Establishing technical quality criteria for Learning Objects

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Abstract: The idea of Learning Objects is now a widely accepted concept for the delivery of modularized e-learning content. Originating from Object Oriented programming, the concept has evolved to embrace almost everything that is digital. Based on literature, experience from implementation and a comparative study of Learning Objects, we argue that the concept needs to be more clearly defined in order to deliver what it promises. We argue that most implementations are not technology- and pedagogy-neutral and do not support sophisticated reuse. In the conclusion, six action areas for establishing technical quality criteria are suggested: a narrow definition, a mapping taxonomy, more extensive standards, and best practise for use of existing standards, architecture models, and the separation of pedagogy from the supporting technology of Learning Objects.

1. Introduction

The concept of Learning Objects has gained wide spread acceptance in the world of e-learning. The main purpose of Learning Objects is to provide a modularized model based on standards, that enhance flexibility, platform independence, and reuse of learning content - as well as providing a higher degree of control for teachers and learners. The definition and meaning of the term Learning Object varies considerably between different actors and communities as well as over time. Much of the changes are due to the fact that standards have matured, that implementation has shown that everything didn't work as expected or depending on focus and theoretical perspective. Independent of this, the idea of Learning Objects is - and has always been - to organize Digital Learning Content into small, fairly context-independent chunks that can be assembled, disassembled and combined in different ways and in different learning contexts. Learning Objects from different vendors can be combined with each other to form a module that can be used in a specific learning context. Ideas that are much inspired by experience from system development which show that component-based approaches are favourable for quality and significantly reduces time to market [7]. Depending on the approach, the management and composition of Learning Objects into larger modules is managed by the teacher, the learner or someone outside the educational institution – for example by a content provider or someone distributing a learning "package". However, much of this is still just a vision and there is an impending risk that the potential multi-billion Euro market for Learning Objects will not develop as anticipated if interoperability and common concepts cannot be guaranteed. A study by the Swedish Ministry for Education [12] show that such issues are common reasons for producers to "sit on the fence" while the educational sector takes on a wait-and-see policy, as they are insecure about the reliability and implications of Learning Objects [12]. A common view is that there is still a lack of flexibility and that much of what is produced doesn't suit a preferred way of working, as described by Reigeluth [22].

The lack of common definitions and models for Learning Objects is a threat to interoperability and technical quality – as well as a threat to the concept itself. McGreal [16] points out, after a review of the Learning Object terminology, that a Learning Object may ranges "from anything to everything". Much of the vision surrounding the Learning

Objects concept has yet to be fulfilled. Most Learning Object implementations do not by far meet this vision. For those reasons it is essential to establish common criteria of quality for Learning Objects.

This article addresses technical quality criteria for Learning Objects.

1.2 What is quality?

Quality as a concept is hard to define and at the same time it is a double-edged sword. On one hand, managing quality is necessary in order to reach certain goals and obtain certain characteristics and properties; on the other hand there is an impending risk to be overambitious about quality and over elaborate things.

In ISO 9000 quality is defined as *"... a characteristic that a product or service must have...*" and ISO 9000 also states that "… *not all qualities are equal. Some are more important than others. The most important qualities are the ones that customers want. These are the qualities that products and services must have*" [1].

By suggesting technical quality criteria for Learning Objects we expect to facilitate the efforts of finding areas in which additional definitions, standards and metrics can enhance the technical quality of Learning Objects in a way that help fulfilling the Learning Object vision. We mean that technical quality criteria are specific characteristics and properties that Learning Objects must (or in some cases ought to) adhere to - including best practice, guidelines and standard specifications – in order to be regarded as Learning Objects.

1.3 Delimitation

The focus of this article is on technical quality criteria for Learning Objects, other quality criteria, such as pedagogical quality, usability or functional quality are out of scope. Such aspects of quality are addressed by van Assche and Vourikari in [27], where they suggest a quality framework for the whole life cycle of Learning Objects. In addition, this article does not try to define the term "Learning Object", rather to identify areas that need to be addressed, in order to provide working Learning Object definitions from a technological perspective.

1.4 Objective

This article reviews some previous work on Learning Objects and evaluates a couple of different models, definitions and approaches to Learning Objects in order to propose technical quality criteria for Learning Objects.

1.5 Methodology

The empirical basis for this article was collected through a comparative study of previous work on Learning Objects. The result from the study was verified against a technical evaluation of 200+ Learning Objects from three Swedish Learning Objects repositories. The repositoiries where selected for being "typical" Learning Objects repositories as well as being among the few Learning Objects repositories that permits public access, which made the study possible. The evaluation focused on four properties: architecture - in terms of separation of data, logics, presentation, and implementation of interaction interfaces; pedagogical contextualization; the use of standards and the extent to wich they are decomposable/composable. Some of the suggested Technical Quality criteria where exposed and tested through implementation within the framework of the Virtual Workspace Environment (VWE) project. This work is described described in more detail in [18].

2. Previous and related work

2.1 Learning Objects: definitions, theories and cases

The movement towards a modularised model and standards for learning content was started in the early nineties by the Learning Architecture- and Learning Objects task force (LALO), formed as a part of the Computer Education Management Association (CEdMA). Inspired by object- and component technology in Computer Science, parts of the e-learning community started to realize the considerable benefits that could be obtained using a modular approach to learning content [2]. The objective of the LALO Task Force is best reflected in the formulation by CEdMA: "*The vision of the LALO task force has been to enable new and existing learning content to be created as independent Learning Objects, such that they can be assembled in any combination to meet an individual's learning needs, resulting in increased personal productivity." [2]*

An important condition in order to realize Learning Objects is the use of Standards for Learning Technology, such as IMS[1], IEEE/LTSC[2], SCORM[3], ISO/IEC JTC1 SC36[4] and others. This is an important reason why the Learning Object community to a large extent has set the Learning Technology standardization agenda. Much of the standardization work focuses on descriptive information (metadata) [3], structure [5] and packaging [3] of learning content and not so much on the learning architecture and Virtual Learning Environment (VLE). However, since many of the content-centred standards have matured, the focus is slowly changing and the VLE is receiving more attention. Examples of this are the work done in the OKI project at MIT [25] and in the eLearning framework (ELF) project, by the British JISC [17]. Some of this work has already been adopted by standard organizations such as IMS which has adopted the Open Service Interface Definitions (OSID:s) from OKI [25] [6].

In this article we assume that international standards (preferably open) is an absolute condition for interoperability and that the kind interoperability that is needed to meet the Learning Objects vision primarily comes from the use of standards. The importance of standards is often emphasised in the literature and [18] [29] [9] and [26] are just a few example that underlines this.

2.2 Learning Objects, Lego and atoms

IEEE made one of the first and most basic definitions of a Learning Object. IEEE is also the organization behind the Learning Object Metadata (LOM) standard. They define a Learning Object as "*...an entity, digital or non-digital, which can be used, re-used or referenced during technology-supported learning." and "Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations or events referenced during technology supported learning*". This is a very wide definition that can be interpreted to include just about anything, which makes the definition somewhat hard to use. The IEEE definition, which was originally adopted from the CEdMA LALO working group, has however served as a basis for other, refined definitions.

The metaphor of Lego™ is commonly used to characterise Learning Objects. Spokesmen for the Lego™ metaphor claim that anyone should be able to assemble a Learning Module for a specific pedagogical context – simply by assembling Learning

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[1] http://www.imsproject.org/
[2] http://ltsc.ieee.org/
[3] http://www.adlnet.org/
[4] http://jtc1sc36.org/

Objects of their choice. The Lego™ metaphor is often criticized for being over simplified [28] [29], which has lead to the development of more sophisticated metaphors. One commonly used metaphor is the "atomic" Learning Object, first addressed by Wiley in [28] and then refined in [29]. The atomic Learning Object is subjected too much stricter rules and not anyone can assemble Learning Objects, and every Learning Object cannot be assembled with any other Learning Object. They must have certain attributes and properties in order to function together. The atomic view (and similar) makes the e-learning life more complicated, but at the same time more realistic. Wiley describes a model based on the complexity of the logic contained, combined with the granularity of a Learning Object. This is regarded at five levels ranging from the "Fundamental Learning Object" consisting of just a "raw asset", to the "Generative-Instructional Learning Object", which is basically an interactive module for learning. Wiley claim that the atomic model is "instructional design theory-neutral", and define a Learning Object as: "any digital resource that can be reused to support learning" [29], hence, just slightly less broad than the IEEE definition.

Sosteric and Hesemeier define Learning objects as digital objects that have a formal educational purpose within a predestined pedagogical context. Sosteric and Hesemeier take on a rather traditional view on learning. It could be argued that there is a risk that such view can limit the pedagogical choices as well as the innovative aspects of using ICT and digital learning content.

McGreal [16] means that the definition should be limited down to units that practitioners already prefer to work with and suggests a definition where Learning Objects are *"…any reusable digital resource that is encapsulated in a lesson or assemblage of lessons grouped in units, modules, courses and even programmes*."

Song and Andersson [23] take a slightly different approach to Learning Objects as they mean that Learning Objects should be regarded as decomposable, and that there must be a separation between data, operations and the carrier of the data. They also argue that an object should be described using a set of attributes and relationships to other objects. Song and Andersson focus mainly on the internal structure of Learning Objects and their relations to other objects. The Song and Andersson approach rests heavily on experience and concepts from Object Oriented Programming (OOP).

In [18] Paulsson and Naeve suggest a model and a taxonomy (the VWE taxonomy) that is compatible with the taxonomy suggested by Wiley [29] and in some ways (architecturally) similar to the model suggested by Song and Andersson [23]. The basic idea of the VWE taxonomy is to separate the data, application logics and presentation of a Learning Object. This is accomplished by the introduction of three different types of components: data-objects (referred to as "Fundamental Learning Objects" by Wiley [29], "raw assets" by Koppi and Lavitt in [13] and Information Objects by McGreal [16]) and resource objects. Resource objects are of two types: Helper Resource Objects and Creator Resource Objects. The first type is used to add application logics and/or presentation to a data-object (similar to a viewer or a plug-in) and the second is used to add application logics, that adds to the learning environment, without necessary being tied to specific content. Figure 1 outlines the VWE taxonomy model.

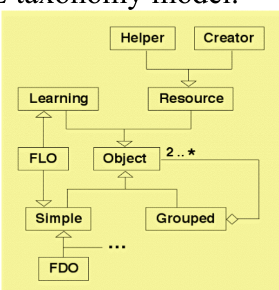

Figure 1 outlines the VWE taxonomy model.

As Wiley points out [29], most definitions conform to the IEEE definition, though they are very different which, confuses the situation. A considerable weakness in most of the Learning Objects definitions is that they state a number of quite advanced properties and characteristics, without saying anything about how this can be accomplished.

2.3 Learning Objects and pedagogy

The basic idea behind the Learning Object concept is suitable for many teachers as it supports a commonly preferred way of working. In [22] Reigeluth outlines a methodology where teachers locates a couple of resources (often books, articles etc. in the non-digital world) in order to make a selection of the parts they want to use in a specific context and reassembling them to a package - often using a Xerox machine or by simple reading instructions (i.e. sequencing). It has however turned out to be hard to make Learning Objects support such methodology in a reasonably context independent way, supporting different pedagogical approaches and still being interoperable and technology neutral at the same time [21]. To start with, Learning Objects need to be decomposable as well as being "ready-to-use" building blocks for composition of modules [23].

Learning Objects have been hyped for several years by the industry as well as by evangelists and ICT educators. The concept has however also been subject to quite a lot of criticism, often from a pedagogical perspective focusing on implications of how technology is implemented. In [29] Wiley introduces Learning objects as "an instructional technology concept". The strong relation to the field of instructional design theory, individual instructions and the idea of "sequencing" learning activities is also one of the reasons for much of the criticism [15] [21]. Partly this relates to the idea of Learning Objects as being "instructional theory neutral", which they in most cases aren't. This is in turn related to the idea of pedagogical context independence, which is a quite important attribute. Besides being a problem that originates from Learning Object definitions and the theories behind them, it is a problem caused by some of the used standards and frameworks. For example, Rehak says in an interview [14] (by Kraan and Wilson at CETIS) that SCORM is *"…essentially about a single-learner, self-paced and self-directed. It has a limited pedagogical model unsuited for some environments.*" Further on in the interview he says: "*SCORM has nothing in it about collaboration. This makes it inappropriate for use in HE and K-12*" This clearly illustrates problems caused by the way that Learning Objects are implemented and used – often claiming a constructivist approach and without considering the shortcomings of the used definitions, model and standards nor it's origin from learning design theory which in turn originates from the 70th ideas on "individual instructions". In [15] McCormick argues that even though many Learning Object advocates claim to support a constructivist and socially interactive approach to learning, it is not very well connected to the mainstream pedagogical literature. McCormick argues that one way to address this problem is to keep the pedagogy outside the Learning Object.

3. A comparative study of Learning Object implementations

The problems described in the section above where also evident from the study of Learning Objects from three Learning Object Repositories (LORs). The resources in the repositories where mainly of two types: *Fundamental Learning Objects* (e.g. pictures, video, and texts), described in the left part of Wiley's taxonomy [13] or *Generative-Presentation/Generative-Instructional Learning Objects* (according the Wiley taxonomy). The second type of Learning Objects also includes web pages, which could be argued to be Combined-Open Learning Objects according to Wiley's taxonomy. The first type of Learning Object has a high level of context independence, pedagogically as well as technically and is to be regarded as data objects that can be used as building blocks for larger modules. Technically, those objects are not limited to learning, but they are described using metadata that loosely puts them in a pedagogical context. This first type of Learning Object is fairly uncomplicated to handle they are mainly used as "raw" building blocks in larger units or "as is", as they are non-decomposable media objects.

The second type is much more complex to handle as they are a result of someone's authoring efforts, where several elements are aggregated into a larger unit (sometimes referred to as a module) - often handled as an instructional unit, based on an intended pedagogical use and sequencing. In our study, these aggregated Learning Objects were commonly constructed using one or many components such as Flash animations, Java Applets, PDF-files or web pages. In most cases Learning Objects were not decomposable and the only factors that distinguished them from arbitrary digital resources was that they where produced for learning, i.e. implemented elements of instructional design and/or a pedagogical model, and that learning domain metadata had been added to describe them; generally according to application profiles of IEEE LOM or IMS Metadata. The metadata provided was in general mainly bibliographic and rather limited. The Application Profiles where only used to a very limited extent. Interestingly, the elements of instructional design were in most cases implemented using application logics - or in cases of web page, using hyperlinks, and not using existing standards such as simple sequencing or IMS Learning Design.

Specifications such as IMS Content Packaging were only used at the next level to combine Learning Objects from the LOR[5]. The effect of this is that such Learning Objects are only decomposable to a minor extent defiance of that many Learning Objects were complex with a high level of aggregation, containing several levels of granularity. The potential for inter-contextual reuse is limited to sequencing and packaging of Learning Objects that are already assembled and stored within the LOR[6].

The study illustrates two of the main problems with Learning Objects: That the variety of definitions leads to a variety of different types of Learning Objects that are not compatible. The fact that Learning Object (according to several definitions) by definition can be almost any digital resource makes the concept relatively pointless. Another problem is that, currently, "reuse" of Learning Objects is often limited to packaging and sequencing of pre-packaged units, which have nothing else in common other than that hey are called Learning Objects, are described using educational metadata, and are packaged and sequenced together. They can however not *function* together in terms of interacting, exchanging data and messages, being subordinate to the same look and feel, or share application logics. None of the studied Learning Objects used any standard interfaces for interaction. This is once again similar to problems experienced within OOP and component-based system development, where such problems are often addresses through narrower and more explicit definitions and taxonomies [8] [11] in combination with architectural characteristics such as "explicit interfaces". Several definitions where analyzed by Brown and Wallnau in [8].

We argue that many of those issues are directly or indirectly related to the lack of explicit definitions and clear architectural models, together with technical (as well as other) quality criteria that are directly related to technical architecture. Many of the pedagogical dependencies and shortcomings seem to be caused by technical bindings of content to presentation and application logics as well as built in instructional design elements.

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[5] One of the studied archives used a built in "packager" for this purpose.

[6] One LOR had functionality for uploading new Learning Objects. In all LOR it would be possible to download the Learning Objects for use together with other pedagogical authoring tools in order to use them together with learning Objects from other sources.

4. Conclusions and discussion

Our study shows that there is a huge discrepancy between different definitions of the Learning Object concept [28] [29] [16] [24] [15]. This makes it hard (if not impossible) to author Learning Objects that owns the qualities that Learning Objects are often ascribed in terms of reusability, interoperability, and context independence. Definitions really range from "anything to everything" [16]. However, the real problem lies in that there is no separation of "anything to everything" from a technological perspective and "anything to everything" from a "content" perspective. "Anything to everything" from a "content" perspective is a good thing as this makes it easier to support different pedagogical directions and methods [18], but "anything to everything" from a technological perspective becomes unmanageable. We suggest the technical and pedagogical definitions of Learning Objects to be separated – within a common definition of Learning Objects.

The lack of common low-level definitions and models is a threat to interoperability, technical quality as well as for the acceptance of the Learning Object concept itself. Our study shows that the pedagogical content is often of good quality and that the ambitions are set high, but that Learning Objects still do not live up to the expectations that would make them context independent, reusable objects. The analysis shows that one important reason is that little consideration is given to fundamental software design principles, such as layering, principles from object orientation, structuring of data etc., which could enhance such properties that are usually ascribed to Learning Objects. As most implementations do not deliver what they promise, the vision has yet to be fulfilled. There is a need to move on from just describing properties and characteristics, to determine how those can be realized.

To address the identified problems we suggest six areas for action in order to establish technical quality criteria for Learning Objects:

(1) Based on the many different directions that are evident from the literature as well as our study, there is a need for a common (more narrow) definition of what is, and what is not a Learning Object. Excluding rather than including, which also mean accepting trade-offs in order to gain a functioning concept by defining "must-have" properties and attributes. This includes the separation of pedagogical and technical issues as stated above. In general, the Learning Object community would benefit from building on experience from the OOP community, from where the term originates. This is a view emphasised by Quinn [20], Douglas [10] and others.

(2) In connection to narrowing down the definitions, there is a need for a taxonomy that maps on to the definition and where granularities as well as special properties are regarded. Most taxonomy efforts studied takes on a strictly pedagogical perspective, suggesting desirable properties, but not how those should be implemented. Such taxonomy was suggested by Paulsson and Naeve in [18], where those issues are discussed in detail.

(3) Standards used for Learning Objects should be extended to go beyond descriptive information, such as metadata, sequencing, and packaging to also embrace standards for interfaces, "machine readable" descriptions of technical properties and interaction interfaces. It could be argued that SCORM adds such properties to some extent, but it can also be argued that SCORM [4] does not do this in either a technology- or pedagogically neutral way [21]. The needs for such efforts are evident from the fact that all interaction and message passing between different parts of the studied "learning packages" was accomplished through "hard coded", proprietary application logics that aggravates reuse and technical independence.

(4) There is a need to establish standards and recommendations that address the internal use of data formats and data structure. Such general technology standards exist, but seem to be rarely used in the Learning Object community. This suggestion is related to area 3 and is important for exchange of data as well as for separating data from logics and presentation.

(5) It should be prescribed for the architecture of Learning Objects to be layered as a part of best practise, in order to separate data, presentation and application logics. As described in previous sections, this would enhance the level of decomposability and context independence, as is also pointed out by Pinkwart et al. in [19]. Layering (or multi-tier architectures) is used frequently in many other areas of application/system development for the very same reasons.

(6) Pedagogy should preferably be kept outside the Learning Object in order to facilitate pedagogical context independence. In [18] it is suggested that the pedagogical model is added as Learning Objects are assembled to form *Learning Modules*. Using such methodology, it becomes possible to do pedagogical contextualization at a later stage in the authoring process, and enhance reusability of different components as well as components mutual pedagogical context independence. In this process it doesn't actually matter whether the pedagogical contextualization is done using techniques, such as IMS Simple Sequencing, or more sophisticated and fine grained models like IMS Learning Design, what matters is that it is done separated from the modules constituent components. In some cases there might be a need to add such "instructional properties" inside Learning Objects, but in such cases this should be handled in a separate layer, using standard specifications for that purpose, and not by hard coded implementations as in many of the studied cases.

4.1 Future work

A lot of research, development and standardization work is still needed in order to realize the technical quality criteria suggested above. More input and experience is needed from other, recently completed, and ongoing projects in order to further refine the above criteria.

Issues such as (3) need to be raised and addressed within standards organizations. Some of the issues are already on the agenda, but the focus is mainly on the VLE and not so much on the interaction and interrelations of Learning Objects. It should be investigated if frameworks such as the OKI OSID:s [25] and/or ELF [31] are applicable/adaptable for the purpose. The role of Service Oriented Architectures (SOA) for Learning Objects (as well as for the over all Learning Architecture) needs to be further examined. Earlier work such as the work by Wilson [30] and Paulsson [18] can serve as a starting point.

The suggested quality criteria (4), (5) and (6), must be further examined through implementation and thoroughly discussed within the scientific community as well as in the standards community. As pointed out by McCormick [15] there is a problem in that there is so many different agendas and cultures involved and this makes it hard to reach consensus. For this reason it is essentially important to take on a multidisciplinary scientific view in order to better explore and understand the complex interplay between Computer Science and Pedagogical Science. Quality frameworks, such as the framework suggested by van Assche and Vuorikari [27], could be extended to embraced the quality criteria suggested in this article.

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