8). Although Barritt and Alderman's definition makes no mention of reusability, it is a key feature included by many scholars in their definitions of learning objects (Littlejohn, 2003; McGreal, 2005; Morris, 2005; Silveira et al., 2007b). In fact, the ability to adapt an existing learning object with little or no modification for use in another situation is what makes reusable learning objects appealing to many users. Because learning objects can be aggregated or disaggregated, repurposed, and reused in chunks (Wiley, 2000a), it is possible to minimize or eliminate many of the expenses and resources required to create new products (Stockdill & Morehouse, 1992).

Effective use of learning objects calls for access to, and awareness of such resources. A careful selection of strategies for accessing, building, hosting, searching, consuming, and distributing such content is also needed (Koohang & Harman, 2007). Without a tool to store, search, locate, access, and retrieve the objects, the effort required to use the objects may be prohibitive. For these reasons, after creation of the learning objects associated with these strategies, the objects should be stored in a form and location that makes them accessible when needed by future users. From this perspective, learning objects and reusable learning objects are interchangeable (Wiley, 1999). This study involved an in depth review of literature on learning objects, reusable learning objects and their associated metadata management schemes through an integrative literature review approach. Results and data from the integrative literature review were then utilized to design and develop a tool that addressed meta-tagging, metadata management, searching for, and accessing of learning objects.

Problems and Existing Gaps

Learning institutions need an economically feasible approach to updating their present course offerings. The use of learning objects has potential to address this need but currently there is no comprehensive, easily used framework for searching, finding, accessing, tagging, building, hosting, consuming, and distributing such content in a manner that will support updating or increasing present course offerings. Although learning objects are available through various sources, a disconnect exists in terms of their access and utilization. This study is based on the premise that an early step in addressing the dissonance created by the lack of a reuse framework might involve the need for an advanced metadata indexing system or a metadata management tool, to support the collecting, storage, and searching of relevant associated metadata. The reuse framework could contribute to efficient metadata management and utilization of learning objects to remedy the dissonance (Gakuu, Kidombo, Bowa, Ndiritu, Mwangi, & Gikonyo, 2009; Matinde, 2015; Moll, 2009).

Learning objects can take many forms. These forms are without a unique, universally recognized classification scheme or agreed upon metadata to identify their characteristics, thereby increasing the difficulty in finding them when needed. The materials, often hosted in or on various servers or repositories, include: libraries of images, videos, audio, and text; curriculum guides and text book guides; exercises, feedback tools, experience surveys, assignment submission tools, and evaluation tools; analogy tools, course maps, advanced organizers, discussion boards, portfolios, wikis, social media tools; and career information resources, virtual labs, and educational Application Programming Interfaces (APIs) or apps.

Ultimately a tool is needed that will permit storing, searching, accessing, retrieving, building, hosting, consuming, and distributing metadata associated with learning objects in a manner that will support updating or increasing access to present course offerings and open learning resources at various granularity levels. Although current users of learning objects have identified some key characteristics to include in such a tool, it is almost certain that more characteristics will be identified over time and it would be helpful if newly developed metadata management tools could accommodate the addition of these features as they are recognized. In their current forms, metadata management tools lack many of the desired features.

Problem Statement I

A problem associated with some existing metadata management tools is that they allow users to input only predefined metadata. For example, format types of learning objects typically include only document, audio, video, or other formats reflecting current technologies and format types. However, as technologies, knowledge, and social and institutional environments change over time, new types of metadata are almost certain to appear. Thus, a more flexible tool that can accommodate new categories and characteristics of metadata with minimal modifications to the tool will be required. The new metadata management tool should enable learning object content designers, deliverers, and consumers to add new metadata to tagged learning resources.

Problem Statement II

Proper classification of learning objects allows for better searches of tagged learning objects. A tool that helps in the management of metadata for open learning objects should accommodate semantics that both professional and general users recognize. Unlike librarians or experts in learning objects management, general users, are likely to have limited knowledge about metadata schemes for learning objects (e.g. Learning Object Management, Dublin Core, Instructional Management Systems, Merlot, Learning Technology Standards Committee, and others). A tool capable of integrating various metadata schemes for learning objects is required to provide users with a means to easily search and access needed learning objects and their metadata.

Problem Statement III

Metadata management tools that allow for both individualized and collaborative uses in tagging and sharing learning resources search lists are likely to be more useful than tools that do not have these features. Most existing similar tools focus on personalized, non-transferable administration of learning objects, rather than collaboration among users and sharing of their discoveries. By having curriculum, course, module, lesson, and topic metadata elements and also allowing users to add/edit metadata of learning objects, users can collaborate to create and manage a list of learning objects. Individualized search lists of learning objects with particulars on the granularity, description and location links to a learning resource aid in the packaging of learning objects with relevant metadata that can target users with similar needs. For example, a teacher can share a list with his/her students or colleagues to provide multiple learning objects on curriculum, course, module, lesson, or topic. Also, by providing links to search history, users can easily share the list of learning objects with other users.

Study Purpose

This study focused on designing and developing a tool that addresses tagging, managing, and searching metadata for learning objects. I performed an integrative literature review of relevant literature associated with learning objects, repositories, meta tagging, and classification standards. The research procedures I used as well as the data I examined helped me develop a metadata management tool prototype to aid in storing references to reusable learning objects and subsequently, searching for, finding, and retrieving relevant stored links to the reusable content. A thorough indexing system of collections with carefully structured and unstructured metadata values adds surety of search terms. This process could contribute to utilization of learning objects for learning designers, deliverers, and consumers, enabling them to find the learning objects and relate them to needs that users have. Some needs are big or small while others are institutionally large or departmentally small in terms of content.

Study Organization

Chapter 1 introduces the learning objects reuse study, highlighting surrounding topical issues, definitions, and benefits followed by the problem statement, the study purpose, and finally how this study is organized.

Chapter 2 contains reviews of literature dealing with key research concepts such as reuse, learning objects, granularity, and metadata. Its introduction focuses on the plain definition of reuse, elaborating the implied and applied meanings of the word in different contexts over time. The chapter explores learning objects and their digital repository-related concepts in various degrees, especially in trying to qualify them as applicable granular structures of reusable products in learning. It also investigates metadata as an administrative scheme for indexing and classifying learning objects. This section outlines the benefits of applying reuse in the process of updating, designing, or developing quality learning content. The chapter also presents reuse of learning objects in different contexts, assuming that a developed metadata management tool could become a solution to help in easily finding and classifying existing learning resources.

Chapter 3 presents the research methodology by focusing on the processes employed in identifying pertinent literature on the concepts, constructs, and issues raised, and elaborating the identification, analysis, synthesis and reporting on the literary data gathered. The section outlines the following: the design and development research co-modified with the integrative literature review method for creation of the tool including literary selection strategy; study design; the research design; literary analysis methods; and finally tool assessment and review.

Chapter 4 presents the literary data findings including analytic discussion of the tool development process from integrative literature review of the selected text. The integrative literature review focused on the learning objects four-volume anthology by Alex Koohang and Keith Harman (2007) as the initial basic text for analysis and synthesis.

Chapter 5 presents the application of in-progress data extracted to develop the metadata management tool including a prototype with its accompanying functionalities and capabilities. It includes development of a new metadata scheme that integrates various metadata schemes exemplified in the Chapter Four texts. The chapter also outlines the sourcing and inclusion for controlled vocabularies built into the tool.

Chapter 6 contains reflections dealing with the entire study. It includes a discussion of the results from the tool review and outlines the designing and development processes leading up to the presentation of the metadata management tool from an intrinsic perspective. Reflection topics include actions and the thoughts behind the tool development, what skills were applied and what lessons were learned, and improvement propositions for future uses based on expert opinions. In the reflection section, particular reasons of relevance for including or omitting certain in-progress research data and literary sources to enhance the study validity (Cooper, 1984, 1998) are presented and discussed. The chapter also presents recommendations about the unique contribution of the tool to education efforts concerning learning objects. The study's significance and limitations are explained with a few concluding remarks at the end. This chapter leads to the references section that includes citation and appendices for all sources of literature gathered and other relevant resources produced or utilized.

Chapter 2: Review of Literature

In my review of literature chapter I examined relevant textual material involving reuse, learning objects, reuse and reusable learning objects, repositories, learning objects repositories, granularity, and finally metadata. I focused on the plain definition of reuse, elaborating on the implied and applied meaning of the word in different contexts over time. My review also derived possible characteristics of reuse in different configurations resulting in a concept model with factors that were a possible reuse conceptualization. I explored repositories in various degrees especially in trying to qualify them as applicable granular structures of reusable products in learning. I also investigated metadata as an administrative scheme for handling classification of terminologies and resource nomenclature. My review further posited that with reuse and metadata integrated into the development of high quality courses, users can meet other curricular needs such as improved search and accessibility to quality reusable learning resources in repositories. My review finally approached the metadata management tool as a solution, assuming that a developed metadata management tool might help in easily searching, finding, and classifying existing identified learning resources.

What is Reuse?

In its simplest form, *reuse* means to take a used product and utilize it again. The key issue to look at when considering reuse would be determining if reuse of a component is desirable in a previous capacity or in a newly applied capacity. This could also involve injecting some form of creativity into an already existing system, exploiting new markets, identifying new users, or combining the old component with existing and new ones. The overarching theme is creatively extending an original product's life. In a strict reuse context, resources are not disposed of, or reprocessed; their lifespans are extended or salvaged for other uses, or same use, by the same or different users.

According to Rothernberger, Dooley, Kulkarni, and Nada (2003), reuse may reduce the cost and development time. Reuse researchers have identified key characteristics that are familiar across many disciplines. Among them: modularity (e.g., where software components are reused in larger applications), evolution (e.g., where system components are reused as they evolve in response to changing needs), portability (e.g., where a program or software tool is reused or applied on many computers), and maintainability (e.g., whereby an unchanged part of a program is reused by attaching it to a different system component) (Biggerstaff, 1999).

There are alternate conceptualizations of reuse where products are involved. Normally, products assume an anticipated use by an anticipated user. The anticipated use occurs within an appropriate environment or context. This means the product is subject to various constraints, allowances, or demands associated with it and its contextual uses. As much as these factors interact with one another during the initial use of a product, these same factors might interact with another user, but in different ways, especially when a product is in reuse. To the extent that a user manipulates the modified interactions in a deliberate manner, productive reuse of a product may be both possible and desirable. Table 1 shows examples of some ways in which the factors might interact to produce desired reuse outputs:

Table 1.

Examples of Reuse Possibilities

No.	Reuse Concept Statement
1.	the same product can continue to be used as originally designed by the same users,
2.	the same product can be remodeled for a different use and different user,
3.	the same product can retain original use by different users,
4.	the same product can be remodeled for different use but for the same user,
5.	the remodeled product can be used differently by the same user, and finally,
6.	the remodeled product, used differently, by different user.

Learning Objects

The term “learning objects” may have a variety of definitions depending on the discourse in which it is discussed. The simplest and most common definition of learning objects is a unit of instruction "used to support learning" activities (Littlejohn, 2003, p.2). You can aggregate or disaggregate these units, store them in repositories, or reference their location to realize various learning outcomes while applying them in various learning contexts (Allen & Mugisa, 2010; Carliner, 2008; Littlejohn, 2003; McGreal, 2005; Wiley, 2000b). A collection of these independent reusable units stored and properly indexed in repositories constitute a reusable learning repository. Merriam-Webster defines repositories as a place, or container where things are stored. Ted Nelson experimented on an early form of reusable learning repositories in his XANADU project around 1960 (Nelson, 1996). In the project, Nelson conceived of a system in which a content creator gains access to content in a fixed archive in its unedited format, but whenever a different user wanted to modify the original content to fit other needs, a new resource is generated thereby making other users have access to multiple versions of the resource. Nelson termed this process as PRIMEDIA to describe the primitive way in which references to original content within a given system operates.

Decades later, Wayne Hodgins coined the term ‘learning objects’ (circa 1994) and by this time, programmers were also using the term while making extensible coding packages (Wiley, 1999). In the past few years, learning objects have become the confluence of instructional technology where instructional designers reuse them in course content design, development, and delivery. The result is an evolution in rethinking the traditional education economy for the next generation.

In order to advance a theory of learning objects and open repository reuse, there is need to understand key elements including definitions of terms, metaphorical analysis, and the scope to operationalize the elements.

A universally recognized working definition of learning objects (LOs) is drawn from Wayne Hodgins who defines LOs as "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" (Learning Technologies Standards Committee, 2000).

McGreal's terminology for learning objects. In defining learning objects, McGreal (2004) suggests viewing them through accepted specifications when applied to interoperate in different applications by different users in various environments. Such multiplicity of factors makes a commonly acceptable single definition difficult. However, there are general terms used to describe learning objects which McGreal (2004) classified into four categories:

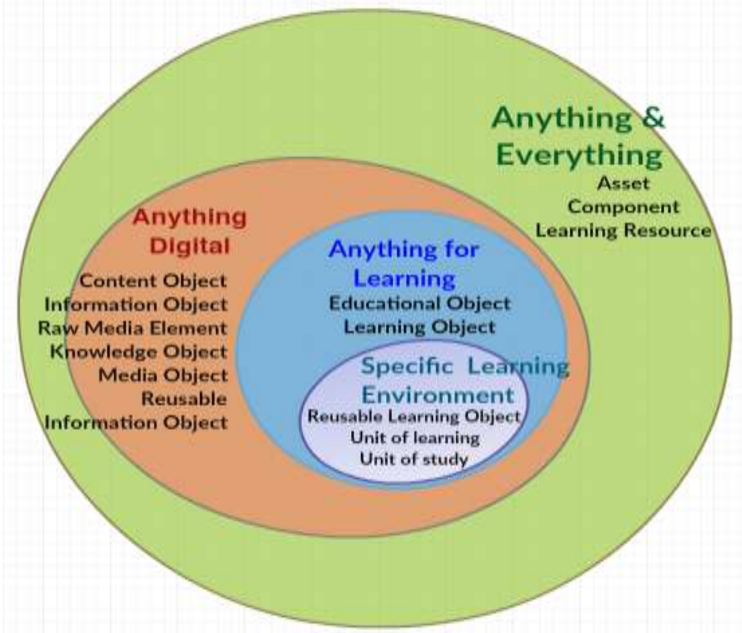
Table 2.

McGreal's Four Categories for Learning Objects Definition

No.	Definition
1.	Objects that could be anything (including educational assets, classroom components, and learning resources)
2.	Objects that refer to digital items (information rich content like media files and accompanying elements)
3.	Digital objects designed with a learning outcome in mind
4.	Specific objects fitting specific standards like Scalable Content Object Reference Model (SCORM) and learning environments such as Reusable Learning Objects (RLOs)

Source: McGreal (2005, p.8)

The four categories shown in Table 2 were widely critiqued for being broad and not demonstrating the level or size of the learning object. To demonstrate the different levels of granularity, McGreal presented a concentric diagram of how everything fits in his scheme of categorization as shown in Figure 1 McGreal's (2004) Terminology for LO.



McGreal's (2004) figure showing terminology for learning objects. Reprinted from *Learning objects: A practical definition*, by McGreal R. Copyright 2004 by Rory McGreal, Reprinted with permission

Figure 1. McGreal's (2004) Terminology for Learning Objects

Some definitions of learning objects share the most basic tenets of object-oriented programing such as encapsulation, feature inheritance, and abstraction (IEEE, 2002; Learning Technologies Standards Committee, 2000; Morris, 2005). In object-oriented programming, software engineers look to data pools called nodes, which act as either parent or child, with both sharing similar referenced or inherited features. This is the polymorphism process where reuse involves referencing the object characteristics instead of recreating them. For instructional designers, learning objects describe unit elements referenced or conscripted onto larger delivery systems supporting the events of instruction (Shank, 2008). Much like the general systems theory, LOs parallels these learning units to denote wholeness as well as differentiation in the smaller elements. The objects would then reside in their conscripted environment and inter-operate at various levels of granularity. Functionality happens when convergence of information pieces become products for use within or outside the system or both (Bertalanffy, 1972).

Context typically is significant in the integration of reuse. While advocating for modern student-oriented learning practices, Shulman (2005) noted that current technologies ought to support foundational knowledge that learners can build their careers on. With currently known perennial lack of teachers for special subjects in remote schools in rural America, a learner desiring to study courses or subjects not available in their curriculum can search, find, and access relevant learning objects packages to bolster or prepare their knowledge base using remedial online session. This blended modern learning context is also in line with extracurricular design-based learning (EDBL) schemes. The EDBL model is useful for self-directed learning, as propositioned by Gerber, Olson, and Komarek (2012). The EDBL-model-learner would earn online credits, giving school administrators relief from having to hire teachers, or offer advanced courses they cannot afford. The learner benefits from reuse of learning objects as the reuse mechanism encourages franchising and other forms of partnerships (Abagi et al., 2008).

Combining information objects forms larger structures known as "Reusable Learning Objects" (RLOs) (Hodgins, 2002, p.78). For course content developers and designers, these LOs are in various forms including texts, java applets, graphics, websites, and video-snips making them support resources to reuse for learning. With the appropriate indexing linkages (commonly known as metadata) combined fragments can form topics, then lessons, which in turn form modules, which in turn form courses, which in turn form curriculum, when appropriately assembled (McGreal, 2004; Rehak & Mason, 2003).

Learning objects utilized effectively in education signify performance improvements in the form of text, images, media, metadata, modules, or any other information resources organized in a manner that would enrich learning experiences (Wiley, 2000a). The objects are generative in nature and can be identified, interrelated, and tagged through data description modalities known as metadata. Through deconstruction and reconstruction processes, learners and designers can use these information objects to build new meaningful learning content that in themselves become knowledge bases or repositories (Bannan-Ritland, Dabbagh, & Murphy, 2000). The objects are only applicable in various usable sized-chunks or granularity levels.

According to Wiley (2000a), there are certain sizes and layers of granularity that will make learning objects more usable when transferred to other learning contexts. Generativity, scalability, and adaptability of learning objects depend on the sizes instructional designers can use to determine the scope and sequence of learning in various environments. Bannan-Ritland et al. (2000) list three fundamental granularity layers activated in instructional environment which are: (1) combined or generative information objects, (2) contextualized frameworks representing macro-level scaffolding, and (3) de-contextualized fundamental information objects at the micro-level.

In non-traditional learning contexts, especially computer-based learning environments and e-Learning systems, learners can take advantage of learning objects and construct their own forms of learning processes and experiences (Shank, 2008; Siemens, 2007). Learners can take advantage of quality and contextually relevant learning content from existing repositories, or utilize presentations, question databanks, rubrics, images, media etc., to fit their individualized cognitive abilities (Bannan-Ritland et al., 2000). Instructional designers can make use of reusable learning objects by employing various tools or knowledge management and content management systems to construct effective learning.

According to Gibbons, Nelson, and Richards (2000), LOs fit process education in various ways including incorporating them in instructional "messages", "strategies", and "representations" among others (p.54).

Learning Objects in Reusable Context

While discussing the future of learning objects Wayne Hodgins portrayed them as a form of reuse in the education field (Hodgins, 2002). For all purposes of definition, learning objects are a good fit as an instructional technology because they become the component in the structure of instructional processes where design, development, and delivery are associated in one way or the other (Wiley, 2000b).

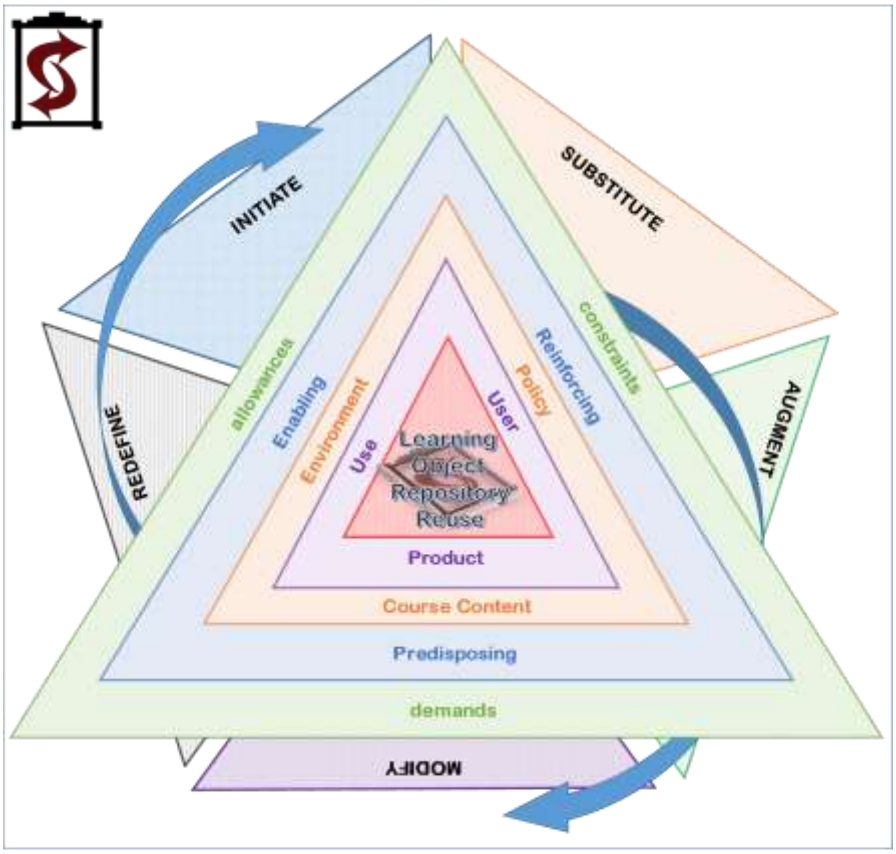
Learning objects take digital materials and adapt them for teaching in various contexts (Cheal & Rajagopalan, 2007). Some learning objects in themselves have a restriction of not being interoperable (Littlejohn, 2003). In order to class them as reusable, software applications enable interoperability only for objects that meet transferable specifications. Specifications bring the challenge of devising modalities that will operationalize reusable learning objects in an instructional design context. According to Shwartzman, Runyon, and von Holzen (2007), learning objects floating freely in a twilight zone are "technically NOT learning objects" until operationalized in an "actual instructional context" (p.37).

Many have argued that instructional design plays a major role in incorporating learning objects into existing systems. Generally, instructional design connotes the practice of retrofitting educational objects and objectives into proctored contexts through custom-built databases, webpages, and interfaces that users operate to provide appropriate branding and meet certain course goals (Koohang & Harman, 2007).

In discussing digital and open course content, Vale and Long (2003) identify the OpenKnowledgeInitiative (OKI) and OpenCourseWare (OCW) projects as pioneering the needed architecture and framework for reusing open educational learning resources. The breakthrough is promoting aspects of digital learning repositories when exploited to expand the horizons of educational products. Reflecting back on the twilight zone analogy, Gregson, Metcalfe, and Crewe (2007) defined twilight zone as a temporary resting point for possession where products assume new functions, exempted from the order for which they were originally created (normal innate function), to be reactivated by other user interventions. Learning objects reuse envisions a minimal transaction impediment between the inventors and innovators with the promise of reusability (Hall, Watkins, & Eller, 2001; Reigeluth & Nelson, 1997; Wiley, 2000a).

There are four general steps associated with design-based approaches for incorporating reusable learning objects into instruction i.e., Substitution, Augmentation, Modification, and Redefinition (SAMR). Instructional designers are adept at retrofitting the SAMR approach at various learning development stages (Puentedura, 2012). SAMR becomes a predisposing stage which digital content, tools, or goals undergo when subjected to reusability.

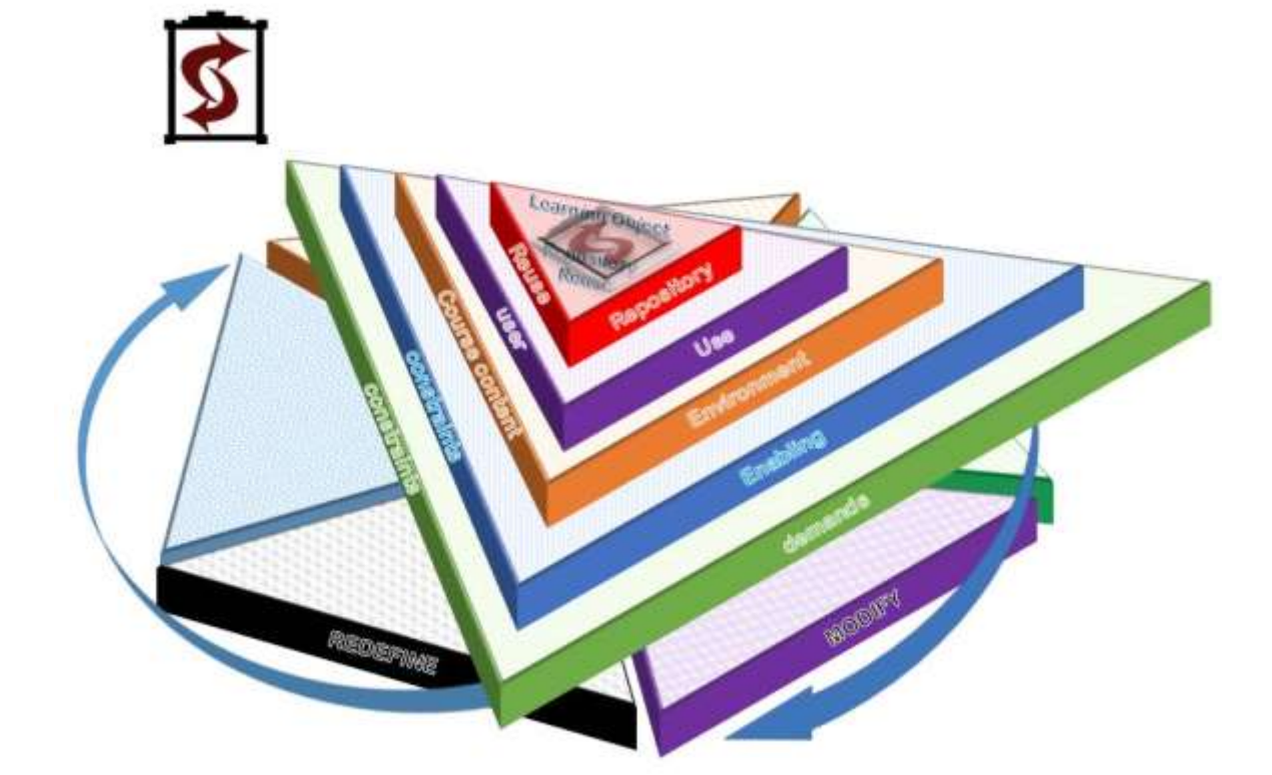
iSAMR. The culture of 21st Century learning calls for learner-centric approaches (Shulman, 2005). The anticipated outcomes of instructions are traditionally the same (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). However, instructional content creation and consumption has evolved due to technological advances or environmental predispositions among other factors (Gabbert, 2003; Reigeluth & Nelson, 1997). Ruben Puentedura (2012) offered the SAMR model to enable content consumers to reuse extant resources. In the SAMR model, there are only resource transformation and enhancement features. Due to multi-disciplinary, inter-disciplinary, transdisciplinary, and emergent new fields, Puentedura's SAMR model needs modifications to include an initiation phase. An initiate-phase will enable the creation of previously nonexistent elements within the reusability taxonomy.



Learning objects repository reuse concept diagram incorporating SAMR/iSAMR models. Adapted from *SAMR: Thoughts for design*, by R. Puentedura. 2012. Adapted courtesy of the Creative Commons Attribution-Noncommercial-Share Alike 3.0 License, by Ruben Puentedura.

Figure 2. Learning Objects Repository Reuse Concept Diagram

From the reuse concept map (see Figure 2 Learning Objects Repository Reuse Concept Diagram), all interacting factors can interchange against the iSAMR model which forms the base of the pyramid. Factors align to signal substitution, augmentation, redefinition, or the modification phases. For example, Figure 3 shows the –product, –course, –predisposing elements, and –demands that ought to be –modified in order to realize reuse. In this sample (see Figure 3 Learning Objects Repository Reuse Concept Elemental Alignment), for effective use of chosen learning objects, the aligned –use, –environment, –enabling factors, or –situational demands need –modification:



Learning objects repository reuse concept elemental alignment incorporating SAMR/iSAMR models. Adapted from *SAMR: Thoughts for design*, by R. Puentedura. 2012. Adapted courtesy of the Creative Commons Attribution-Noncommercial-Share Alike 3.0 License, by Ruben Puentedura.

Figure 3. Learning Objects Repository Reuse Concept Elemental Alignment

Learning objects iSAMR transformational analysis. A situational analysis provides practitioners interested in the learning objects to investigate the particularity and complexity of a single case. This analysis, including a needs analysis, enables a practitioner to have an understanding of existing or non-existing resources bounded within desired circumstances and relevant contexts (Cheal & Rajagopalam, 2007; Poulin, 1999). Instructional designers, being content agnostics, usually plan and place learning objects within instructions to realize the most value and meaning in complex objective-based frameworks or arrangements. The iSAMR phases are as follows:

Initiate: this stage envisions a situation where novel programs are proposed. Through domain analysis, stakeholders would build collections that work in concert with identified needs. The drive is for new subject demands, arising skills gap, workforce retraining, or transdisciplinary learning initiatives. Key stakeholders scrutinize their needs, and match them with learning objects at respective granular levels that would address these needs.

Substitute: in cases where resources in the repositories are better in quality or the latest in addressing the current affairs, stakeholders would only substitute resources that fit the criteria to be replaced/substituted.

Augment: this is where stakeholders see their existing content as sufficient but bolstered by elaborate quality examples. Augmentation would mean incorporating and co-opting resources to complement what already exist with functional improvements.

Modify: through a maintain-or-retire process, stakeholders can tweak existing learning resources to fit new learning objectives, or meet supplemental needs that were previously outside the purview of the original learning design. This stage allows for significant course or content redesign.

Redefine: allows for valuation and re-evaluation of known learning programs or structures and fully adopting quality resource equivalencies. Redefinitions may occur at corporate/managerial level when original missions, visions, objectives, and learning outcomes evolve through planning, restructuring, and investment.

Reuse and Reusable Learning Object

There is a lot of interest and research literature generated for the concept of diffusion of innovations world-over (Clark, 1983; Gronn, Clarke, & Lewis, 2006; Kozma, 1994; Reeves, 1993). Considerable effort seems to go to diffusing learning innovations to meet learning needs of communities within their context even when it comes to teaching with novel technology (Kozma, 1994). Innovations such as Byers' (n.d.) Teaching and Learning Using Locally Available Resources (TALULAR) initiative aimed to be easily accessible, simple to operate, and save re-invention energy or time while making use of local resources. The TALULAR initiative exploits locally available resources, which curtails re-development, re-manufacture or recycling transaction costs (Gwayi, 2009). SCORM setups successfully implement reusable learning objects especially in the most notable learning content management systems (LCMS) like Sakai, Canvas, WebCT, Blackboard, Moodle, among others. SCORMs are ready-made to operate on various platforms at different granularity levels for efficient delivery of instructional objectives (Allen & Mugisa, 2010; Mason, Oblinger, & Mackintosh, 2005; McGreal, 2004).

Granularity

A granule, according to Merriam-Webster (2004), is the smallest part of the whole especially one of numerous particles that form the whole unit. In education, it is the smallest instructional unit that is capable of aiding in the achievement of a learning objective either on its own or as part of a whole (Allen & Mugisa, 2010). Granularity would therefore become the scale or quality in which a section of a process or a system allows for deconstruction and transfer to a different context (Duval, Ternier, & Assche, 2009).

A common example given to illustrate granularity is a typical book with chapters, pages, paragraphs, illustrations, and figures. A book's chapter parts can disaggregate for use in a different course when selectively reused in a different course. The disaggregated units when successfully reused variously meet certain goals and objectives (Allen & Mugisa, 2010) depending on the "degree of componentization" (Silveira, de Araùjo, Amaral, de Oliveria, Schimiguel, Ledòn, & Ferreira, 2007a, p.151).

The most common components of reused items include designs, ideas, test cases, audio files, images, videos, and analysis documents which can be assembled or disassembled, at macro or micro levels to attain a specific desired learning outcome (Bannan-Ritland et al., 2000; McGreal, 2005; Rothernberger et al., 2003; Wiley, 2000b).

Learning objects and granularity characteristics. McGreal's (2004) imagery of learning objects (see Fig. 1) hardly paints a perfect graphic depicting a sure structure or nature of learning objects. Whereas McGreal places Reusable Information Objects (RIOs) at the second layer, Johnson and Hall (2007) classifies them as course content items, practice items, or assessment items. McGreal bases his universal approach on an operational definition. Johnson and Hall (2007) on the other hand, present a design process imagery whereby there is a distinct interrelationship between digital learning elements and their context. Context here includes the scale and relationships between learning objects themselves, the learning management systems or frameworks they are in, and finally any accompanying metadata schema (Bannan-Ritland et al., 2000; Bertalanffy, 1972; Johnson & Hall, 2007; McGreal, 2005; Nilsson, Johnston, Naeve, & Powell, 2007).

Duval and Hodgins (2003) acknowledge that course development and instructional design processes may make it difficult to differentiate the layers of subsumed learning objects within various systems. That is why there is a call for universal identification standards system known as metadata. The probable taxonomy of learning objects relative to its granular elementals in any learning system would look as shown in Figure 4. Taxonomy for Learning Objects Granularity especially as described by Johnson and Hall (2007, pp.200-201):

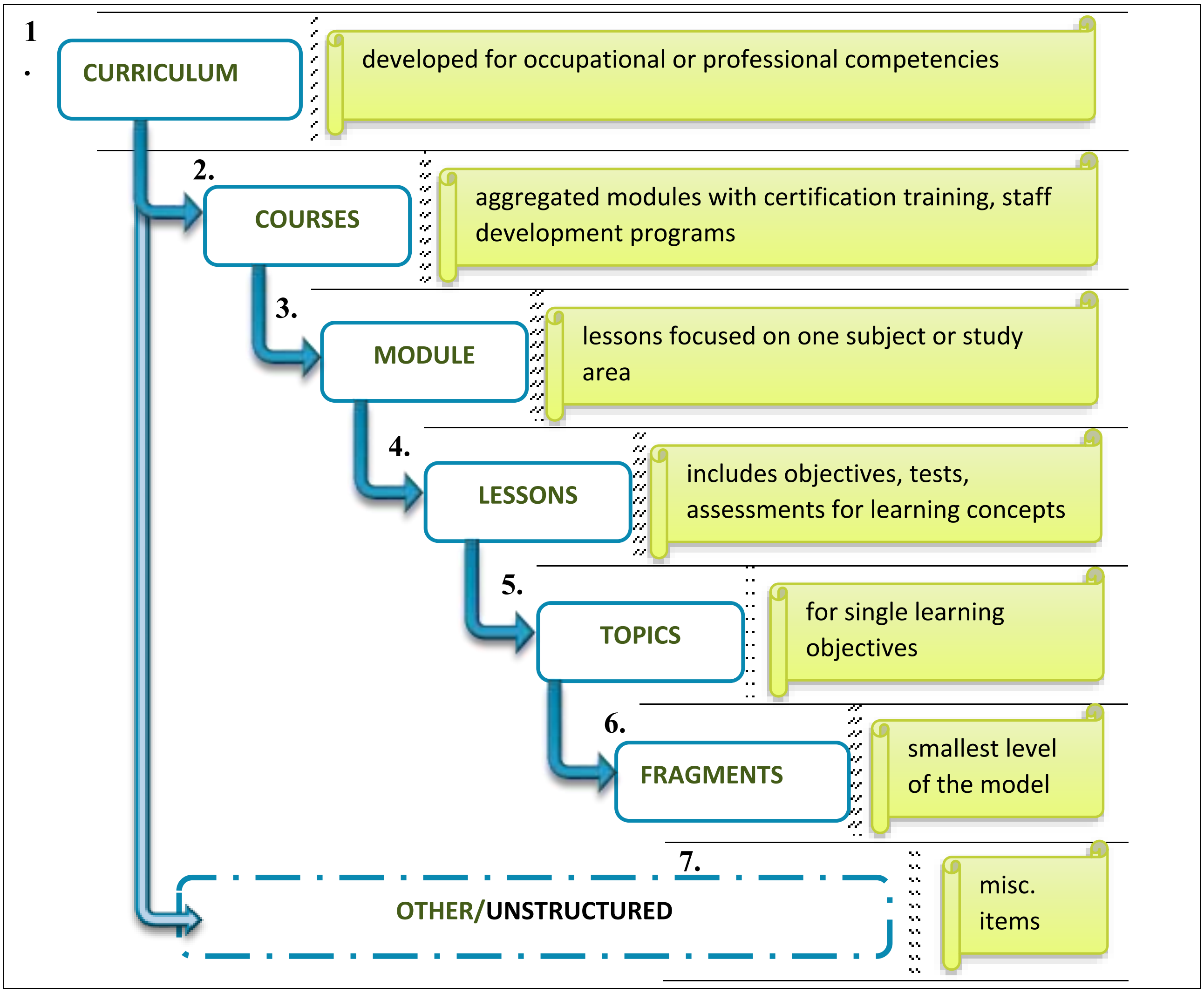


Figure of proposed extended ontology sourced from EnCoMpaSS, 2002. Adapted from Johnson, K., & Hall, T. (2007). Granularity, reusability and learning objects. In A. Koohang & K. Harman (Eds.), *Learning objects: Theory, praxis, issues and trends (Vol. I)*, (pp.181-207). Santa Rosa: CA: Informing Science Press. p.200. Adapted courtesy of Creative Commons Attribution-Noncommercial-ShareAlike 3.0 Unported License.

Figure 4. Taxonomy for Learning Objects Granularity

An aggregation or disaggregation of learning objects and their elements in various forms, chunks, or sequence gives rise to a granularity taxonomy. From Figure 4 illustration, fragments are the smallest divisible components in the learning objects granularity scheme. They may include examples, pictures, texts, videos, sentences, data, illustrations, animations, etc.

Learning objects, once applied, are hard to identify except through metadata (indices) because they may form part of digital libraries (Duval et al., 2009; Duval & Hodgins, 2003;

Johnson & Hall, 2007; Morisio, 2006). This is what led to the prevailing definition describing them as objects allowing reuse, cutting, trimming, or retrofitting (Learning Technologies Standards Committee, 2000).

According to Naeve (1999), when designing learning modules or planning a curriculum, instructional designers try their best to match content with context. At times, this makes applicability of content to context a sub-goal while targeting the learners and their latent knowledge base to the content. Traditionally, this was the effective way of developing courses to create meaningful learning. To reuse the same courses elsewhere, instructional designers disambiguate the content from the context. The process involves deconstructing components of the course to make them as abstract as possible and therefore, applicable in different contexts apart from the original. This transformation makes the course components flexible, customizable, and thus reusable. The separation is a step toward their reusability. Because learning objects tend to be digital, in a globalized virtual context, their reusability and associated extensible features dominates the education economy (Silveira et al., 2007b; Wiley, 1999).

Among the greatest features of learning objects in education is their reusability in diverse learning contexts by different learners at the same time (McGreal, 2005; Wiley, 2006b). Learning objects allow for automation and dynamic personalization of content to individual learners. This idea is similar to traditional pedagogy in academia where best practices in teaching pass on to other generations or cohorts (Zairi & Whymark, 2000).

Learning objects as singular independent units or generative information objects can plug-in to populate frameworks (Bannan-Ritland et al., 2000). As plug-ins, they meld into some places within the context of an existing system. Vitharana, Jain, and Zahedi (2004) called this template functionality. In the process, the plug-in feature works in conjunction with an enabling large object or co-equal elements to other objects, or being an object capable of supporting other objects, produce cohesiveness, effectiveness, malleability, and complexity to achieve reusability.

Other general features of reusable learning objects include simplicity and understandability. Simplicity and understandability as desirable feature for reusable learning objects mean the process of updating an entity is seamless without affecting other associated entities or processes (Prieto-Diaz, 1993). Most software engineers deal with complex designs and implement large scale information processing. They therefore require that development environment and tools remain robust, maintainable, extensible, reusable, and scalable (Pfleeger, 2001; Siemens, 2007; Vitharana et al., 2004).

Reusable learning artifacts might plug-in at any phase or granular level, among them: (1) –as standard data interchange format, (2) –architectures, (3) –designs, (4) –programs & common systems, and finally (5) –modules. In his seminal work, David Wiley (2006b) proposed Learning Object Design Sequencing Theory (L. O. D. A. S.). L. O. D. A. S. is a framework that provides a design guide for learning objects. Wiley propositioned that instead of instructional designers going through the trouble of creating their own taxonomy of learning objects, L. O. D. A. S. would provide the guides for analyzing and synthesizing content areas to pin point a prescriptive linking material. Learning artifacts then become 'linked' reusable learning objects allowing reusability in different contexts. Wiley worked on five classification modes of learning objects enabling the linkages, namely:

(a) “stand-alone types
(b) combined (accompaniment) types such as illustrations and audio resources
(c) combined modifiable types allowing for customization to match context theme, strategies
(d) generative types capable of reproducing applications and reference-capable material for other uses
(e) generative-instructional types which are superstructures that support and enable assorted advance learning activities”

Source: Wiley (2006b, pp.81-82)

These five archetypes play a key role in how to apply them at specific contexts. For example: stand-alone types can be a soothing audio file that a yoga instructor would port and play during a yoga session while combined types could be a PowerPoint presentation in a lesson where an instructor voices-over slides to elaborate key facts.

Once the characteristics of the learning objects are discernible, instructional designers can easily modify, adapt, or reuse them to fit different instructional goals and objectives as well as apply them to different contexts. To discern learning objects within a repository, they each need a unique, rich, descriptive identification management system.

Metadata and Classification Systems

Metadata are descriptive data about existing data, or simply put, "data about data" (Mitchell & Farha, 2007; Pomerantz, 2015). Metadata represent theoretical information attributed externally to objects or internally as the abstract nature of objects. Their use and functions is critical in the assemblage of learning objects because of the need to know elemental compositions that may be compatible for aggregation and disaggregation depending on the granularity levels.

Metadata provide, and serve as unique identifiers, maps or invisible codes that allow search optimization within libraries of resources (Pomerantz, 2015). Metadata employ naming conventions to ease accessibility, identification, and administration of various elements of learning objects especially in the digital arena. Metadata enable easier classification and management of LOs. Metadata also enable easier classification of resources in repositories requiring search and storage functions (Mitchell & Farha, 2007; Puustjärvi, 2007). By tagging learning resources to their elemental characteristics, learners and instructional designers looking for specific keywords can call-up specific or cluster of similar resources from a library through search functions. Metadata serve the purpose by enabling unique identification of resources or contextualizing its elements. Without such a framework, resources are lost or drowned in uncharted environments.

Designing a metadata management tool with elaborate schemes of classifying, tagging, and identifying resources might guide users or creators, in applying the most relevant metadata to learning resources. This allows for creating meaningful metadata to enable search and find functions within a reusable learning objects framework. Consolidation of the terminologies, descriptions, keyword, and characteristics from listed establishments and authorities as metadata contributes to the construction of a working nomenclature. This classification scheme provides a clearer picture into the full life cycle of the learning objects (Mitchell & Farha, 2007; Pomerantz, 2015). A simplified metadata scheme will ease its use in structured classification, at the onset, and can be modified (unstructured) as more learning objects are aggregated and disaggregated.

Professional catalogers commonly do cataloging because they have knowledge of standards of classification that make resource searches self-explanatory and easy to find. Catalogers apply refined standards and techniques as tools of their trade; they are less likely to be skilled in classifying or defining resources outside their fields of expertise. Particular topics such as do-it-yourself (DIY) or street-smart tourist resources among others may require broad approaches. This makes structural classification tools (such as the logic/Boolean approaches) built into most search databases efficient, but incomplete.

Catalogers can continue creating simple search indices for open learning object resources within a system, but a new framework should also include unstructured classification modes. The new framework works in concert with Boolean logic such that metadata tokens include AND/OR functionalities for both the professional catalog scheme and the common street-smart user.

Open access courses, including their resource storage and hosting capabilities, take many forms. These forms are without a universally recognized classification scheme or agreed upon metadata to identify characteristics of the courses, thereby increasing the difficulty in finding them when needed (Friesen, 2004; Puustjärvi, 2007). The materials, often hosted in various servers or repositories, include: open libraries of images/videos/audio/text, curriculum guides, text book guides, exercises, feedback tools, experience surveys, assignment submission tools, evaluation tools, analogy tools, course maps, advanced organizers, discussion boards, portfolios, wikis, social media tools, career information resources, virtual labs, and educational API's or apps.

A number of online open access courses have sprung up recently, including those run and managed under EdX, Coursera, MIT OCW, Udacity, and Open Yale, but there lacks a guiding, permanent, or universal (structured) classification that allows for their utilization (Duval et al., 2009; Friesen, 2004). Also lacking is an unstructured metadata system that would allow these open learning resources a searchability advantage, where universally known indices can be used to reference their utility in the repositories.

Summary of Literature

This chapter interrogated pertinent characteristics of reusable learning object in the literature reviewed. Also analyzed were the various aspects of the nature of open learning objects and repository reuse within given general systems. From the literature reviewed, there is a gap that leads to the purpose of this study: a need exists to design and develop a tool that addresses tagging, managing, and searching metadata for learning objects. Antecedent needs also arise: establishing such a framework would reduce the transaction costs related to course content upgrade and development, viz a viz reusing learning content. With the advancement of the ICT infrastructure, institutions can take advantage of its perceived benefits and tackle related issues of progressively advancing their labor force through easily accessible, relevant and high quality reusable learning content (Ehlers, 2008; Ehlers & Pawlowski, 2006; Salmon, 2005). Instructional designers often look for the most effective and simplest means to achieve goals and outcomes, thus, some hold that once a needs analysis is carried out, it is unnecessary to duplicate and waste resources in the processes of instructional design only to arrive at the same data (Carliner, 2008; Rossett, 1987). The nature of reusable learning object repositories characterized in various levels of granularity is one way of solving some of the identified needs through this study.

Chapter 3: Research Methodology

This research methodology chapter is about procedures or processes undertaken to realize the stated research purpose. The methodology integrated two research approaches (i.e., the design and development research and integrated literature review research) to get to the development and delivery of a metadata management tool.

Selecting a Research Approach

Studies seek to inquire and understand phenomena. From a philosophical perspective, researchers engage a subject matter in a given context with various interacting factors including suppositions of the inquirer (Creswell, 2013). While searching for a topic to research, I was curious to know more about reuse of learning objects, which I had only known then as 'stand-alone-educational-resources.' I wanted to find out about their past, present, and future accessibility and how to search, find, and reference them. I wanted to find out the answers in a naturalistic, experiential and exploratory way. Once the answers came forth, I wanted to apply them and make adjustments where possible until they could be used to solve arising issues in an educational context. I was imagining a theoretical framework as the result of my inquiry process, but as I spent more time with all my data sources, my final predicted goal evolved to the creation of a metadata management tool. The best research approach to engage all my input and state of knowledge within my perceived goals, therefore, fell to qualitative research methods.

From a traditional social research perspective, my study falls under developmental research design, but I included integrative literature review components to inform particular topics of interest and tool development. I examined definitions and characteristics of learning objects related to their storage, search, retrieval, use, or reuse in educational settings. The research process involved comprehensive syntheses of background literature and culminated in development of a metadata management tool prototype. Initial background knowledge is a vital aspect of development and design research where I needed to understand the problem within its qualifying context especially with a promise to make significant contribution to the body of literature (Merriam, 1998). Qualitative research methods not only help in generating solutions, but also can produce new, transferable, detailed knowledge focusing on the procedural design, development, and implementation of the proposed metadata management tool (Eberhardt, 2012).

The ideals of developmental research are to solve complex problems in real world contexts all the while studying the procedures and outcomes in situations where little or no research has been conducted (Richey, Klein, & Nelson, 2004; Tracey, 2009). From van den Akker's (1999) point of view, there is to be established a motive for developmental research so as to engage the research problem accurately while dynamically adjusting emerging solutions to cater for contextual problem complexities. Design and developmental studies are unique approaches because they unravel new issues or resolve ambitious educational improvement problems through process research (van den Akker, 1999; Richey & Klein, 2014).

Using a Qualitative Approach

Given the nature of the problem, the qualitative approach is a good accommodative research strategy to interpret, and naturally investigate the problem and its accompanying solution. This approach allowed me to consult a variety of source material, look at cases, draw on personal experience, observe, synthesize existing text, and describe in-progress data, all the while weighing their meanings toward the development of the problem solution. According to Mertens (2014), three possible reasons for selecting the qualitative approach are: a) to interpret phenomena from the researcher's worldview, b) the prevailing nature of the problem under study, and finally c) the practical lived experiences "associated with the nature of qualitative methods" (p.160). My assumptions coming into this study fit all the listed reasons: I had some pre-existing knowledge about my subject matter based on my educational background and upbringing. The problem to study seemed new and was quite a phenomenon, especially against the current proliferation of digital technology in the learning processes of the 21st century. Finally, the variables I was contending with were wildly unpredictable and could not fit tests or controlled environments save for intervening and living the experience while documenting live observations.

Researcher Stance

Momentous journeys begin with a single step. The LO reuse and repositories idea began with a need to source alternative methods teachers and students could employ to access learning materials. My journey to unravel the learning resources problem started when my academic committee presented me with the premise many years ago. The notion was that learning materials and supplies are a persistent problem in the rural areas. I was to investigate how others in developed countries implement reuse of educational products. Reusing learning materials and repurposing products for educational use came as partial solutions in the past. For example, the TALULAR initiative propositioned by Andy Byers and studied at length by Gwayi (2009) is touted as a success story. As a follow-up, I investigated how other education systems implement reuse of products for learning. I wanted to determine the specific resource needs of schools that reused materials address. My investigative response was also to include a report on the implications of designing learning resources with reuse in mind, and possibly determine the future of reuse in education.

My background and rural learning experiences, especially coming from a developing nation, contributed significantly to my ideation of reuse. I hailed from a situation where local learning resources were available and accessible for little to no cost. I remember being in a class of 40+ pupils with one teacher struggling to give each of us attention. Sometimes, as a class, we went to junkyards or forests to source for arts and craft, or biology resource. Both students and teachers improvised with gathered reusable learning resources, and such experiences taught lifelong learning skills based on what we salvaged. Learning occurred spontaneously from an assortment of resources. In one instance; a student from a large farm brought farming products and by-products. Those from a carpentry family business brought discarded wood, sawdust, and so forth, for learning and improvisation. It was easy to incorporate these readily available raw materials into our learning processes; but lab assets, textbooks, and curriculum samples, were rare, shared, and fought over.

Having experienced rural schools in Africa struggle to teach with limited resource, and the straining teacher-to-student ratios, ideas began formulating as I investigated whether there may be other forms reuse may take in education.

Fast forward to today, at the turn of the century, learning and access to education in developing worlds has indeed advanced. Populations are surging but schooling infrastructure remains stagnant. Interconnectedness of the world and proliferation of learning technologies has also encroached into the schools. The latter presented an opportunity for a reuse future I had been investigating.

My journey that began with how to create easier, cheaper, and accessible solutions to physical learning resources then evolved, and I delved into the ethereal world. Digital learning resources are a significant factor in the 21st Century learning process. Creativity often begins as humble inquiries and suggestions like the one from my academic committee members. By the time an idea becomes an invention, the originating thought seems to have leap-frogged. I ended up addressing the needs of the same schools in search of learning resources but this time, it was digital, quality, openly accessible learning objects.

While looking at solutions for physical reusable learning resources, the initiating needs were to provide a means for locating cheaply available resources and grant universal access. Digital resources seemed to allow for meta tagging descriptions that make meaningful contributions to a value-laden educational object for others seeking the same. At the same time, a number of responding needs have arisen with advancements in technology that retroactively prompted my ideological shift. Private schools, tutors, and home-schooling parents, from time-to-time, need a repository of readily available quality learning resource to scaffold their students' learning experiences. From the beginning of my study, there was a need to improve the learning process through better access to quality learning materials. Creating a prototype of a tool that is capable of efficiently managing metadata to enable searching and finding these high quality-learning resources appeared to offer a possible solution.

Research Design and Development

Widely known for its intervening methodologies, the design and development research approach sprung from two pioneering efforts of R & D (research and development), presenting interactive, cyclic, and spiraling methodological means to explore, and solve real world problems in specific contexts (van den Akker, 1999). This study focused on descriptions of its subject making it have a case study orientation where I highlighted the subject area in a real world situation (Yin, 2011). I reviewed learning objects, their operations, maintenance, and classifications within particular systems, especially how other establishments applied them at various granularity levels using industry specific standards. According to Merriam (1998), these studies are flexible with no fixed criteria, and motivated toward a generalizable solution by drawing upon theory or any other technique. For me, the main aim remained exploring and documenting the entire process of design, development, and improvement of the metadata management tool (Mertens, 2014).

The process for designing and developing often leads to a more complete understanding of the topic under study and involves planning, conducting, and process reporting including procedures encountered (Richey & Klein, 2014). Developmental research varies in terms of focus, or the problem definition, framing, and execution using various research methodologies. This allowance enabled me to incorporate an integrative literature review component that served to extract synthesized data from pre-selected, relevant learning objects literature. Richey and Klein (2014) identify two main formats of research design and development, i.e.:

(1) "the study of the process and impact of specific design and development efforts," and
(2) "the study of the design and development process as a whole, or of particular process component"

Source: Richey & Klein (2014, p.7)

I studied the designs and developmental processes that culminated in the tool development as the main goal. The problem statement and purpose for my research involved the development of a metadata management tool prototype that would allow its users to carry out specific functions with accumulated learning objects stored in repositories.

The first design and development research format by Richey and Klein (2014) is distinct in that it is undertaking the research process and studying that process. I did both concurrently. The design and development process led to the identification and location of relevant literature grounded in the gathered data. By studying the process of the research while developing the tool, I also integrated construction of specific functions into the metadata management tool prototype to perform specific desired tasks. For example, while compiling controlled vocabularies, I had to search for the most updated data sets, and rationalize their inclusion into the tool design so that users would have the most relevant listings to choose from when tagging or searching for the learning objects.

The design and development approach allowed me the liberty of incorporating various strategies that enabled thorough explanation and exploration of the phenomenon. I gained an understanding of the problem through an analytic generalization rather than predicting and controlling as with experimentation cases (Creswell, 2013; Leedy & Ormrod, 2005). Richey and Klein (2005) further contend that the literature review aspect of design and developmental studies often formulates conceptual frameworks which, in my case, were directed toward tool construction. The initial literature review shed more light on where to find the educational resources along with credible authors who have documented the history, definitions, and transformation of learning objects. In getting to new knowledge creation, Blignaut (2007) posits that multiple parallel processes complement and work in concert with existing normative tools and processes to bring about "innovative solutioning" (p.19). I pursued my problem statement solution in this study through the merger of integrative literature review with design and development research methods.

Integrative Literature Review

With integrative literature review studies, a researcher may employ alternative problem-solving models or conceptual frameworks. Integrative literature review in this study enabled me to generate and propose new ways of thinking about reuse and learning objects as new topics. I considered alternative models or conceptions derived directly from critical analysis and syntheses that already existed about my subject area in the corpus of text (Cooper, 1984, 1998).

In both research orientations (integrative literature review with design and development research), the methods utilize rigorous, accepted research protocols including contextual and content analysis. Doing so places the subject area into the context of documented text in a field. Integrative literature reviews only go so far, without explaining the reasoning behind, for example, model development in my case. While solutions to real-life problems may be unraveled and propositioned for the tools design and development, there would be no discussion of the ultimate value for the proposed tool. Research design and development methods addressed this apparent gap.

Integrative literature reviews, much like developmental research, are based on either mature topics or emergent issues and therefore tend to take a less structured or merging of methods approach to meet their intended purpose (Richey & Klein, 2005; Torraco, 2005).

Concepts and constructs such as granularity and metadata schemes discussed in the literature review section formulated a priori terminologies used to populate data structures and tables in the database of the metadata management tool. Other constructs and extant literature such as prevailing concept models, data guides, content and context analyses, policy standards (e.g., Dublin Core), metatags and metadata elements that support the search and classification of digital learning objects, formulated fields and individual/granular cases populating categories, sub-categories, and descriptions were among instances within the overall table structures of the metadata management tool. Through the exploratory nature of the developmental research approach, concise wording, performance processes, and collective inputs proactively and retroactively interacted to build the tool's requirements, functions, and capabilities.

Points of views can be highly subjective in integrative literature reviews and require good evidence to back them up or control for methodological diversity and heterogeneity (Deeks, Higgins, & Altman, 2008). Integrative literature review entailed collecting, collating, and synthesizing ideas from plausible, credible, professional, and realistic sources. Based on advice from my advisor, I pre-selected the learning objects four-volume-anthology by Alex Koohang and Keith Harman (2007) as the initial basic text for analysis and synthesis. Data mined from these volumes were another form of literary output used as an input to the tool development. I examined definitions, characteristics, classification, and metadata schemes of learning objects that allowed for their identification, search, or cataloging, and applied the streamlined findings, discussions, and data to the development of the reusable learning objects tool (Richey & Klein, 2014; Richey, Klein, & Nelson, 2004).

I also explored an initial conceptualization of reuse in the introduction (Torraco, 2005) then did the literature review that led up to building a taxonomy and other conceptual classifications of constructs. In-progress data in this process lay the foundation for the tool's database. As in developmental research, I explored possible metadata management tool capabilities, including additional functions as they became apparent aiming to improve either the process or product (Richey & Klein, 2014).

Tool Design

The procedure used to meet the objectives of this research included integrative review of literature and ultimately delineating and then defining key terms and concepts that envelop learning objects. Effective tool development design often begins with a clear understanding of context, content, uses, users, and how they interact to provide solutions to hypothetical problems (Hall et al., 2003). At the onset, I was curious about my topic then set to find out its status quo from my lived experiences as an instructional designer. I built my knowledge and lexicon of the subject matter through consultations and literary studies. I tested existing systems to sample the current affairs of how various libraries, institutions, and other learning centers handle open educational resources. I came across the notion of open-books, Massive Open Online Courses (MOOCs), and open educational resources (OERs) which were valuable explorations to fine-tune my niche area involving digital learning resources. My effective literature exploration began at the introductory chapter with a variety of analytic problem statements to build a clear understanding of context, content, and issues (Creswell, 2013).

Whitmore and Knafl (2005) outline five phases of integrative review (i.e., problem identification, literary search, evaluation, analysis, and presentation). I adopted these phases for this study and produced large spreadsheets of data. The data from Koohang and Harman (2007) learning objects literature were consolidated and synthesized. I also extracted and mined relevant data from samples, examples, and prototypes illustrated by various authorities. This approach ensured the maximum number of eligible literature or any other auxiliary data sources to be considered, combined, and comprehensively reviewed (Broome, 1993; Whitmore & Knafl, 2005). The review output process formulated another avenue of input in the tool development.

Tool Development

In this phase of the research process a coding and programing expert was engaged to construct a database management system. The developed system used PHP coding and utilized MySQL database command line tools. The prototype of a metadata management tool was designed and developed for online accessibility and, as a web-based service, it worked well in places with internet connectivity and on platforms with web browsing capabilities. The tables, fields, and records of the database contain relational metadata on learning objects. The database is web-based to allow for public access. Users with appropriate permissions are allowed to log in with unique ID's to upload resources or reference information of the learning objects. Among other built in and support functions in the tool environment, user tagged information is administratively moderated for accuracy, verifiability, and fidelity. After indexing the learning resource information, users can perform searches of the available uploaded content that could form a digital library if it continues to be populated. Users do not necessarily have to log-on to perform learning resource searches.

The system prompts users to maximize the use of controlled vocabulary when tagging the learning objects. The entries in the controlled vocabularies were mined from the integrative literature review and other research input processes. Frequently used terms eventually also become tagging options. The users have access to existing metatags or they can create new terms that best describe the elements of their resources. A controlled vocabulary developed for this study includes names of countries, language spoken, subjects, licensing, dates, granular sizes of learning objects, and formats, among others.

The tool prototype allowed for updating existing database table structures or adding new tables. These processes would be useful when the new tables or fields could enhance user experiences by providing better resource descriptions and better searchability. New records may also be created based on existing tabular schemes and metadata standards from various recognized industry players like MERLOT, Instructional Management Systems (IMS) Global Learning Consortium, EduCOM (now known as EDUCAUSE), and Learning Object Metadata (LOM) among others. Future iterations of the metadata management tool may have other functionalities to add, modify, or delete data elements where there is need to create, modify or delete new metadata schemes in the digital library. The need to perform such supra-functions on the system arose during the test-runs of an early version of the metadata management tool. Through agile and recursive tests and inquiry, I proactively explored newer capabilities and functions into the system and may continue to do so for future improvement (Allen, 2012).

Tool Reviewers

Reviewers for the online tool assessment survey were key players who constitute valuable stakeholders in today's modern learning construct and would be able to opine the tools value from their user perspectives because they are stakeholders in the eLearning and blended system. I particularly aimed to get expert reviewers with knowledge and experience to interrogate ancillary features added to the tool during its retroactive tool development process. The expert reviewers did meta-tagging evaluation related to controlled vocabulary use in learning objects and digital library systems. They had meta-tagging knowledge and experience in either building, maintaining, or cataloging digital libraries. Using subject matter experts as target reviewers was expected to go a long way in improving the tool functionalities and capabilities. According to Fairclough (1993), this kind of systematic structured inquisition aims to ensure better coverage, authority, objectivity, accuracy, and currency.

In-progress Collection of Data

Progressive data collection occurred in various stages: from the entire design and development study process, to integrative literature review data, and finally expert reviewer data. In-progress data and documentation reports on the entire study continued until completion of a satisfactory beta version of the tool was ready.

Design and development in-progress data. In-progress data were systematically gathered, synthesized, and recorded as the research process unfolded (Richey & Klein, 2014; Tracey, 2009). The process involved critically examining selected data and concisely summarizing vital steps, phases, and chapters of key literature. Data emanated from listed examples of instruments, data collection instruments, comparable technologies including unique case studies.

In this study, I discussed the extracted findings and applied them to the tool design. I documented and reported changes initiated from retroactive needs, functions, and capabilities. The unravelling of progressive research data enabled a puzzle piecing and connection-making approach when the process and phases of the re-design, re-development, implementation, and evaluation were recursively done. Such data informed my researching experience as discussed in the final reflection and lessons-learned at the end of this final report (Saldaňa, 2012)

Strategies for internal validity: design and usability. This study established the background, need, and purpose for a metadata management tool. To establish validity, Tracey (2009) suggests a multiple intelligences approach where researchers engage in description of the context that govern a tool's creation. Iterative procedures allow validation through 'designer usability' documentation (Tracey, 2009, p.556). Richey and Klein (2014) define designer usability documentation as measuring the success factors of product design and development. The success factors are product efficiency, effectiveness, and the satisfactory extent it meets intended goals.

A multipronged usability testing of the tool involved expert reviewers to measure these success factors. The reviewers tested the tool by performing various functions of the built components including functions that were outside the bounds of the tool. According to Tracey (2009), other factors to consider when carrying out usability validation include: (a) testing its ease of use, (b) testing the accuracy in achieving design purpose, and finally (c) providing manual to guide on how to use the tool. I included all these test success factors in the tool review instrument.

I developed a usability manual with information on the key components of the metadata management tool. The manual helped potential test users map component accuracy as well as being a definition and navigation guide. Alongside the manual was a tasks item kit with relevant performance instructions and resources. These review components helped maintain higher accuracy for better test measuring as well as providing relevant potential samples and detailed guidance. Test users reviewed the manual complete with system illustrations and secure access information. They performed half-hour, self-guided tasks and gauged their successes on the operations. The test users also had an opportunity to reflect on their experience and make modular suggestions where they saw fit. I established nominal and empirical values for task successes as evidence showing the prototype effectiveness that helps gauge the ease of use of the tool.

Alongside performing assigned tasks, the test users were asked to gauge the metadata management tool using a standardized learning object review instrument (L. O. R. I.). The L. O. R. I., developed by John C. Nesbit, Karen Belfer and Tracey L. Leacock (2004), helps gather data on the perceptions of the tool's effectiveness and general usability. During the literature review stage of the research, I requested permission to use the L. O. R. I. in this study. One of the instrument developers acknowledged and granted permission to use the latest version, L. O. R. I. 2.0 (Nesbit, Belfer, & Leacock, 2009). Dr. Nesbit granted me the permission after our correspondence in 2014 (personal communication, April 15, 2014).

Integrative literature review data. Because this study combined elements of design and development research and an integrative literature review, data from analysis and synthesis of reviewed literature informed the tool design and development. I reviewed pre-selected literature about learning objects, standards, metadata, learning content management systems, and repositories to identify key components and characteristics that may be marked for reuse. I incorporated a number of learning objects samples to populate the tool. I found them from identified course listings from open online course providers, such as the Open Course Ware (OCW) consortium, and the Open Knowledge Initiative (OKI). The output of the integrative literature review became a prompt or trigger for designing functions, standards, and capabilities of the metadata management tool. It was through looking at what was out there regarding learning objects design, use, reuse, characteristics, storage, categorization, standardization, and finally integration that I became aware of much of what to incorporate into the new tool.

After multiple discussions with my dissertation advisor, I selected and reviewed the four volumes of Alex Koohang and Keith Harman (2007) learning objects anthology because it is a comprehensive collection of literature on learning objects and ancillary issues discussed by key authors and industry players.

Literature review procedure. Using the selected 4 volumes of texts and available learning objects resource literature, I explored the literature allowing for interrogation of varied professional perspectives from other countries, institutions, or organizations with a variety of analytic practices, hypotheses and reuse modeling. This literature titles including the authors (as shown in Table 3 and Table 4) below enabled me to build a clear understanding of context, content, and issues surrounding the topic (Creswell, 2013), i.e., learning objects and their regard toward the tool design and development.

Table 3.

Four Primary Volumes of Literary Source (Summary)

Volumes	**Harman K., & Koohang, A.**	**No. of Topical Titles**	**No. of Authors**
I	Learning objects: Theory, praxis, issues, and trends	14	26
II	Learning objects: Standards, metadata, repositories, & LCMS	11	26
III	Learning objects and instructional design	14	36
IV	Learning objects: Applications, implications, & future directions	15	38
		54	126

For analytical purposes, I extracted data and tabulated them for comparison and contrast. Doing so clearly exposed how various professional organizations have implemented, reviewed, and enforced learning objects standards, metadata elements, and digital library management.

Table 4.

Volume II of IV Volumes of Literary Source (Comprehensive Sample)

Volume II		TOPICAL TITLES	AUTHORS
Learning Objects: Standards, metadata, repositories, & LCMS		Harman K., & Koohang, A.	26(total)
	2.1	Learning object metadata: use and discovery	-Jennie L. Mitchell and Nicholas Farha
	2.2	Syntax and semantics of learning object metadata	-Juha Puustjàrvi
	2.3	Learning objects metadata: semantics, content rules, and syntax	-Lisa Baures and Ann Quade
	2.6	Learning Content Management System (LCMS)	-Sonja Iribeck and Joanne Mowat

I extracted data from the volumes and used it as the input for the database tables that were populated to the extent possible with controlled vocabulary. I also generated equivalency tables where possible to demonstrate comparable item sources to match with new ones and retrofit others into the metadata management tool's scheme. A sample preliminary data extraction spreadsheet (see Table 5) shows organization of this raw data after extraction from one topic: 2.1 Learning object metadata: Use and discovery.

Table 5.

Volume II Data Extraction (Raw Sample)

	TOPICAL TITLES	AUTHORS	Volume II: Learning Objects: Standards, metadata, repositories, and LCMS					
		Harman K., & Koohang, A.						
2.1	Learning object metadata: use and discovery	-Jennie L. Mitchell and Nicholas Farha	ORG	Formats/Models	Project/System	Terms	Metadata	Samples
	Introduction	Leslie, Landon, Lamb, Poulin, 2004; Baker, 2003; Friesen, & Nirhamo, 2003; Hatala & Richards, 2002; Hatala & Richards, 2002; Miller, 1998;	EduTools,COREs: CanCore (Canada's Learning Resource Metadata Initiative), Dublin CORE, IMS Global Learning Consortium)	XML, RDF (Resource Description Framework)		Discovery, aggregation, community and evaluation, meta-tagging, content management, digital rights and fulfillment, technical consideration, pricing issues, application profiles, indexing culture, semantics		
	Syntax and Semantics: The language of Learning Objects Models	WCET, 2004; Leslie, Landon, Lamb, & Poulin, 2004; Duval & Hodgins, 2004;	IEEE	TCP/IP, HTML, XML, VHS		Aggregation level, Structure	LCMS (Learning Content Management System)	Blackboard

Literature validity. The line between valid and invalid academic literature has become blurry especially after the proliferation of web 2.0 (Fairclough, 1993; van Noorden, 2011). In this information explosion age, publishing is cheaper, easier, and instantaneous, necessitating the need for gatekeepers (van Noorden, 2011). In academia, fact checkers are peer reviewers and renowned authors. Reputable works often prefer peer reviewers because they have earned expertise or influence in their fields through evidence-based documentation over many years of diligent work. Academic benchmarks have therefore been set where credible published works gain traction in their respective niches. It is useful to draw a line between the compounding euphemisms known as "alternative facts" or "discredited literary works" versus real data, factual events, and credible purveyors of dependable research literature.

I was alert to filter out unknown and unreliable sources of information to achieve a higher credibility and fidelity of literary data under this study. I used authors such as Koohang, Harman, Wiley, McGreal, Creswell, Richey, Klein, Torraco, and other recognizable and key players in their respective realm. Credible authors reinforced the fidelity of this research work.

According to van Noorden (2011), there is a need to register 'invalid' researches, data, journals, books, etc., masquerading under the guise of rigorous 'peer-reviewed literature' when in reality they do not hold true to acceptable academic benchmarks. I took into consideration discredited work listings as cited by van Noorden (2011) and OASPA, to avoid red-flagged or pariah information that may jeopardize the foundations of this research or new knowledge. In this literary work, I did not cite journals or research data that had red flags, or were under a recall for fraud by accredited institutions and offices.

Whereupon there was still pending academic debate, I cited the works as originally presented, or, where necessary, detailed the implications of incumbent issues concerning the status of variable concepts.

Authenticity criteria; social impact factor and author h-indices. Systematic structure inquisition of existing literary work aims to ensure better coverage, authority, objectivity, accuracy, and currency (Bohannon, 2013; Fairclough, 1993). It is important to believe peer-reviewed, serialized phenomena captured in existing normative information publishers. Keeping to mainstream research databases helped me weed out fabricated, false, and discredited 'alternative' facts or literature.

I took the following measures to enhance confirmability, credibility, and dependability of the corpus of text. I sourced Journals with average to high social impact factors with variable favorability of between 2–5-year rankings. The study used altmetrics from the citation universe across subjects and around the world (The Web of Science, www.isiknowledge.com) to gauge author H-indices (number of times authors and co-authors are cited). However, this was not an ultimate standard of measure for all literature in this study because information sources and resources across different academic fields and disciplines usually have variable publication traditions and are thus incomparable in terms of ranking.

Confirmability, credibility, dependability. All literature identified was cited in one way or another for confirmability. This was to ensure sufficient evidence for other researchers to replicate it (Torraco, 2005). Academic-database-key-word-search as well as recent articles were sorted systematically to identify any realignment of the study concepts over time. In-text citations provided a sampling for key authors who influenced and contributed literature in the topical field together with their seminal work. I perused relevant literature, abstracts, footnotes, and reviewed anthologies, including analysis of accompanying research methods and findings.

Tool evaluation data. Reviewers of the prototype followed through core functions of the developed tool. At the time of the review, the tool had four primary capabilities, i.e.:

A. user sign-in function
B. search function
C. input new learning object function, and finally
D. list of all learning objects in the entire digital library.

The tool evaluation also probed specific attributes that addressed the three identified research problems. These were:

Problem Statement I: input predefined metadata function,
Problem Statement II: view integrated elements from various metadata schemes, and finally
Problem Statement III: sharing learning resources search lists function.

Each of the core functions had sub-functions that reviewers were exected to interrogate. A comprehensive user manual and assessment guide were available to help users utilize all features of the tool. The guides showed samples with illustrations and screenshots to accurately help users navigate the tool GUI (graphic use interface) as they performed various tasks and activities. There was technical assistance and an in-person guide on stand-by to help reviewers with any questions that they had. The review protocol embedded questions in the three core activities to gauge user success, failure, and effectiveness in accomplishing assigned tasks. Some questions gauged the value of the tool functions on a Likert scale while other questions were open-ended to probe deeper into the reason and intent behind a reviewer's feedback.

Chapter 4: Data Analysis

This section discusses the literary data dealing with learning objects from Koohang and Harman (2007). The four-volume set on the learning objects was chosen because it contained a total of 54 peer-reviewed articles from 126 authors, all discussing current practices, issues, trends, and futures surrounding the topic under study. I identified a topical area, systematically searched relevant peer-reviewed chapters as well as cited mainstream articles from credible informants, and weaved the narrative in accordance with my interest of populating the metadata management tool. One may never achieve an exhaustive analysis in research of any given area, but by selecting narrow and targeted literary sources, a comprehensive data extraction is possible. I reviewed the selected volumes of text that contained relevant data about existing metadata library systems from various institutions, governing bodies, and learning objects projects across the globe. The Koohang and Harman (2007) volumes contained relevant learning objects literature and project samples with a good measure of interacting topical elements that informed the metadata management tool design and development. The volumes and their titles are:

I. Learning objects, theory, praxis, issues, and trends
II. Learning objects, standards, metadata, repositories, and LCMS
III. Learning objects and instructional design
IV. Learning objects, applications, implications, and future directions

Alex Koohang and Keith Harman Learning Objects Four Volumes

Each volume contributed valuable data that I used at first instance or enhanced later in successive volumes. This section highlights pertinent in-progress data that unraveled as I reviewed and integrated the literature into the prototype element design.

Volume I: Learning objects theory, praxis, issues, and trends

Volume I is the foundational volume in the learning objects series. It introduces the prospects of studying and applying the topical issue in an educational context where access to digital learning resources is becoming ubiquitous. This volume describes the elemental nature of learning objects. It also discusses application of their latent features in an instructional design context. It is a foundational piece that informs key aspects of the tool interface design especially in terms of development and deployment. Topics highlighted are LO aspects such as granularity, reusability, metadata standardization, learning objects architecture and their ontologies, among others.

From the texts, it became apparent that learning objects display a revolutionary potential when applied in the 21st Century education setting. Volume I introduced me to the general concepts of learning objects. Some of the most important information was as follows: LO origins and operational definition, proponents and key movers including authors, institutions, and professional groups/charters, and finally theoretical justifications for enjoining latent LO potential into instructional design. The doyen of learning objects cited in the texts included, but were not limited to, Friesen, Hodgins, McGreal, Wiley, etc. Chapter 1 authors (Schwartzman, Runyon, & von Holzen, 2007) discussed the theoretical aspects of learning objects. Various authors posited that inasmuch as there is latent and evidentiary promise for learning objects implementation in pedagogy, there is more to take to account before efficiently applying them in various learning platforms or contexts.

Quinton (2007) discussed ideal education attributes of learning objects. These ideal attributes became my sub-goal alongside the earlier identified research problem statement. In the quest to design and develop a tool that would address the research problem, modularity and transferability became some of the ideal aspects of learning objects in education. At this point, there was more discussion on their design, undergirding theories, and promises rather than their integrity as learning tools used to achieve learning outcomes. From this information, I became aware of context playing an important role in LO utilization. By discussing object designs, templates, architecture, and users, I formulated learning objects design principles to incorporate into the metadata management tool's development while maintaining their efficient utilization. Standardization became a factor as I adopted a systems thinking approach in achieving the research purpose.

Among the most outstanding promissory notation from part one of this volumes was that learning objects can permanently alter modes of learning from the prevailing traditional delivery. Changing the learning landscape would occur when learning objects give way to efficient instructional designing, better content development, and delivery. This promise latches on the current rise and proliferation of technology as a means to mediate and distribute learning content. A brief summary explaining the role technology has played in education over the years confirmed the notion that utilization of learning objects over internetworked systems presents challenges of contextualization, namely, granularity and usability. After elaborating on usability theory and introducing granularity, the authors transitioned the narrative to the second part of the volume by addressing "how" such transformation can occur. They addressed the technologies with some of the prevailing syntax and semantics, where technology encounters challenges about universal utilization of learning objects. From the samples and examples given, I became interested in "learning objects contextualization strategies" and "nested systems learning objects models" as presented by Quinton in chapter 4 (Quinton, 2007, pp152-156).

The entire volume got me into the track of formulating ideas on how to implement granularity, interoperability, and reusability. Theoretically, most authors discussing granularity in volume I argued that the more a learning object can be disassembled and re-assembled at various granular levels, the more reusable it becomes (Cheal & Rajagopalan, 2007; Johnson & Hall, 2007). This notion fed well into the sequencing of learning objects as the metadata management tool was developed.

Context drove usability development. The data extracted in this volume helped to carefully construct and utilize beneficial components of learning objects reusability. Of particular interest was the ontology highlighted in chapter 5 topic: Granularity, Reusability and Learning Objects by Johnson and Hall (2007).

While I anticipated more information in the later volumes, I took an open stance to allow future modifications that might transform the design and development process. At first, the 'Proposed Extended Ontology from EnCoMpaSS' seemed to be a stable model to emulate. However, I was open to alternate considerations after reviewing the entire four-volume set.

More information unraveling meant more iterations of the metadata management tool during the early development process. As Quinton would say in his opening remarks:

> “One's thinking becomes different when exposed to new and unfamiliar worlds. Certain common ideas become inexpressible, whereas other previously unimagined ones spring into life, finding miraculous new articulation in some instances, that which cannot be adequately articulated in one context may in another, become fully comprehensible. It is at the juncture of prior and new understanding that the potential for creativity arises.”
>
> Source: Quinton (2007, p.113)

The statement drove me to start developing a logical hierarchical organization structure to better facilitate the re-design of the metadata management tool, always leaving room for adaptability and modularity to resolve unforeseen problems in the development process.

Volume I drove the usability development of the metadata management tool. Within its chapters were roadmaps of possibilities. These possibilities became highlights on what to expect down the road when developing the metadata management tool. For example, Mohan (2007) discussed a few global repositories (e.g. CAREO and MERLOT) and peer-to-peer repositories (e.g. POOL and SPLASH) presenting them as samples of LO application. This volume discussed metadata standards such as Dublin Core Metadata Initiative (DCMI) and Learning Objects Metadata (LOM), exposing me to functional architecture that support and help in maintaining learning object repositories. Volume I also presented general and broad hypothesis of metadata samples, taxonomy comparisons, interoperability issues, and trending projects in the learning objects arena. One key example was Figure 5 illustrating how to map two taxonomies to each other. This helped me in "relating and exchanging learning objects" metadata schemes between institutions (Sontag, 2007, p.452):

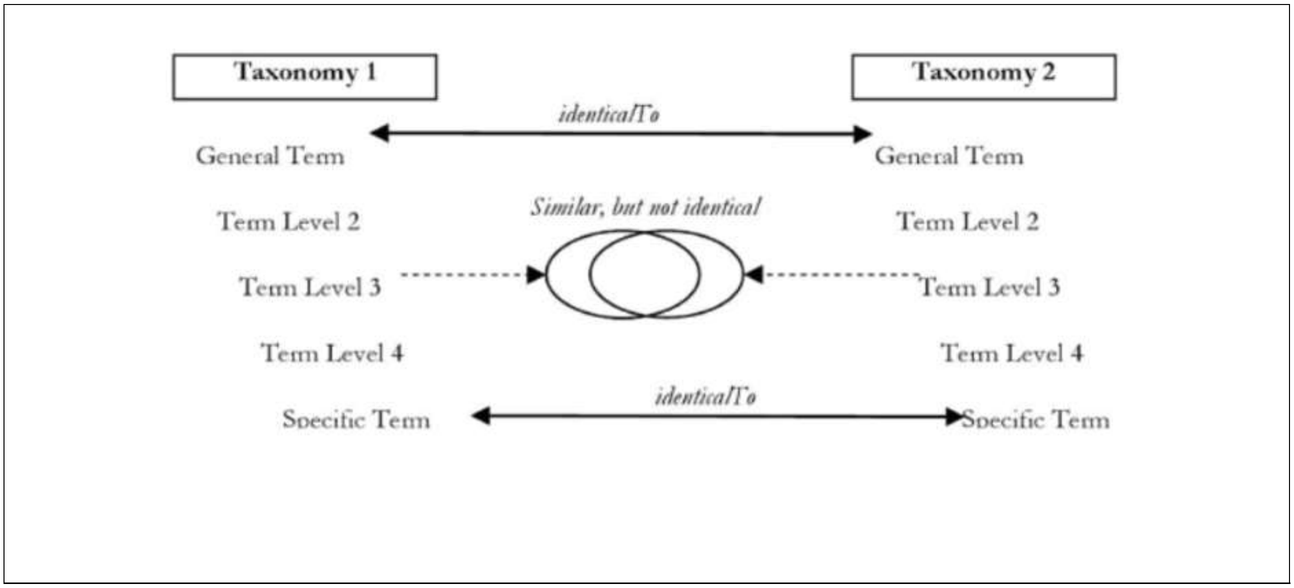


Figure of mapping two taxonomies to each other. Reprinted from Sontag, M. (2007). Syntax and semantics of learning object metadata: The IEEE/IMS LOM and beyond. In A. Koohang, & K. Harman, (Eds.), *Learning objects: Theory, praxis, issues and trends (Vol. I)*, (pp.417-505). Santa Rosa: CA: Informing Science Press, p.452. Reprinted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 5. Mapping Two Taxonomies to Each Other

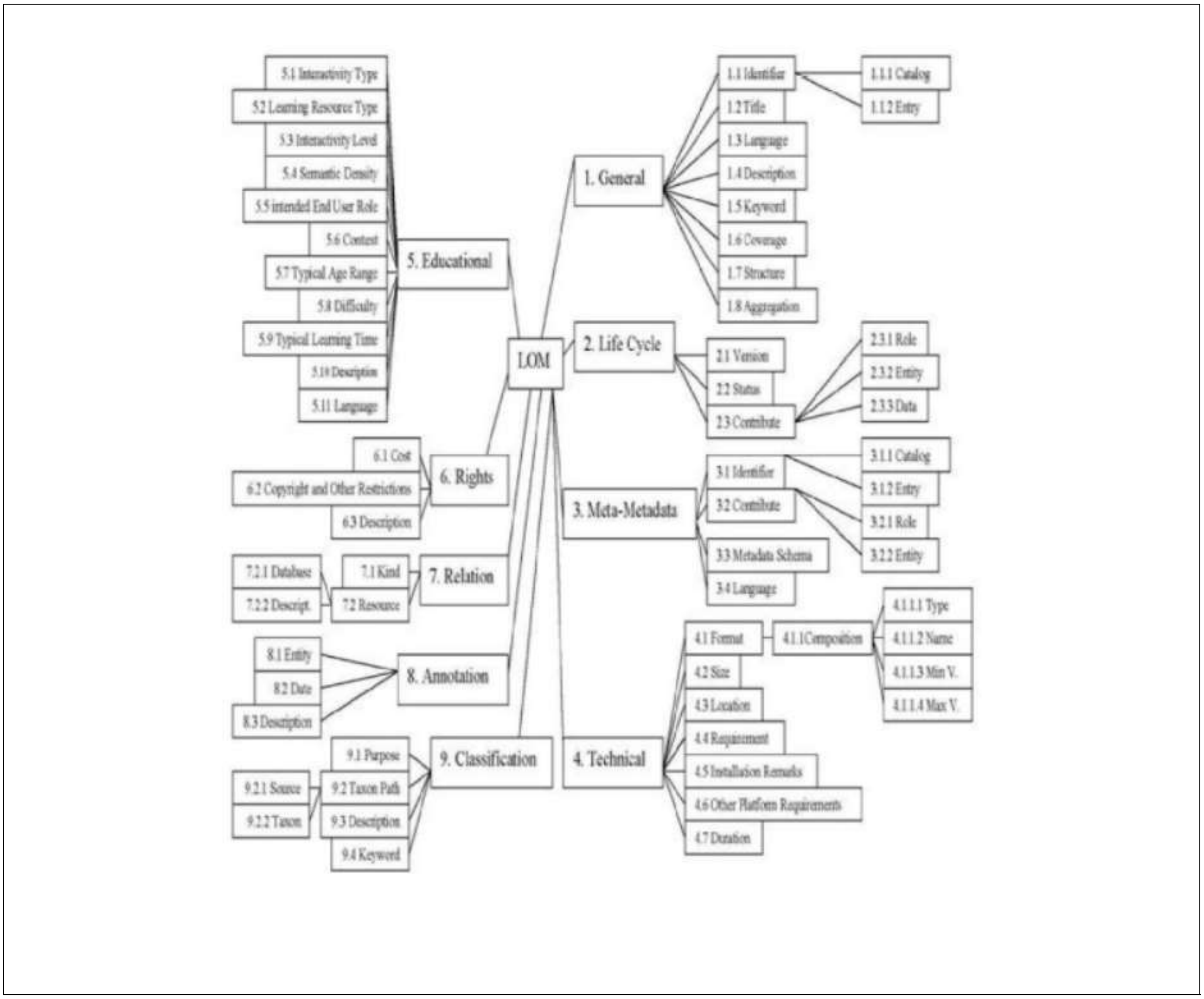
Systems interoperability was a key issue to my objective from universal accessibility to consuming and distributing learning objects in a manner that might cut costs and save time. Sontag (2007) posited that learning objects' intraoperative idealism was their reusability in multiple system platforms, and the potential to cut down time and costs of recreating high quality materials already available elsewhere.

Volume II: Learning Objects Standards, Metadata, Repositories and Learning Content Management Systems

Volume II introduced learning object language models especially the semantics, content rules and syntax. It further highlighted existing trends using learning objects repositories, successful architectures and prevailing debates. Volume II discussed how industry players have implemented learning objects concepts and theories. This volume formed the bulk of data I extracted re-formulated for the metadata management tool.

After reviewing generic approaches in volume I, volume II helped me get into a kind of sub-layer of the domain semantics. Motelet, Baloian, and Pino (2007) discussed automation processes that could help populate and generate meta-metadata for educational resources. They introduced variant perspectives and issues on application profiles. Also highlighted were the various metadata scheme operated by specialized organizations, among them: The Dublin Core Metadata Initiative, LTSC, IEEE LOM, CANCORE, SCORM Metadata as well as IMS Global Metadata. The authors argued how it is too complex to instantiate specifications such as the LOM, which has about 60 attributes and still keep the reusable resources simplistic to a wider audience. Mitchell and Farha (2007) specifically decried that there is "too much metadata" (p.2). I took to account that "metadata creation needs to be simplified" accounting for both technical elements of learning objects as well as vocabulary definitions that fit common user terminology (Motelet et al., 2007).

Metadata. Baures and Quade (2007) introduced and defined metadata. Metadata is widely known as data about data. The two authors outlined four definitions after laying out the rules that are vital for data management. Metadata describes various natural characteristics of objects. For the metadata management tool to be able to perform 'search', 'gather', 'store', 'request', and 'expose resources' within repositories; metadata is the perfunctory element that will help administrate successful database system operations. I found the semantics, content rules, and syntax discussed in this chapter very informative. The chapter also showed how metadata elements enhance LO interoperability, structuring, and aggregation. By introducing metadata standards as a means to codify reusability and classification of LOs, the authors in this chapter showed how descriptive data can broaden the scope of organized information to 'encompass educational context'. Figure 6 showing "IEEE LOM tree structure" is another key sample that helped me structure the tool development (Baures & Quade, 2007, p83).



IEEE LOM tree structure. Reprinted from Baures, L., & Quade, A. (2007). Learning object metadata: Semantics, content rules, and syntax. In K. Harman, & A. Koohang, (Eds.), *Learning Objects: Standards, metadata, repositories, and LCMS (Vol. II)*, (pp.63-91). Santa Rosa: CA: Informing Science Press, p.83. Reprinted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 6. IEEE LOM Tree Structure

I extracted data in IEEE LOM Tree Structure to the extent possible. I used keywords to compare and map their semantics and syntax with other metadata standards such as the IMS Global, MERLOT, DCMI, LOM, among others. According to Mitchell and Farha (2007) when repository systems were initially setup, various institutions, organizations, and developers only chose to utilize search and indexing systems that suited their purpose and database operation. Today, the need for interoperability has encouraged industry players to move away from legacy and proprietary applications. Proliferation of cloud computing has also encouraged open metadata standards. This volume discussed at length the processes, negotiations, and compromises the key players engaged to settle for various resource description semantics and syntax within an open learning objects repository system. Among the notable stakeholders were IEEE, Dublin Core Metadata Initiative (DCMI); EDUCOM (now EDUCAUSE) consortium; Instructional Management Systems (IMS); Computer Society/Learning Technology Standards Committee (LTSC).

Interoperability. Volume II highlighted the value of interoperability among the various standards organizations while still leaving room for simplicity and improvement in implementing reusability of learning objects. Universal acceptability of meaning and characteristics applied to learning objects would enable better aggregation/disaggregation at functional and meaningful units. The illustration of "Learning Objects Metadata" Mitchell and Farha (2007) structure helped me visualize the elements (p.7) as shown in Figure 7.

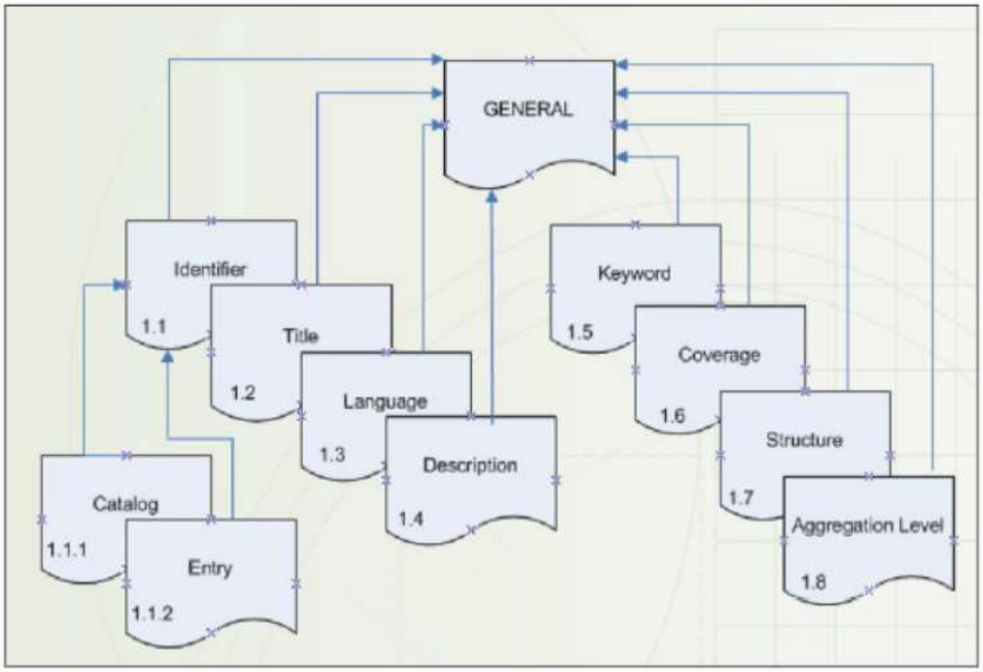


Illustration of Learning Objects Metadata. Reprinted from Farha, W. N. & Mitchell, J. L. (2007). Learning object applications & future directions. In K. Harman, & A. Koohang, (Eds.), *Learning Objects: Standards, metadata, repositories, and LCMS (Vol. II)*, (pp.1-40). Santa Rosa: CA: Informing Science Press, p.7. Reprinted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 7. Learning Objects Metadata

I attempted to use the general multilayered structures (as shown in Figure 7) provided in this chapter at the beginning but later flattened the layout so that users could have the freedom to index fields they felt were relevant or applied to the learning resource during its tagging process. Nesting search fields was most useful in guided searches to help focus resource search.

Various application profiles and vocabulary congruence are important for a universal understanding of learning object classification and tagging. Nilsson et al., (2007) discussed at length the process of integrating and reconciling various metadata standards that I ultimately adopted. This chapter also demonstrated an elaborate action plan on how to extend and combine metadata descriptions. The metadata elements, often encoded in resource description documents, commonly known as RDFs or Extensible Markup Language (XML), can at times be directly combined, or relatively associated, or contrasted for the best fit. Where difficulties arise, the authors recommended 'abstract modelling'. In the abstract modelling process, where there is direct relation of elements, 'ad-hoc' processing applies, but if relational difficulty persists, 'interoperable processing' applies. During interoperable processing, when there was difficulty in relating two or three application elements, I attempted to interpret the property or characteristic in question. This led to probability placement of the value as a child-element within the general premise of another element or other application profiles. Where I encountered incomprehensible elements, I left the premise blank. An elaboration of this process is given in Figure 8 with a sample of "Combining the XML languages of LOM and Dublin Core" (Nilsson et al., 2007, p.275).

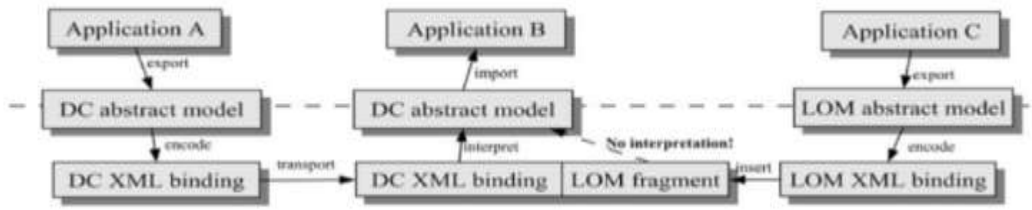


Illustration of combining the XML languages of LOM and Dublin Core. Reprinted from Nilsson, M., Johnston, P., Naeve, A., & Powell, A. (2007). The future of learning object metadata interoperability. In K. Harman, & A. Koohang, (Eds.), *Learning Objects: Standards, metadata, repositories, and LCMS (Vol. II)*, (pp.255-313). Santa Rosa: CA: Informing Science Press, p.275. Reprinted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 8. Combining the XML Languages of LOM and Dublin Core

Vocabularies. Throughout this volume, I extracted metadata to populate the metadata management tool at various levels. This chapter discussed two probable metadata levels at length. First, learning object content and its technical characteristics. Second, learning object contexts ascribing characteristics of the resource within its assumed, related, or created environment. Some sections of the literature separated the level premises as 'value vocabulary' and 'element vocabulary' (Nilsson et al., 2007). The authors distinguished these two terms as follows:

> “value vocabularies: are used to construct taxonomies and thesauri that describe relationships between concepts in terms of broader/narrower, containment etc.
> element vocabularies: are used to construct application profiles, schemas, and ontologies that describe how metadata instances are to be constructed.”

Source: Nilsson et al. (2007, p.291)

The Nilsson et al. (2007) chapter helped me understand domain semantics. A number of examples demonstrated keyword interchangeability and run-time interaction through listed examples of Learning Content Management Systems (LCMS) and classification hierarchy systems such as the Dewey Decimal. The learning management systems exemplified in this volume included WebCT, Blackboard, Learnwise, Moodle, and Lectora. These samples clearly demonstrated to me "standards for content metadata, content sequencing, and content packaging" (Mitchell & Farha, 2007, p.32).

Granularity. Search, storage, and retrieval of learning objects are core design and development issues for this study. The topics were explained elaborately by Silveira, Omar, and Mustaro (2007b) especially how to operationalize them in a reusable learning objects environment for a large-scale learning project. Granularity became a key component in the architecture of the repositories. The authors showed how to put together various granularity levels of LOs to achieve fully adaptive learning objects within their repository system. They introduced user profiles, tiers, or layers of usability, and finally adaptability to accommodate various learning experiences.

The "multi-granular" interacting layers were Courses Tier; Reusable Learning Objects Tier; Presentation; Learning Model Tier; Learning Styles Tier; and Instructional Design-Middle Tier (p.150).While all the tiers were interdependent and traversed one another within the system, I paid particular attention to the reusable learning objects tier which tied in well with earlier cited interoperability schematics by Johnson and Hall (2007). Johnson and Hall highlighted four interoperability scales, i.e., [1] "between learning objects" [2] "between learning objects and learning management systems" [3] "between learning objects repositories" and [4] "between metadata schema." I discussed with experts and we considered many tool designs that would accommodate interchangeability, interoperability, and adaptability of all its internal elements. This meant adding optional components that would enable users from different contexts to understand better the nature of the learning objects.

I found the user profiles highlighted in this volume very helpful and adopted them. The profiles, as presented in the literature, were four agencies who utilized the learning objects repository. They include:

> a. learners - persons pursuing learning goals and objectives through digital applications
> b. creators - author or producer of a learning object at various granularity levels
> c. information-seeker - persons searching for educational resources through a discovery process
> d. agents - organized executive system or application through which the learners, creators, and info-seekers interact"
>
> Source: Silveira et al. (2007b, p.146)

These four system agencies, originally propositioned by the instructional management systems (IMS) as an architectural approach, are vital to the operations of any learning objects repository. I noticed that I could present them in different ways. Therefore, I adopted the idea and nature of the four roles, portraying and defining them under different naming conventions later on.

Volume II also referenced a number of international players aside from the various established US-based metadata standards often cited in the entire volume of literature. The broad-based approach enriched my knowledge on how other countries handle the topical issue. It also exposed my entire design and development process to international alternatives. Noted international schemes included Reusable Learning Object Authoring & Delivery (RELOAD), Portal for Online Objects in Learning (POOL), SingCORE, UK LOM Core, BELLE, JISC, JORUM, and EDINA among others.

The raw data from these establishments helped me narrow-focus some terminologies when synthesized to achieve in-mapping best fit. "A way forward" that had been proposed by Nilsson et al. (2007, p.282) was emulated so as not to conflict with emergent metadata formats including "formal and informal semantics" (p.296).

I extracted a lexicon of keywords to use as meta-metadata. some in my listing were e-course types; plug-ins, e-packs; question databases, question types, interactive media, critical thinking activities, instructional resources, flashcard, glossary, video, animations, eBooks etc. Volume II was a valuable data mine because its topics highlighted efficient, non-redundant meta-metadata structure for the tool development and deployment.

Volume III: Learning Objects and Instructional Design

Volume III dealt with learning objects and instructional design. Topics covered explained the underlying paradigms and linkages between designing learning objects at various taxonomic levels to meet instructional and pedagogical objectives. The extensive focus on interoperability of learning objects across practical platforms continued to shed more light on the technological challenges and opportunities that come with learning objects standardization. The data synthesized from this volume was vital in informing the interoperability framework of the metadata management tool. More so, when it came to collaboration and community-building aspects that foster reusability of learning objects (Johnson and Hall (2007) introduced interoperability in Volume I), Volume III advanced a theoretical overview of probable designs for interoperable LOs. Light, Harrigan, Bringelson, & Carey (2007) discussed various project experiences and expounded on how a community can collaborate to feed into the reusability system to include outside resources. In volume I, Johnson and Hall (2007) postulated that interoperability exists in four different capacities, namely:

1. “between learning objects
2. between learning objects and learning management systems
3. between learning objects repositories, and finally
4. between metadata schemas”

Source: Johnson & Hall (2007, p.189)

In this volume, Light et al., (2007) extended the processes to include community and collaboration inputs through a "well-defined scope" while "addressing discipline-specific" challenges among other issues (p.198). I integrated these aspects by providing learning objects metadata to ensure thorough definition of the field and the instructional goals they address. These descriptions were taken as the best approximations possible because according to Memmel, Ras, Jantke, and Yacci (2007), the precise future usage of learning objects is hard to predict or "sufficiently annotate" (p.294). I adopted the sample of unit metadata for the metadata management tool with slight modifications as shown in Figure 9 "Unit Metadata" (p.301). I modified the sample to converge operationally like elements such as 'version' and 'type' to avoid laborious repetition.

NAME	DESCRIPTION
General	
Name	id of the element
title	title to be displayed (optional) for certain types of units
language	language of the element
description	informal description of the unit (for other authors)
Keyword	associated glossary entries
Lifecycle	
Version	version number
status	status (draft, final, revised, unavailable)
contribute	
Author	id of the corresponding author
Date	creation time of the element
technical requirement*	
type	type of requirement
name	name of what is required
minimumversion maximum-version	minimal version maximum version
educational	
presentation	presentation style (formal, informal)
Rights	
cost	could payment be necessary? (0/1)
Relation*	
kind	type of relation (requires,is-required-by,has-part,is-part-of)
newpage	only relevant for "has-part": defines pagebreaks
resource	id of the referenced element
version	version number of the referenced element
classification	
type	classification type (algorithm, axiom, corollar etc.)

Illustration of unit metadata. Reprinted from Memmel, M., Ras, E., Jantke, K. P., & Yacci, M. (2007). Approaches to learning object oriented instructional design. In A. Koohang & K. Harman (Eds.), *Learning objects and instructional design (Vol. III)*, (pp.281-326). Santa Rosa: CA: Informing Science Press. p. 301. Reprinted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 9. Unit Metadata

Memmel et al. (2007) also discussed the concept of asset container versus units to demonstrate the multidimensionality of learning objects. All these components come together in a paradigm known as an access point. The access point presents the common ground (also known as interface) that provides the services promised by the reuse system processes. This chapter also shed light on how various architecture styles, design patterns, and frameworks address granularity of learning objects at an abstract level while advocating for a multidimensional learning object architecture. A multidimensional architecture is the most appropriate approach to foster adaptability that supports instructional design.

Generally speaking, a metadata management tool works as a cross-platform, system-neutral, web-service product. It integrates a database system hosted securely online to take advantage of open accessibility on the World Wide Web. This aspect not only promotes learning objects metadata tagging beyond localization scope, but also envisions a framework that incorporates various contexts/learning environments. After being exposed to this perspective, I subsequently removed previously perceived constraints of aiming reusability for instructional designers and learners in higher education only and included K-12, vocational skill seekers, and any potential learning objects consumer. The developed tool would therefore promote use and collaboration from all three "key context collaborators," i.e.; amongst university students and faculty, amongst secondary and post-secondary teachers and students, and finally amongst higher education organs deploying high quality objects (Light et al., 2007, p.218).

The collaboration scheme provides novice users and learners with adequate guidance to account for values that are transferrable and applicable in relevant context.

Figure 10 of the "Schematics of the Collaborative Design and Development Process" (p.205) shows how various learners from different context such as high school, or a university, can interact with their teachers and professors to think through how their student learn then collaboratively tailor learning objects metadata searches that meet their needs and goals.

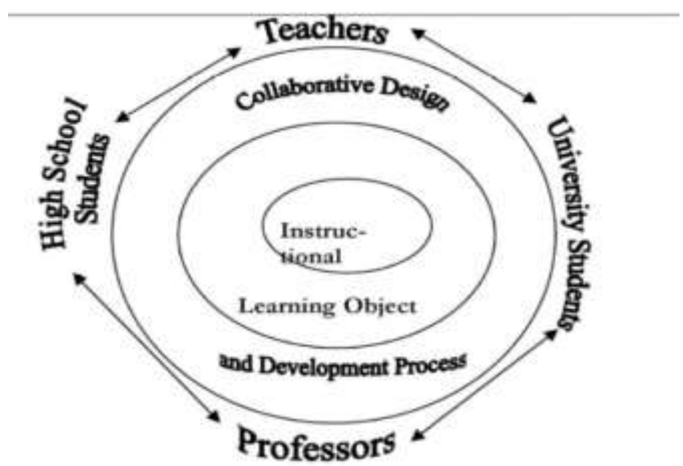


Illustration of schematic of the collaborative design and development process. Reprinted from Light, P., Harrigan, K. Bringelson, L., & Carey, T. (2007). Collaboration and community building: Extending design processes for learning objects to foster reusability. In A. Koohang & K. Harman (Eds.), *Learning objects and instructional design (Vol. III)*, (pp.197-218). Santa Rosa: CA: Informing Science Press. p. 205. Reprinted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 10. Schematic of the Collaborative Design and Development Process

The schematic helped me focus the tool development and design toward a key target audience that I at first defined broadly as stakeholders. At the onset, stakeholders included departmental administrators and government agencies. In view of the literature in this chapter, I repurposed the tool elements to address course material designers, deliverers, and consumers as the core target audience. This modified inclusion and the co-operative drive amongst users helps in multi-university initiatives as exemplified in Co-operative Learning Object Exchange (CLOE) systems. Light et al. (2007) discussed how CLOE bring 25 universities to share, contribute, and reuse quality learning objects freely without costs and legal impediments.

Toward the end of volume III, Farrell and Carr (2007) continued to build on the topics of usability, granularity, and interface modeling architecture for learning objects. The chapter on blended models of instructional design for learning objects demonstrated how to operationalize the various hyper-media design models. The authors provided practical application of learning object design models. This included the granularity sequencing architecture drawn from case studies. The example explained the perspective of an individual learner searching for learning resources in a digital learning management system. The elements portrayed two figures and when combined, showed how granularity sequencing can be effective. The sample also provided an understanding of how elemental search criteria can be very useful to help individual learners easily find what they are looking for.

While discussing the blended model, the authors in this chapter presented Figure 4 "Get Started Architecture: Granularity and Sequencing Model for Learning Objects" and Figure 5 "Sample Learning Self-directed Paths showing the stages of process resource search. When I combined these diagrams, I could easily see contextual usability in action. The combined diagram in Figure 11 showed the needs of the target users in a repository system taking center stage. Farrell and Carr (2007) clearly illustrated how “Instructional

Units and Learning Objects Situated within an Authentic Learning Context" flow intuitively (pp.375-378). I adopted the granularity layers as search criteria to help the target audience intuitively focus or direct their searches toward meaningful metadata sequencing or criteria.

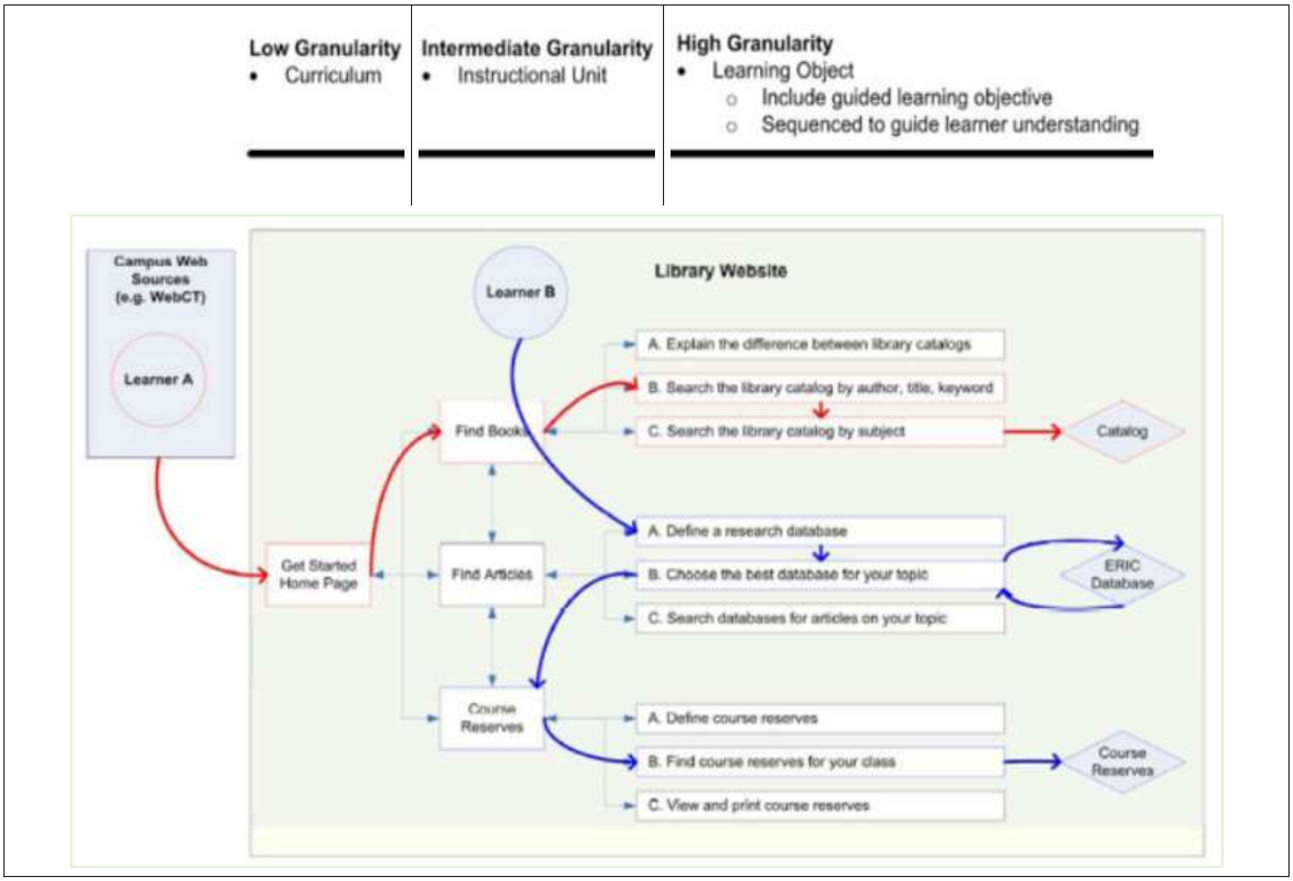


Illustration of combined granularity sequencing model and learning self-directed paths to show layer of granularity during a resource search sequence. Adapted from Farrell, K., & Carr, A. E. (2007). A blended model of instructional design for learning objects. In A. Koohang, & K. Harman, (Eds.), *Learning Objects: Learning objects and instructional design (Vol. III),* (pp.359-405). Santa Rosa, CA: Informing Science Press. pp. 375-378. Adapted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 11. Combined Granularity Sequencing Model and Learning Self-Directed Paths

Volume IV: Learning Objects, applications, implications, & future directions

Volume IV was last in the book series. It contained discussions on probable advancements in the learning objects field. The authors highlighted applications and future trends of LOs in the face of proliferation of "e-learning" or "online learning." The volume also presented mundane cases of learning objects architecture in various traditional and alternate learning environments. Some authors (Edwards & Partridge, 2007; Taylor, Slay & Kurzel, 2007) explored classroom technologies integrated with mobile learning, examining how it builds upon models and case studies presented in volume III. Volume IV continued to inform the conceptual content packaging of learning objects. The data I mined from this volume informed my perception of LO accessibility, adaptability, and reusability of components built into the tool design and development. The prevailing theme was that the cost of reproducing high quality, interactive multimedia learning objects is becoming prohibitive against learner demands for a 21st Century educational predisposition. The institutions, organizations, self-paced learners, or homeschoolers, cannot afford to develop for themselves every learning tutorial they need, or all video samples and learning support materials required in their learning experiences (Mu, 2007).

The research in this volume established a need that learning content creators, deliverers, and consumers should be able to search, find, and easily retrieve these high quality learning objects while taking full advantage of the world wide web of resources. The metadata management tool bridges the disconnection whereby resources exist but cannot be easily accessible. Volume IV discussed at length the prevailing discontinuity and gave a number of reasons. One of the reasons given was the differences in resource tagging, encapsulation, and encoding languages, or LO characteristic description within certain metadata schemes. Acknowledging that legacy e-learning systems have continued to store and operate proprietary applications, Vossen and Westerkamp (2007) contended that implementing standards should enable resource sharing via the web. While assuaging educators from, for example, – SCORM (Shareable Content Object Reference Model) which has become a restrictive standard geared for specific platforms – the authors advocated for a service-oriented provisioning of learning objects by implementing a web service paradigm. Such is the future directions that the body of literature on LOs propose. Cognizant to the fact, I, in consultation with subject matter experts, elected to design and develop the metadata management tool in Service-as-a-Software (SaaS) model distributed through any universal web browser platform.

Other implications noted in this volume were the rapid proliferation of learning objects and associated repositories emerging daily due to continuous high demand for advancing academics, professional development, and the various computer based learning services that dot the 21st Century education culture. While these new teaching services exist alongside traditional brick-and-mortar institutions, Farha and Mitchell (2007) said their accessibility costs are climbing because of outmoded cross-platform sharing schemes. Edwards and Partridge (2007) discussed various e-learning models that were "supposedly" going to usher in cost saving (p.91). The delivery approaches for personalized, anywhere, anytime, interactive, high quality content-laden learning objects have gained traction (Patokorpi, Tétard, Qiao and Sjövall, 2007; Taylor et al., 2007). Ontological approaches to applying learning objects to the learning environment are poised against various barriers, challenges, and concerns. Among the useful ontologies that I adopted, but somewhat modified to suit a simplistic architecture, is in Figure 12

"Example of Learning Environment Ontology" (Taylor et al., 2007, p.48) which overcomes the complexity barriers discussed.

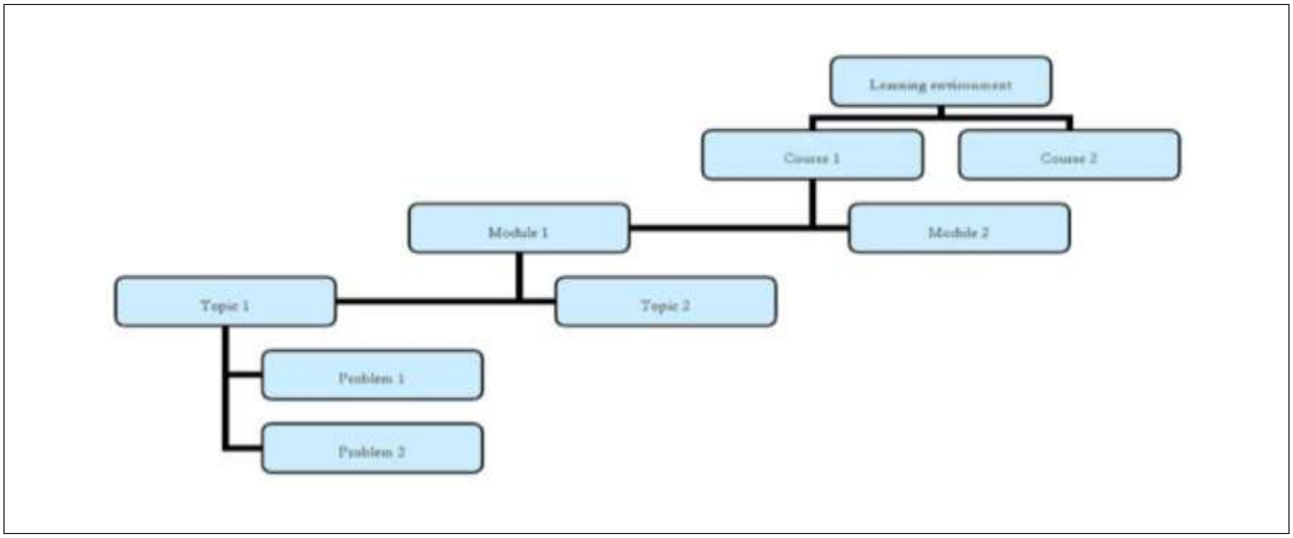


Illustration of example of learning environment ontology. Reprinted from Taylor, J., Slay, J., & Kurzel, F. (2007). An ontological approach to learning objects (Doctoral dissertation). In K. Harman, & A. Koohang, (Eds.), *Learning objects: Applications, implications, and future directions (Vol. IV)*, (pp. 35-61). Santa Rosa, CA: Informing Science Press. p. 48. Reprinted courtesy of Creative Commons Attribution+NonCommercial+ShareAlike 3.0 Unported License.

Figure 12. Example of Learning Environment Ontology

To account for time and resources costs incurred while creating high quality learning material, the authors proposed reusability models to avoid expensive institutional ownership and ensuing legal negotiations. Combes and Valli (2007) gave an in-depth foresight into how copyrights and legal issues can become the barriers of actualizing learning object reuse. I therefore opted to utilize resources within universally accepted minimal-to-no-cost modalities for reuse, modification, alterations, and re-invention that include learning objects, fair use, and creative commons clauses. This framework avoids legal barriers and issues. Where inconsistencies in learning object searches might occur, I tried to incorporate interoperability and standardization modalities into the tool design including universal classification of learning objects.

Extrinsic factors were not the only issues addressed in this last volume. Intrinsic factors such as pedagogic paradigms and actual realization of learning objectives from LOs were among other concerns. To resolve such issues, I took keen interest in how the various authors handled context transfer approaches in this volume. Among the elaborate contexts highlighted was the M-learning implementation by Patokorpi et al. (2007). The authors discussed the results and important probable aspects of a large mobile learning project. Key knowledge information from the mobile learning project that I gathered included the implementation of multimodality, interactivity, personalization, ubiquity, and context-awareness. Overall, the literature revealed that instructional delivery context in the current and proposed future repository systems ought to promote and empower learner-driven processes much like the models presented in volume III by Farrell and Carr (2007). Kurzel (2007), Duitama, Defude, Lecocq, and Bouzeghoub (2007) discussed domain modeling for instructional component of learning objects. Because the authors called for a global framework to account for some level of customization, I decided to try to build specialized user profiles into the tool. The profiles would log user searches and activity to reinforce their commonly sought subjects, search terms and search results within their granularity relevance. To compensate for the discussed instructional design elements, I would also include the following into the tool design: (1) a rich description field to outline resource goals and objectives, (2) a language field, and (3) an origination country as keyword and tag.

Future prospects for online learning look promising especially coming off the successes of yesteryears' distance learning programs (Kurzel, 2007). The authors in this volume gave foresight into what today's generation – digital natives – could look forward to in eLearning. Farha and Mitchell (2007) projected "digital natives" and digital immigrants converging in new learning environments; making it easy to see how learning has transformed from the agrarian-industrial ages to an information-technology-driven economy today. I was conscientious to this vital transitive element even as traditional models of learning are flipping. The flip is that learners are not being passive receptors of knowledge through lectures; they are co-creating knowledge and actively guiding their learning process. The digital generation, Farha and Mitchell (2007) assuaged, can easily embrace learning objects and utilize multiple networked learning repositories to construct how they learn in new contexts such as: virtual labs, open-worlds, augmented realities, virtual realities, digital gamification elements etc. I noted that learning objects and their metadata management prospects provide vital support resources to drive learning in these new learning contexts.

The metadata management tools should aim to develop what is currently an underutilized foundation for new knowledge infrastructure, a case well presented by Bednar, Welch, & Graziano (2007). In their argument for new knowledge foundations, learning objects reuse and associated metadata schematics ought to operate on a relevance basis without becoming information overload disasters. Support infrastructures are therefore necessary as well as structured, sequenced, and specifically tailored repository content management that delivers useful e-Learning indices or granular learning resources to meet the perceived needs of its user. Searched learning objects need to be relevant in "particular user context" to realize their full utility (Bednar et al., 2007, p.178). Volume IV's theme was best captured in Combes and Valli (2007) citation of Johnson's (2003) thoughts about designing and developing new tools to cater to new learner needs and digital predispositions:

> “New tools for authoring learning objects are foreseen they would make learning design more accessible, more flexible, and more efficient by building good learning design transparently into the authoring environment. A future can easily be imagined in which these well-designed, reusable learning objects are even dynamically assembled by intelligent software agents on the fly, in response to the real-time needs of learners”
>
> Source: Johnson (2003, p.2)

In conclusion, the literature convinced me that the initial difficulties, barriers, and challenges can be resolved. The need for vocational training skills, and the need to upraise the level of information literacy skill at the workplace, in K-12, during homeschooling, or for pre-service teachers, is great enough to look to technology as a probable solution for today's learner and 21st Century learning experiences.

Chapter 5: Results

This chapter presents the application of extracted in-progress data to develop and formulate new schemes including usability functionalities into the metadata management tool. I applied extracted data from the literature with some modification and other elements were utilized with no modification. The perspective in this chapter takes after the reuse ideology presented in chapter 2. Whereas there are multiple possibilities of reuse presented earlier in this text, three of the possibilities applied to create a new metadata scheme for the tool. For example, (1) using existing metadata scheme elements with no modification, (2) using existing metadata scheme elements with some modification, and finally (3) creating a completely new scheme. Significant data extraction and processes were involved in creating the new tool including but not limited to: aligning best fit of metadata elements from the identified schemes, deliberations and consultation from experts in the field, system modelling and GUI designs (see Appendix A), and iterative testing of early versions. This chapter contains the product of the various processes highlighted in chapter 3 and the produced results after the integrative literature review.

Structured Data Extraction

I listed all the volumes in tables with data showing the following attributes: volume title, number, topical chapter titles, and their authors. Volume I has 14 chapter with 26 authors. Volume II has 11 chapters with 26 authors. Volume II has 14 chapters with 26 authors. Volume IV has 15 chapters with 38 authors. In total, I perused 54 topical titles from 126 key authors.

Like most monographs, these volumes segment into chapters, titles, headings, and sub-headings. I organized the segments as granular structures to help me deconstruct the large-sum texts into manageable chunks or sections. Chunking is an elaborate strategy in instructional design that enabled me to consolidate, organize and identify themes and synthesize the theoretical semantics from the large volumes of content. Adopting this strategy also enabled me to outline every significant data point as a node. Chunking is an appropriate technique for knowledge-intensive tasks associated with most integrative literature reviews (Laird, Rosenbloom, & Newell, 1986). I arranged each of the volume chapters, headings, and sub-heading in rows alongside their corresponding page numbers and sections to anchor them as reference-able terminologies as shown in Table 6.

Table 6.

Volume II Chapters and Chunk Nodes

Volume II	TOPICAL TITLES		AUTHORS	PAGE REF.
2. Learning Objects: Standards, metadata repositories, & LCMS	Harman K., & Koohang, A.		26	
	2.01	Learning object metadata: use and discovery	Jennie L. Mitchell and Nicholas Farha	2p.001a
		Introduction	Leslie, Landon, Lamb, Poulin, 2004; Baker, 2003; Friesen, & Nirhamo, 2003; Hatala & Richards, 2002; Hatala & Richards, 2002; Miller, 1998;	2p.001b
		Syntax and Semantics: The language of Learning Objects Models	WCET, 2004; Leslie, Landon, Lamb, & Poulin, 2004; Duval & Hodgins, 2004;	2p.003
		Organizing Learning Objects: Your Standard or Mine?	Niemann, 2005;	2p.004
		IEEE – Learning Technology Standards Committee	IEEE, 2005; Memorandum of Understanding, 2000; Position Statement 11484.12.1-2002; Learning Object Metadata (LOM) Standards Maintenance/Revision, 2002;	2p.005

I marked 268 page reference terminologies from volume II as highlighted in Table 6. *Volume II Chapters and Chunk Nodes.* I also attributed significance to the in-text cited authors and organizations among other authorities. For example significant contributions of the Memorandum of Understanding, 2000 and Position Statement 11484.12.1-2002 that I followed-up to retrieve original data and understanding I needed.

In each of the terminologies extracted, I assigned a node, then I subtexted them into targeted thematic data concepts, project samples, and notable keywords. By applying an a priori technique for data sorting, I added columns to contain semantics, syntax, examples, procedures, and references. I only anticipated a few terms at the beginning, but the list of terminologies grew as the integrative literature review wore on. A priori coding approach enabled the likelihood of recognizing a developing pattern as the data was extracted (Rogers, Sharp, & Preece, 2011). Ten conceptual and thematic nodes including the authorships helped in clustering the extracted data. Because data chunking makes large textual extraction manageable and where patterns become apparent, I derived newer segments with clearer descriptions becoming nodes in their own right (Glaser & Strauss, 1967). The following are among the ten notable containers in my tabulated data: Authors, Organizations, Formats/Models, Projects/Systems, Terms/Terminologies, Samples, Metadata Scheme, Metatags, Data Types, and finally Labels.

Existing metadata schemes. I extracted 590 data labels from the four volumes with over 100 resource types. I incorporated these resource types in the tool design as resource labels and descriptors, i.e., metatags. Most of these texts, words and phrases were not value-laden if not implemented into the metadata management tool in a simpler, useful, and systematic format. Metadata schemes were mentioned extensively in the Koohang and Harman (2007) learning objects anthology. Metadata is an effective management and administration convention for learning objects in digital libraries. I cited various organizations and institutions as authorities who have helped develop and consolidate metadata for controlled and open systems of learning object repositories, especially for resource definitions and references.

Below is a list of some of the most prominent organizations.

1. Learning Object Metadata (LOM)
2. UK LOM
3. Institute of Electrical and Electronics Engineering, Incorporated
4. CanCore
5. SingCore
6. Dublin Core Metadata Initiative (DCMI)
7. Joint Information Systems Committee (JISC)
8. Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE)
9. Global Learning Ob-jects Brokered Ex-change (GLOBE)
10. IEEE Computer Society Standards Activity Board
11. Instructional Management System (IMS)
12. International Organization for Standardization (ISO)
13. New Media Consortium (NMC)
14. Advanced Distributed Learning (ADL)
15. Portal for Online Ob-jects in Learning (POOL)
16. Content Object Repository Discovery and Registration/Resolution Architecture (CORDRA)
17. Multimedia Educational Resource for Learning and Online Teaching (MERLOT)
18. California State University Center for Distributed Learning (CSU-CDL)
19. IEEE Learning Technology Standards Committee (LTSC)
20. Education Network Australia (EdNa Online)
21. eduSource Canada

22. W3C
23. National Institute of Multimedia Education (NDIE, Japan)
24. Campus Alberta Repository of Educational Objects (CAREO)

I noted that most of these organizations use codified lexicon describing various aspects of their repository architecture. Still, metadata standards fail to account for "dynamic content" that enhances reusability and agile customization embedded in most dynamic learning objects (Duitama et al., 2007, p.253). Some metadata schemes and functionalities created by these organizations for specific localized projects have since evolved to assume newer values. Others have become defunct, whereas most remain open for reuse, revision, and repurposing. I extensively looked at universally renowned schemes of metadata standards currently in use at various organizations. The organizations are:

1. Dublin Core Metadata Initiative (DCMI)
2. EDUCOM (merged with CAUSE to form EDUCAUSE)
3. Instructional Management System (IMS) Global Learning Consortium
4. Learning Technologies Standards Committee (LTSC)
5. IEEE's Learning Object Metadata (LOM)
6. Multimedia Educational Resource for Learning and Online Teaching (MERLOT)

EDUCATE: A New Metadata Scheme

Developing a new metadata scheme fed into the impetus for a paradigm shift in the learning objects reusability field especially in the face of noted gaps illuminated by this study. A review of existing systems and a subsequent consequential mapping attempt I elaborately carried out allowed me an in-depth conceptual knowledge of their constructs. While disassembling and reconfiguring existing formats, I was able to devise inclusive content definitions, semantics, and syntax for the new scheme. The new metadata management scheme, which was titled the EDUCATE metadata system, allows for singular definition of metadata elements without potential ambiguity. The EDUCATE format caters to the dynamic learning objects properties while still allowing for future extensibility.

The majority of data extracted to populate the metadata management tool architecture came from Koohang and Harman's (2007) volume I and II books, whereas volumes III and IV had data extracted from select relevant chapters. After refining the data, I consolidated some elements or used them as is after removing duplicates. Examples included digital media format, granularity levels, and samples or components of learning objects such as file names. My new scheme fields became controlled vocabularies to aid in resource tagging. These included: Courses, Modules, Lessons, Topics, Edited books, Curriculum, Fragments, Podcasts, Journal Articles, White paper, Objectives, and Goals. The controlled vocabulary listing was in alphabetical order and simplified to help in shared indexing. Some fields to attribute to the learning objects will be mandatory metadata to help handle the resource relational association in the digital library.

Controlled Vocabularies

Controlled vocabularies are very useful to describe learning objects according to their latent characteristics. Controlled vocabularies are select defining terms. The terms, when taken collectively as a reference glossary, give structure to the library of resources. When controlled vocabularies are applied as a standard, they become resource definition frameworks (RDFs). The controlled vocabularies help map resources within a library or repository. RDF data inform system users about a LO's assumed characteristics and at times they become latent resource descriptors.

I applied controlled vocabulary to the prototype after mining them from the integrative literature review process. The system users can maximize the use of controlled vocabulary. Users have this data auto-populated where applicable in describing learning objects. Controlled vocabulary includes names of countries, languages, subjects, licensing, and dates, among others. In order to be most comprehensive, I gathered more data from organizations such as the United State National Center for Education Statistics (U.S. NCES), Canadian and United Nations Classification for Instructional Programs (UN CIP). I also extracted subjects and degree programs data from large online education providers and major universities in continental United States.

Other Controlled Vocabularies Sources

I went beyond standard nomenclature to work with what catalogers are currently utilizing in the Library of Congress scheme. The metadata management tool will enable a combination of these classification efforts to work in concert with what users find familiar while also accommodating professional and non-professional-minded catalogers. I added additional classification systems that inform the choice of taxonomies to include the Joint Academic Coding System (JACS) and US National Center for Education Statistics (NCES). These schemes helped me characterize courses within majors/minors of subjects as shown in Table 7.

Table 7.

Metadata Tokens

SEARCH TYPE	METADATA ELEMENT
Subject	Joint Academic Coding System (JACS), Uniform Resource Name (URN), ISCED, Library of Congress
Creator Name	Contributor (Author) surname, personal names, other names, publisher
Title	Learning object descriptions with single instances only
Keyword	(All) Name, Title, Subject, Resource objectives, resource name
Technical Format	There are over 70 media types including application, audio, image, message, model, multi-part (templates), text, video, etc.
Resource Value	Curriculum/Courses/Modules/Lessons/Topics/Fragments/Edited books, Podcasts, Journal articles, White paper, Objectives, Goals, etc.
Contribution Date	Auto-generated by system
Licensing	Creative commons or Copyright Restrictions

International Standards Classification of Education (ISCED) and the Library of Congress Authorities also enabled elemental classification of disciplines that I mapped to a 3-Tier-ISCED Fields of Education and Training. These tabulated data formulated the controlled reusable vocabularies for the metadata management tool. The effort recognizes utilizing established classification of instructional programs and common education data standards.

Expert Review Results

Four experts with varied fields of expertise provided feedback related to the prototype of the metadata management tool. The four experts had specialty in the following areas:

1. A college librarian with specialty in cataloging and classification of instructional programs experience.

2. A college librarian with specialty in data curation and research also experienced in metadata management.
3. An emerging technologies expert with learning objects management and programing experience.
4. An instructional content and design expert with learning objects usability experience.

The experts performed six core tasks that aligned with the three problem statements identified in this study. The four recruited participatants responded positively and took part in the tool review session. The composition of the reviewers varied with respect to their professional and education backgrounds (Creswell, 2013; Saldaňa, 2012). Their distribution was multifaceted in that the reviewers marked more than one aspect of themselves as illustrated in Table 8.

Table 8.

Reviewer Expertise and Positions

	Role	Percentage	Count
1	Student	50.00%	2
2	Teacher	25.00%	1
3	Researcher	50.00%	2
4	Professor	25.00%	1
5	Administrator	50.00%	2
6	Other (please specify)	25.00%	1
	Total number of unique reviewers		4

Table 8 captured both reviewers' roles and expertise as they marked the question in their own perception, for example a reviewer could be an administrator and a student at the same time, or professors could consider themselves a principal investigator in a research project. In terms of highest level of education completed, there was one undergraduate, two masters, and one doctoral reviewer. Variety in this sampling was supposed to allow for multiple rich feedback that informs qualitative researches in-situ (van den Akker, 1999) znd these recruits captured well prospective tool users who could become the content creators, deliverers, and consumers.

After aligning their availability schedules, I organized a review session to administer the survey instrument. The session included a databases expert who was on hand to attend to any concerns about the backend programing questions. Prior to meeting, I presented all the participants with the Institutional Review Board documentation (see Appendix B) with regards to their rights, risks, student benefits, and options for further assistance, redress, or voluntary withdrawal at any point during the review session (see Appendix C). I reread the informed consent form to acknowledge their explicit consent then presented the purpose and procedure of the review process. The outline of the guided systematic tasks were as follows:

1) Watch a 3-minute overview video tutorial
2) Read the detailed tutorial document (optional)
3) Explore key features of the tool (sign in, search, share searches, tag, and view resources)
4) Concurrently fill out an online survey as they performed assigned tasks

Task 1: Sign in. All participants successfully signed in.

Two participants were very satisfied with the sign in procedure, one was satisfied, and one participant was neutral.

Task 2: Search. All participants indicated they successfully completed task 2. Two participants indicated they were very satisfied or satisfied with the guided search process whereas two indicated they were neutral. Further probing showed that most reviewers preferred the search area list to be in alphabetical order to improve finding and marking their areas of search interest.

One reviewer noted they would like to be able to go back one-step in the search process instead of having to go back to the beginning of the search when they hit the back button. One reviewer received an error message when they attempted to go back. Also noted was a consideration to change the title of the page from Select Table, which the reviewer felt was a technical term that only experts would understand but could confuse an ordinary user. At this point, one reviewer started to experience technological difficulty based on unfamiliarity with an operating system that seemed to slow or impede their objective review of the tool functionality by claiming it was "…hard to separate problems in the tool from problems in the test laptop OS[sic]."

Task 3: Universal search. All participants successfully completed task 3. Three reviewers recorded that they were satisfied with the universal search process while one said they were dissatisfied. This reviewer noted that the text for the results search box on the upper right corner of search results was a bit confusing to them. The reviewer suggested that it would make more sense if it changed to "filter search results." Another observation was allowing compound searches for keywords. As the reviewer noted in their comment:

> When I type "kibong", I was able to find a learning object with "Research" in the title. However, when I typed "kibong, research", there was no result found. Obviously the search is trying to find all the search words in the same field.

Other observations made included suggesting changing universal search to keyword search. One reviewer experimented with including quote marks to a similar search term but found no results yet they had expected the previous same results to display.

Task 4: Search by history. All participants indicated that they successfully completed task 4.

Three reviewers noted they were satisfied with the process with one recording neutral. The neutral reviewer noted that the search by history did not capture their previous search term from the universal search task. This view seemed to be shared with another reviewer who commented the following:

> It appears that "Search By History" does not include the full history. For example, it does not include the first search from the "Universal Search" activity in task 3. If the link to the search is important for sharing, I would say that having a link to even a search with no results would be important to keep an eye on important key terms.

A reviewer praised the ease with which the URLs for search by history appeared but added another concern about auto-proxy by saying:

> Easier to use your Path link icon than copy/pasting. Will there be permalinks for the item record as well as for the item itself? (I worry about how well URLs for proxied items - or auto-proxied items could accidentally be transmitted)

Task 5: Input new learning object. Three participants noted that they completed the task successfully.

One reviewer who had been having trouble with the technology noted that they were unsuccessful because of the following:

> Field names (eg Curriculum) do not necessarily connote the same things to users with different backgrounds -- for consistency, provide helps to direct user to your standardized connotation/definition (with example). Preselected options for fields in this test are incomplete (and sometimes not ordered in predictable fashions, notably alphabetical or not, but also topical clusters could make sense), yet they are very long.

Two reviewers were satisfied with input learning objects process while one was neutral and another dissatisfied. The responses were as shown in Table 9:

Table 9.

Task 5: Responses for improving "Input New Learning Object"

RESPONSE	COMMENT
Dissatisfied	Some lists are way too long to scroll through.
Satisfied	Your metadata fields should have descriptions to help tool users more easily understand what information should be added to the field. You should also considered creating a controlled vocabulary for fields where necessary.
Neutral	Using the drop-downs was somewhat difficult. It was not clear that they were searchable, which made navigating the longer lists (particularly subject and keywords) very difficult. Within keywords, it was difficult to add appropriate ones. The only way to add multiple keywords was to put them all in as a list which makes this hard to search, so there needs to be a way to add multiple keywords that are not already on the list.
Satisfied	responses to difficulties. This has great potential nonetheless.

Task 6: List of learning objects. All participants successfully performed task 6. All participants recorded that they were satisfied with the function and included improvement recommendations as follows:

Table 10.

Task 6: Responses for List of Learning Objects

RESPONSE	COMMENT
Satisfied	When typing "objectives" in the search box, it would be nice if all "objectives" in the filter results are highlighted.
Satisfied	The page search box in the top right on the page should be labeled differently to indicate that it is a page search and not a search function for the database.
Satisfied	Having a back button for this section is very helpful. It would be useful to add this for more search / listing pages.
Satisfied	functionality is OK, but the prompts need refinement (eg, direct user to universal search, not plain (fielded) search

Metadata Alignment schemes. In this task, the reviewers reviewed a metadata schemes alignment matrix.

This section involved participants interrogating various metadata schemes and reflecting on their thoughts about how the current integrated metadata scheme EDUCATE was incorporated into the tool. Various reviewers expressed their thoughts especially drawing from a stance in their fields of expertise. Their comments are as follows:

Table 11.

Task 7: Metadata Alignment Schemes

COMMENT
Generally, this is a nice tool. I do wish for some improvement to the UI: as mentioned in individual tasks, when I had to go through a long list to find items, I'd like to be able to type a few letters and filter out items. Also, when creating new learning object, it would be nice to have definitions of each field available for users' reference, as the boundaries between terms such as "course", "topic", "fragment" are not clear-cut.
Mapping multiple metadata schemes is very difficult as I'm sure you've already identified. Did you find metadata schema like MODS which is used by the Library of Congress which can be a more flexible rather than trying to blend multiple schema?
I don't have any specific feedback about the scheme. I do think that it needs to be clearer in the interface when you add an object that folks are choosing 1 level (Curriculum to Fragment). This might be clearer if you had folks choose that from a drop-down then had them select/add the names of the higher-level pieces that they fit within.
I'm wrestling with the same problem in a different project. I hope you can tell me what you come up.

Learning object review instrument. Three participants completed this section. One participant partially completed this section. The responses are in Figure 13 Learning Object Review Instrument Data. For the applicable components of the LORI instruments, the tool did not score a low point. Reviewers indicated the tool scored average to high on feedback and adaptation, motivation, presentation design, interaction usability, accessibility, and finally standards compliance.

#	Field	Low1		2		3		4		High5		N/A		Total
1	12.1. Content Quality: Veracity, accuracy, balanced presentation of ideas, and appropriate level of detail	0.00%	0	0.00%	0	0.00%	0	75.00%	3	0.00%	0	25.00%	1	4
2	12.2. Learning Goal Alignment: Alignment among learning goals, activities, assessments, and learner characteristics	0.00%	0	0.00%	0	25.00%	1	25.00%	1	0.00%	0	50.00%	2	4
3	12.3. Feedback and Adaptation: Adaptive content or feedback driven by differential learner input or learner modeling	0.00%	0	0.00%	0	0.00%	0	66.67%	2	0.00%	0	33.33%	1	3
4	12.4. Motivation: Ability to motivate and interest an identified population of learners	0.00%	0	33.33%	1	66.67%	2	0.00%	0	0.00%	0	0.00%	0	3
5	12.5. Presentation Design: Design of visual and auditory information for enhanced learning and efficient mental processing	0.00%	0	33.33%	1	0.00%	0	33.33%	1	33.33%	1	0.00%	0	3
6	12.6. Interaction Usability: Ease of navigation, predictability of the user interface, and quality of the interface help features	0.00%	0	0.00%	0	100.00%	3	0.00%	0	0.00%	0	0.00%	0	3
7	12.7. Accessibility: Design of controls and presentation formats to accommodate disabled and mobile learners	0.00%	0	33.33%	1	33.33%	1	0.00%	0	0.00%	0	33.33%	1	3
8	12.8. Standards Compliance: Adherence to international standards and specifications	0.00%	0	0.00%	0	66.67%	2	0.00%	0	0.00%	0	33.33%	1	3

Figure 13. Learning Object Review Instrument Data

Overall review. For an overall review, three reviewers marked the tool as good. One marked it as average (see Figure 14). All reviewers indicated the tool accomplishes its built functions and provided further comments that, in their view, would improve the score to excellent. These comments are in Appendix D.

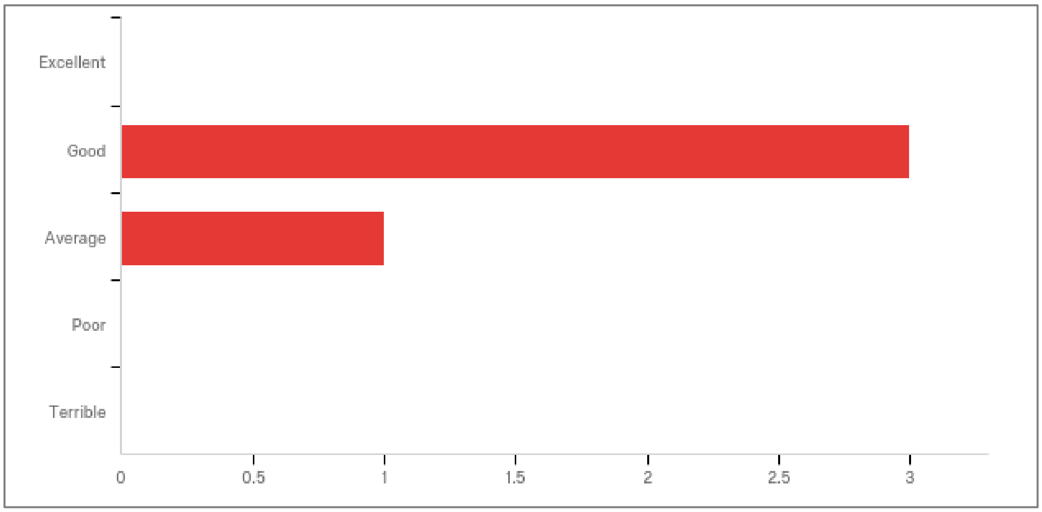


Figure 14. Overall, how would you rate the tool?

The mentioned successes of all the designed functions positively reflects on the prototype actualizing solutions to the identified problem statements of this study.

Problem Statement I: A problem associated with some existing metadata management tools is that they allow users to input only predefined metadata. For example, format types of learning objects include only document, audio, video, and other formats reflecting current technologies and format types. However, as technologies, knowledge, and social and institutional environments change over time, new types of metadata will appear. Thus, a more flexible tool that can accommodate new categories and characteristics of metadata with minimal modifications to the tool is required. The new metadata management tool should enable learning object content designers, deliverers, and consumers to add new metadata to tagged learning resources. For this first problem statement, the reviewers were able to use the tool to assign new metadata to a LO. The ease of use in this aspect reverberates with removing barriers of complexity discussed earlier in this study (Taylor et al., 2007).

Problem Statement II: Proper classification of learning objects allows for better searches of tagged learning objects. A tool that helps in the management of metadata for open learning objects should accommodate semantics that both professional and general users recognize. General users, unlike librarians or experts in learning objects management, are likely to have limited knowledge about metadata schemes for learning objects (i.e. Learning Object Management, Dublin Core, Instructional Management Systems, Merlot, Learning Technology Standards Committee, and others). A tool integrating various metadata schemes for learning objects is required to provide users with a means to easily search and access needed learning objects and their metadata. For this second problem statement, reviewers felt there needs to be room for expanding EDUCATE's metadata scheme. One reviewer wanted alphabetized drop-down lists for all controlled vocabularies. Another wanted auto-search and auto-population of multiple tag selections instead of hiding them under the fold. A reviewer proposed a new element in the scheme to differentiate, and then assign separate data fields for LO creation date, publishing date, and upload date.

Problem Statement III: Metadata management tools that allow for individualized and collaborative uses in tagging and sharing learning resources search lists are likely to be more useful than tools that do not have these features. Most existing similar tools focus on personalized non-transferable administration of learning objects, rather than collaboration among users and sharing of their discovery. By having Curriculum, Course, Module, Lesson, and Topic metadata elements and allowing users to add/edit metadata of learning objects, users can collaborate to create and manage a list of learning objects. Individualized search lists of learning objects with particulars on the granularity, description and location links to the learning resource aid in the packaging of learning objects with relevant metadata that can target users with similar needs. For example, a teacher can share the list with his/her students or colleagues to provide multiple learning objects on curriculum, course, module, lesson, or topic. By providing links to search history, users also can easily share the list of learning objects with other users. For this final problem statement, two reviewers successfully shared their search history results and most noted that sharing is a definitive function that is lacking in similar tools they have come across. One reviewer suggested hover texts to define the various element in the tool aside from placing them in the tool manual. This would go a long way in universal acceptability of terminologies and establish better relationship between concept and term (Mitchell & Farha, 2007; Nilsson et al., 2007). A reviewer verbally expressed that ADA-compliance features be made to accommodate and improve universal accessibility. Although one reviewer sad the tool was “very robust and allows experienced users the ability to clearly label and search for learning objects”, the reviewers generally agreed that there is room for improvements to the tool.

Chapter 6: Discussion and Conclusions

All resources explored during the research process fed to designing the tool. The result is a prototype of a metadata management tool as well as informative literature on learning objects. The prototype demonstrates the feasibility of creating a tool that enables the tagging, managing, and searching of metadata for learning objects. I anticipate the tool could contribute to better metadata management and utilization for learning objects especially for learning designers, deliverers, and consumers. When more fully populated, the tool could allow for easier finding of learning objects tagged with meaningful descriptors related to learning needs that users have. I noted and learned key lessons during the research process. This chapter gives a reflection of my research experience along with proposing future directions. I present recommendations about the unique contribution the tool might have to education efforts especially in the face of the current digital learning era.

What the Metadata Management Tool Does

In-service teachers, pre-service teachers, teaching assistants, private tutors, and instructional designers, often look for better strategies, tools, content, facilities, and platforms among other things to impart or improve learning. Finding examples, alternative methods, and means of elaborating various concepts via high quality resources often enriches learning and potentially spurs creativity in the learning process.

Creating a tool, with the aim of simplifying the searching, finding, and linking of various educational resources, becomes essential especially if it promises to deliver high quality items. The developed prototype provided a working demonstration of a tool that enables users to access learning resources on a 'software-as-a-service' platform. Added advantages of the tool could include reduced overhead of time and resources spent in curriculum design and redesign, lesson planning, sample finding, or template reuse.

My journey footsteps, whether small at one time, or leaps at other times, informed the decisions that influenced the final destination: the conceptualization of a reusable learning objects tool development for metadata management.

Skills I Applied when Creating the Tool

I undertook a research design and development methodology to examine the problem and come up with solutions. This approach enabled the planning, conducting, and reporting on the entire process and procedures encountered during the study. According to Richey and Klein (2014), in-progress project data is not hard to collect, since collecting everything sometimes provides "records of failure" and uncertainty that are crucial and consequential in the entire study process (p.104). I sought to understand all aspects of the problem, probable solutions, and the status of affairs in the field. This meant reviewing considerable relevant literature that generated data as preliminary groundwork.

The integrative literature review I conducted at times supported or refuted and then added to the prior knowledge I had about key concepts and aspects of my case. I needed to know what educational resources are available, and how they deploy in educational settings. I needed to be aware of the various LO systems standards and interoperability protocols. I looked into how the impact of international/universal deployment related to the solutions I proposed and the suggestions my circle of experts brought in. I took a proactive approach at the beginning by embedding solutions from the experts into the early phases of the design and development process, then a reactive approach to eliminate duplicated measures or outmoded technological approaches and to add important measures and information that were overlooked when using the proactive approach. This meant that I excluded, omitted or added some things during the reactive process.

Proactive Solutions to Arising Gaps

Adjustments reflected responses to identified functional aspects of the tool development process. Where I discussed newer functions, or expanded terminology lists, I tested each element to check its viability and persistence over time. Most of my tool development and design decisions solidified after consultation with various stakeholders and experts in the field. While my reactive approach responded to functions, the proactive approach was an a priori action to incorporate various elements into the prototype base construct. Both processes in the tool development were exhaustive, exhausting, and sometimes bittersweet.

Discussions with Experts

Consultations, meetings, and discussions with experts did not cease with the creation of base prototype elements. At the beginning, solutions on how to source quality digital learning resources emanated from general knowledge. Views of library patrons, instructional design experts, performance support designers, and my database developer enhanced my familiarity with the literature and other elements of the project. I attended conferences, OER symposia, and round table brainstorming sessions with industry stalwarts discussing the future of learning objects prior to conducting the integrative literature review.

Proactive and Reactive Solutions

Throughout my research and investigative process, I consulted with people experienced in storage, retrieval, and identification of learning resources that are both physical and digital. By engaging in both proactive and reactive approaches, I was able to identify gaps. I also learned valuable lessons when shopping for reuse LO solutions. Sometime I accommodated the gaps or reconsidered the original need in order to make the tool functional/accessible. However, additional gaps persisted, like the need to map newly developed metadata with existing industry standards, or the need to sustain user search profile and history. The current metadata management tool had to align with the scope of the original problems. It had to be useful and capable of locating anticipated quality resources for the users before incorporating new solutions and future considerations.

When new thoughts arose that would scaffold the existing capabilities already designed in the system, it felt like new groundwork needed to be done to implement and cover newer gaps. This led me to explore existing literature to find solutions. Where research methodology was silent, I incorporated other plausible methodologies to justify the solution for my unique gap. The integrative literature review informed adjustments to in-progress project data I used to build new cases and scenarios. I consulted subject matter experts consistently to refine the development and designs of the tool whereby its performance, functions, and probable capabilities were tested, added, and deleted in real time. Though laborious, sometimes I eliminated large portions of literature that no longer seemed to be supporting literature after collecting and refining it over long periods.

Documenting the research design and development stages also was challenging especially given the iterative nature of all processes involved even after the finalization phases. In one instance, I felt the tool was ready with its four pertinent functions. I developed a user manual to assist users in those four functions. Shortly thereafter, a fifth equally important add-on 'destabilized' the original user manual flow. This was the "search-by-history" function added onto a finalized manual later on. "Universal search" was another equally important feature lately retrofitted into the existing scheme of functionalities. Given the unique nature of every tool development and design research, accommodating the needs and multiple demands of key players working on the entire process became second nature to the entire study process.

Other Lessons Learned

Design and development research is a complex undertaking. It also is a useful research methodology to apply in solving real-life problems because of its exhausting iterative exercise. New gaps spring up at every stage. My experiences revealed to me that applied solutions become new unintended consequences that I considered and reconsidered against original research purpose. However, the chosen combinatorial methodology was the most versatile format to address arising issues in the end. Its adaptability based on iterative feedback from each developmental stage counteracted any foreseeable flaws that might have hampered progressive improvements to the tool design. The ease with which design and developmental research accommodated other relevant or useful methodologies also added variety, robustness, reliability, and validity into the entire process. With such advantages, coupled with rigorous documentation, the research process became replicable given the same scope and nature of the problem.

Study Significance

I explored the influence of reuse as an ideological case for learning objects offered by higher education institutions and other consortia. Particular characteristics of reuse that fit an operational definition of reusability were then established and I used them throughout this study.

The study builds on and contributes to work in reuse of educational products. Although studies in educational product reusability have examined repositories as reusable, no clear literature and understanding focuses on defining, classifying, searching, finding, and reusing manageable metadata schemes for such educational products at various granular levels. As such, this study provides additional insight into the classification system and metadata management of reusable learning products. The analytic focus on the classification and development of a prototype tool is a significant contribution.

Although numerous studies (Chia-Shing, 1994; Kim, 2009; Moseley, 2013; Wiley, 2000b) identify actual LO use and how instructional designers modified them to fit specific contexts; there is little analytic discussion on how to apply them broadly at various granular levels. There is almost no literature addressing utilizing a definitive metadata management tool to guide their application in curriculum development (Naeve, 1999; Nilsson et al., 2007). This research addressed these research gaps by constructing a tool for learning objects metadata management enabling searching, finding, and efficiently referencing them to serve similar adaptive purposes in a global context.

Study Benefits

Learning objects metadata that are readily searchable within carefully indexed schemes, using a universally intuitive meta-tagging system,could makes the access process easier for students and teachers alike in terms of accessing quality educational content. This study resulted in developing and advancing standardized controlled vocabularies with expandable caveats that could increase the ability to share resources across disciplines as well as enable collaborative resource tagging where there are equivalencies (Riley, 2017). The developed tool has the potential to promote searching for and finding of LO by providing access to appropriate educational resources at needed granularity levels. Once found, these learning resources could contribute to curriculum revisions. Students also could use such a tool to search for, find, and view relevant content or course pre-requisites.

Accessing learning object resources using metadata search functions in the tool could expose resources regarding tagged topics of interest that can allow more students to study at their respective pace and independently before embarking on active learning activities in classroom meetings (Gabbert, 2003). Content designers, deliverers, as well as content consumers can jointly collaborate in tagging and classifying resources meaningfully for their utilization thereby accessing the educational resources as a single solution to their variant needs.

Study Limitation

Application of this study's method of searching and finding learning objects were limited a specific collected library of over 70 meta-tagged resources. Although this approach was useful for determining the overall functionality of the prototype, many more entries would be required to determine the practical utility of the tool for a more extensive collection of users.

As a researcher, my subjectivity and lived experiences influenced the interpretation and delimiting of the definitions of my subject area. To some extent, subjectivity affects some terminologies like reuse and the conceptualization of granularity of the learning resources. Jaeger and Christaller (1998) say interpreting and understanding subjective definitions from a thoroughly critical or objective point of view is hard to realize absolutely due to unavoidable specified factors related to most researchers' interest. This study developed a matrix of reuse factors through the filter of theoretical reuse practices in specified domains. Because there is a plethora of classification taxonomies, it becomes imperative to delimit the reuse definition in a given study: reuse is sustained utilization of products, services, or tag resources by current users or the first time use of an existing product or service by another new user without significant modification in the original form. My interest in reuse of educational products or continued-use of the products and services, necessarily served as factors influencing the prevailing interpretation of learning objects reusability for this study.

Future Improvements

The metadata management tool allows for improvements based on formative and summative evaluation procedures. The prototype is a web-based application allowing anyone with access to the internet to test-run its functions. Where applicable, there is a chance to update its core database tables or library of controlled vocabularies. Reviewers of the tool recommended improvements in displaying all existing elements alphabetically to ease finding the terms. Also worth adding may be a hover definition feature that explains elemental categories so that the tool establishes a universal acceptability of terminologies and better relationship between concept and term (Mitchell & Farha, 2007; Nilsson et al., 2007). Whenever new sets of standards by other organizations are instituted, elaborate metadata schemes can be added to accommodate them without affecting the core functions of searching, tagging, and finding quality learning objects.

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Appendices

Appendix A. Early Iterations of the Tool GUI

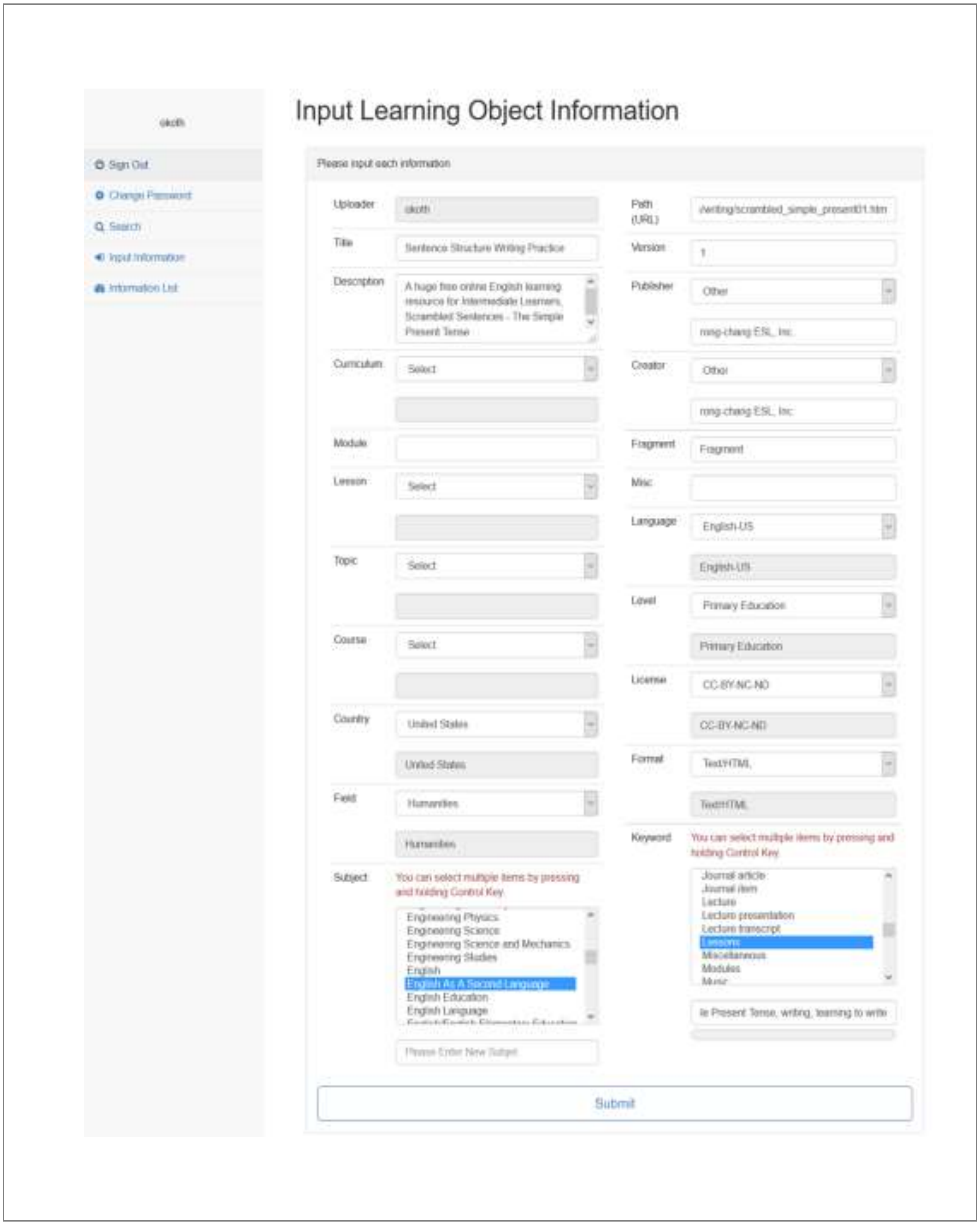

Figure 15. Early Iteration of GUI for Database Content Upload

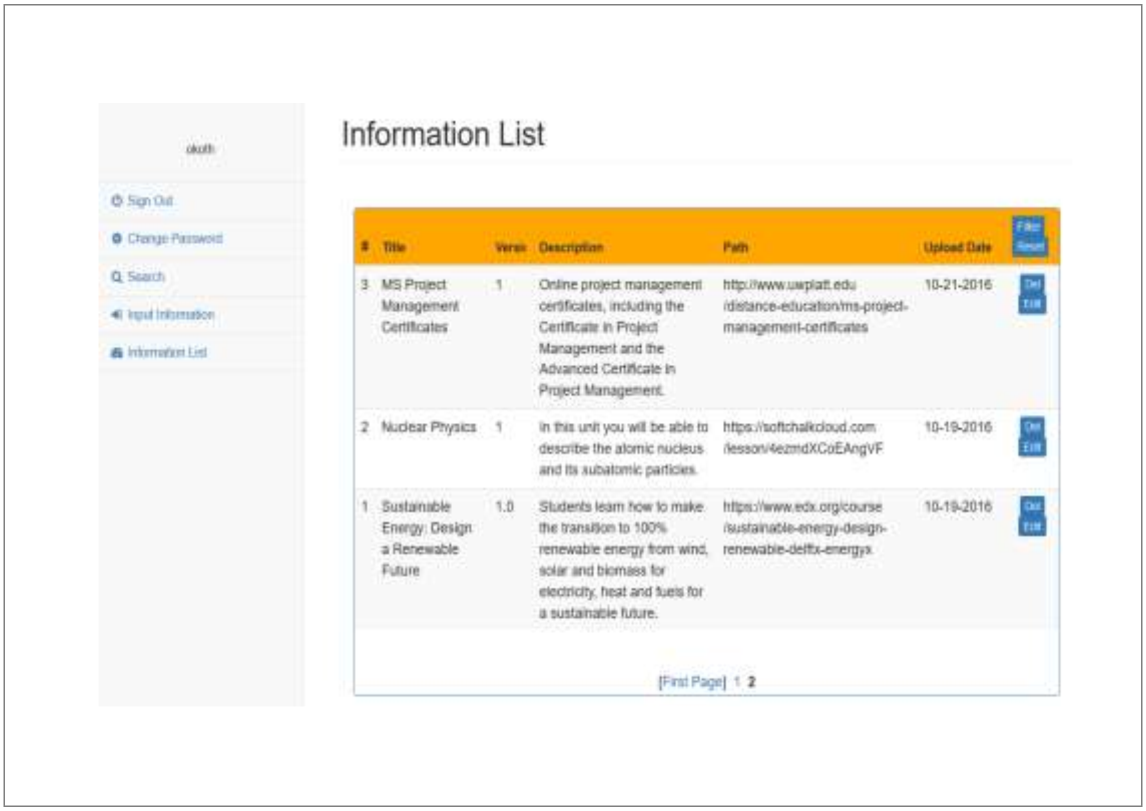

Figure 16. Early Iteration of GUI for Database Content Information List

Figures 15 and 16 illustrates the terminologies used for earlier navigation as input information and information list. In the latest prototype, these terms changed to input new learning object and list of learning objects respectively.

Appendix B. IRB Approval Letter

VIRGINIA TECH.

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	December 12, 2018
TO:	Ken Potter, David O Okoth
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)
PROTOCOL TITLE:	Design and development of a reuse tool to support the use of open source learning objects
IRB NUMBER:	**14-628**

Effective December 7, 2018, the Virginia Tech Institution Review Board (IRB) approved the Continuing Review request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

https://secure.research.vt.edu/external/irb/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 5,6,7**
Protocol Approval Date:	**December 22, 2018**
Protocol Expiration Date:	**December 21, 2019**
Continuing Review Due Date*:	**December 7, 2019**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irb@vt.edu) immediately.

Appendix C. Informed Consent Form

Title of Project: Design and development of a reuse tool to support the use of open source learning objects

Investigator(s): Okoth David, Instructional Design and Technology Program, **Email:** okoth@vt.edu **Tel:** (540) 951-7012
Advisor: Dr. Ken Potter, Program Leader – Instructional Design and Technology; **Email:** kpotter@vt.edu **Tel:** (540) 231-7039

I. Purpose of this Research Study: This research study focuses on the design and development of a reuse tool that addresses the storing, searching, and locating of open source learning objects. Open source learning objects with a universally acceptable meta-tagging system may make the learning process easier for teachers and students in terms of accessing quality educational content especially in developing countries. The developed reuse tool is Service as a Software (SaaS) cloud-based online platform accessible anywhere. Study results and accompanying reports may be published at a conference or other appropriate academic fora.

II. Procedures: You are a participant in this study because you are a teacher/expert/practitioner(s) in education or administrator(s) and line users of course content and classification who constitute key stakeholders in the eLearning and blended system. Participation is voluntary and confidential. Reuse, design, repurposing and modification of open source learning objects are normally something you normally considered when preparing your lessons/classes/syllabi/curricula. The research procedure will include optional review of the tool's user manual and filling out an online survey. Individuals will not be personally identified. All data will be reported in aggregate.

III. Risks: Participation in this research does not place you at any risk of harm. Confidentiality is assured. The researcher will work to ensure all materials collected through this study are stored securely and remain confidential.

IV. Benefits: While there may be no direct benefit to you as a participant, results from this study may be helpful in the understanding of course building processes. This study is directly related to the development of appropriate interventions for course designers, deliverers, and consumers to help them effectively integrate reusable open source learning objects in their learning or design process. Additionally, if interested, you may contact the researchers at a later time for a summary of the study results.

V. Extent of Anonymity and Confidentiality: All the data gathered will be kept confidential. Participants will be identified by random codes such as KY7L3E which only the researcher will have access to. The results of this study may be published and/or presented at academic meetings without naming you as a subject. No reference will be made in oral or written reports that could link you to the data nor will you ever be identified as a participant in the study. All survey data will be stored securely on Instructional Design and Technology Program secure servers. The data will be destroyed after the standard two years following study completion date. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight and protection of human subjects involved in research.

VI. Compensation: There is no compensation provided to the participants of this study other than an appreciation for participating and contributing to the body of literature in this topical area.

VII. Freedom to Withdraw: As a participant, you are free to withdraw from a study at any time without penalty and you may choose to not answer any questions or respond to experimental situations without penalty.

VIII. Participant's Responsibilities: I voluntarily agree to participate in this research study. I have the following responsibilities: review and sign/initial the consent form then fill out the provided online survey about the reuse tool.

IX. Participant's Permission: I have read the consent Form and conditions of this research study. I also understand that I have the **right to refuse to participate** and that my **right to withdraw from participation at any time** during the study **will be respected** with no coercion or prejudice.

I hereby acknowledge the above and give my voluntary consent:

PLEASE NOTE: PRINTING THE CONSENT FORM RECOMMENDED FOR THE PARTICIPANT'S PERSONAL RECORD KEEPING.

____________________________ - - - - - - - -   ________________
Signature or PRINT NAME   or [INITIAL]   **Date**

Virginia Tech Institutional Review Board Project No. 14-628
Approved December 22, 2018 to December 21, 2019

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Appendix D. Overall Review Comments from Experts

Table 12.

Task 7: Overall Review and Comments

Q11.1 - How likely are you to use this tool in future?	Q11.3 - What experiences have you had with similar tools?	Q11.4 - What did you like most about the tool? (Please explain why)	Q11.5 - What did you like least about the tool? (Please explain why)	Q11.6 - Overall Comments: Do you have any ideas or suggestions for improvements tha...
Somewhat likely	I have had some experience with similar tools			
Somewhat likely	I have had some experience with similar tools	I like that this tool helps you see at a glance the type so that an instructor or instructional designer could imagine how it could fit into the learning experience they are designing.	I think the biggest barrier currently is the terminology and on-boarding the user more thoroughly. I think a K-12 instructor would really benefit from this sort of resource, but the current iteration would be difficult for him/her to use.	I think this is moving in a good direction but still needs work to be used by a general audience. I would also be interested to know how someone with a screen reader would experience this interface. I worry that it would be a little overwhelming now. This might mean doing more to limit adding one-off descriptors or titles to keep the lists under control.

Somewhat likely	I have had some experience with similar tools	It's very robust and allows experienced users the ability to clearly label and search for learning objects.	It's very robust. This tool can easily overwhelm users. It would be helpful to have embedded descriptions of the different fields.	
Somewhat likely	I have had better experience with similar tools	An established database of learning objects metadata would tremendously help learners, instructors and instructional designers alike.	Long scroll lists. It's frustrating to have to go through the items to find what I want.	No