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Original citation:
Anane, R. (2014) 'The Learning Object Triangle' in Huang R.,Kinshuk, Sampson D.G., Spector M.J., Chen N.-S.(Eds). Proceedings - IEEE 14th International Conference on Advanced Learning Technologies, ICALT 2014 (pp: 719-721). IEEE, DOI 10.1109/ICALT.2014.209

http://dx.doi.org/10.1109/ICALT.2014.209

Publisher
IEEE

Anane R. The Learning Object Triangle. The 14th International Conference on Advanced Learning Technologies (ICALT 2014), Athens, July, 2014, pp719-721.

The Learning Object Triangle

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***Abstract* — One critical factor in the effective deployment of learning objects (LOs) is the availability of relevant metadata categories. This work is motivated by the view that metadata identification is enhanced by a clear definition of a learning object. The aim of this paper is to offer a holistic approach to LOs and to introduce a definitional framework informed by the LO lifecycle. A LO is defined in terms of three main facets: mediation (potential for facilitating learning), transition (ability to be used in different learning environments) and specification (description of LO characteristics, as metadata). Unlike most evaluation instruments, the framework integrates explicitly information on learner experiences such as annotation, evaluation and attention metadata.**

Keywords – mediation; transition; specification; reuse; instruction; metadata; experiential; context; e-learning

I. INTRODUCTION

The automation of learning provision that the introduction of learning management systems (LMSs) has initiated has been reinforced by a gradual devolution of the instructional process to learning objects (LOs). A LO is often seen as a discrete and self-contained educational unit, with a lifecycle which consists of three main stages: creation and publication, access and retrieval, deployment and use.

Although LOs are widely used they have been the subject of intense debate over their scope and characteristics. It has now become evident that the effective deployment of LOs is dependent on the availability of relevant and effective metadata categories. As a result, most of the recent efforts in LO management point to the need for common structures for representing different types of metadata, including metadata related to learning experiences [1]. One significant feature of the LO lifecycle is that the transitions between its stages are facilitated by the use and generation of metadata. Despite references to overlapping and complementary attributes in many LO definitions, the lack of a unified model may be an obstacle to the identification of appropriate metadata.

This work is motivated by the view that the specification of metadata is enhanced by a clear definition of a LO and by the identification of its important characteristics. In contrast with many fragmented and resource-based definitions, a holistic approach to LOs is proposed, which incorporates context-based information. The main contribution of this work lies in the definition of a LO in terms of three fundamental facets, and in the promotion of a more comprehensive approach to LO metadata.

The aim of this paper is to introduce a LO definitional framework and its structure.

II. LEARNING OBJECT DEFINITION

Attempts at defining a LO range over a wide spectrum where technical properties and purely didactic attributes form two extremes. In a sample from a set of publications, a LO is defined as:

a) ‘a digitised entity that can be used, reused or referenced during technology supported learning’ [2].

b) ‘a digital self-contained and reusable entity, with a clear educational purpose… [LOs] must have an external structure of information to facilitate their identification, storage and retrieval: the metadata’ [3].

Most of the definitions refer to items such as educational objective, type and structure of content, reuse and description/metadata. Although there is convergence on a subset of attributes the definitions are still anchored in a LO-centric perspective. With the wider access to LOs in repositories and the deployment of LO-based e-learning programmes, the role and behaviour of real users put more emphasis on the learner-content interaction. The learning facilitated by the LO can therefore be enhanced by the recorded activities of learners, and their interaction experiences can be analysed to produce attention metadata. Moreover, a LO can be annotated and the learning experience that it mediates evaluated by learners. As a result, the issue of LO effectiveness has acquired a new urgency. The following definition of a learning object is proposed in terms of manifestation and underlying processes:

A learning object -(1)- is a digital unit of instruction, which mediates learning experiences, and -(2)- which can be discovered and accessed, and -(3)- used in a variety of instructional contexts, learning environments and computing platforms.

III. THE LEARNING OBJECT TRIANGLE

The definition encapsulates the three fundamental facets of a LO: (1) *mediation* of learning by the LO; (2) specification of the LO characteristics, as metadata, to facilitate discovery and selection; and (3) *transition* of the LO to different learning environments to enable reuse. These facets are integrated into the Learning Object Triangle, as depicted in Figure 1. The term ‘transition’ is based on the perspective introduced in McCall’s Triangle of Quality. ‘Transition’ and ‘specification’ were chosen in order to emphasise the digital nature of the LO, as a software artefact, and to capture the different levels and complexity of contextualisation. The facets of the Learning Object Triangle are refined into their essential features as follows:

Mediation (instruction, interaction, manifestation)
Transition (instructional, environmental, technical)
Specification (organisational, instructional, operational, experiential)

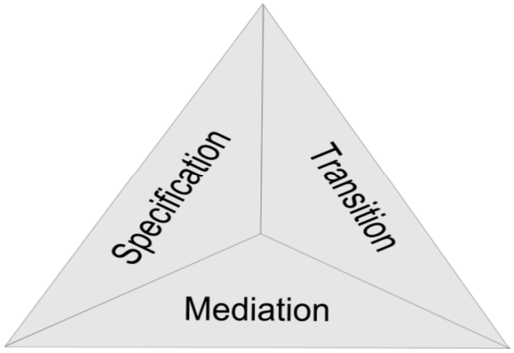

Figure 1. The Learning Object Triangle

A. Mediation

Mediation refers to the potential of a LO to facilitate learning in a specific domain, through a combination of instruction and interaction, underpinned by its manifestation in digital media [4].

Instruction

Instruction involves engaging the learner in an activity designed to meet specific objectives using appropriate methods and tools. The instructional context and learning material are the outcome of instructional design. This usually consists in determining the needs of a stereotypical learner, defining the objective of the instruction and creating an 'educational intervention', using LOs. The intervention may involve collaborative interactions, exercises, simulations and self-assessment. Interactions with LOs are often guided by instructional strategies and can be personalised. Moreover, the instructional process may be enhanced by information generated during learning experiences such as annotations, evaluations and attention records.

Interaction

In an instructional context, interactions may be defined as reciprocal events between learners and LOs [5]. Different levels of interaction can be used to promote active learning and cognitive engagement. Learners may be able to decide on the selection, representation or display of LO content [6]. Two main forms of interaction can be distinguished:

1. Interaction supported by the features of the medium which affords control over the learning process.
2. Feedback by the learning object, such as grading of performance and adaptive provision of content.

Manifestation

Manifestation refers to the actualisation and the packaging of a LO. The instructional material of a LO can be constructed from digital assets, such as paragraphs of text, screen titles, video, animation, diagrams and sound narration. As a software artefact a LO should conform to sound software engineering and human computer interaction (HCI) principles. Its interactivity level is determined to a large extent by its manifestation. A LO may be expected to operate in different learning environments and computing platforms under specific constraints. This often requires compliance with learning and technical standards.

B. Transition

Transition is concerned with the ability of a learning object to be used in different environments, beyond its original context. The transition process is driven by instructional needs and is assisted by environmental and technical compatibility.

Instructional

Instructional transition points to the capability of a LO to be reused in a new instructional context, in response to an educational need. This transition is driven by the educational alignment between the learning objectives of the LO and the learning needs of the new context. Transition is governed by two overlapping modes: transition from one educational context to another, with or without modification, and transition from one educational element to another, through aggregation, dis-aggregation and LO sequencing. The granularity of a LO and the extent to which it is self-contained can affect instructional transition.

Environmental

This refers to the potential of a LO to continue fulfilling its objectives in a new (virtual) learning environment. Environmental transition is enabled by system interoperability and by conformance to learning standards in particular. As many educational programmes are mediated by learning management systems (LMS), one important form of interoperability is between a LO and an LMS. The repurposing of the LO can be assisted by the incorporation of interoperability mechanisms, as applied in SCORM compliant LOs [7]. However, the lack of semantic interoperability between some data models may be an obstacle to environmental transition.

Technical

Technical transition is concerned with the ability of a LO to overcome platform heterogeneity in its deployment. This form of transition is facilitated by technical compatibility between the host computing platform and the LO. Issues of portability and technical interoperability often arise when a LO is deployed locally or accessed remotely. This has a bearing on protocols, architectural platforms, operating systems and virtual environments. For example, the availability of a Java virtual machine or of a Flash software platform may be a requirement for effective interaction.

C. Specification

The specification of the characteristics of an identifiable LO is a structured description of its organisational properties, its instructional attributes, its operational capabilities, and its associated interaction experiences. The specification, as metadata, is designed to facilitate the discovery, selection and use of appropriate LOs, and to support the transitional process. The Learning Object Metadata (LOM) and the Dublin Core are often used for expressing metadata.

Organisational

This type of metadata relates to the organisation and management of LOs in repositories. It also supports the search and retrieval processes. Information that falls under this category consists of intrinsic and objective metadata, such as date, author, cost, identification and ownership. Other types of information include structure, classification/taxonomy documentation, location information, legal issues and rights. In the LOM some of the information is embedded in the General, Classification, Rights and Lifecycle.

Instructional

The aim of instructional metadata is to facilitate the selection of a LO and its integration into an appropriate instructional context, either by itself or as part of an educational aggregate. In a broader context it supports instructional transition and is considered the most critical component of the specification. In addition to information on learning objectives, prerequisites, educational context and semantic density, the metadata would also include interaction characteristics, such as interactivity type and level. Related information is held in the Educational and Relation categories of the LOM.

Operational

The function of operational metadata is to enable the deployment and operation of a LO in different learning environments and computing platforms. Metadata related to system interoperability and technical compatibility is provided to support environmental and technical transitions. Relevant information includes compliance with learning standards, media type of a LO, format, software and hardware requirements. Operational metadata would also cover the interactive features of its manifestation. This type of information is usually specified in the Technical category of the LOM.

Experiential

This category of metadata is concerned with the experiences of learners in using LOs. Interaction-based metadata can originate from the attention given to a LO, the annotations of a LO or its evaluation by learners. This is collectively referred to as experiential metadata. In some systems attention metadata was generated from log files [6], and in others annotations have assisted in the efficient use of LOs [8]. The evaluation of LOs and their rating, either explicitly or implicitly, have become an important part of the metadata in many repositories. Unlike the three previous categories, experiential metadata is context-based and derives from a process of interaction. Part of this information can be held in the LOM Annotation.

IV. METADATA AND SEMANTIC TECHNOLOGIES

The proposed approach combines resource-based and context-based information. In contrast with most evaluation instruments, the learner perspective is represented by concrete experiences rather than by an implicit stereotypical behaviour. This shift of emphasis towards dynamic and experiential information cannot be accommodated adequately by the LOM because of its lack of semantic metadata.

Semantic metadata offers greater flexibility and support for higher levels of interoperability. It also enables reasoning and enhanced personalisation. In ALOCOM [9] ontologies have been introduced successfully to enhance reusability, whereas in another system the LOM was extended with ontology-based semantic annotations for meaningful interactions with learning objects [8]. Semantic technologies were also used to promote a process-oriented approach to metadata; reasoning over learner-LO interactions was seen as a basis for adaptive environments [1].

V. CONCLUSION

A holistic approach to the definition of a LO was proposed in terms of three fundamental facets: mediation, transition and specification. Their refinement into key features has identified a more extensive set of metadata categories designed to enhance the mediation process. This approach is best served by the adoption of semantic technologies for modelling LO metadata.

In its application to a number of LO evaluation instruments the definitional framework has highlighted their inability to cater adequately for learning experiences, in general, and experiential metadata, in particular. This limitation may have implications for the design and structure of learning object repositories.

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