

Criteria for Pedagogical Reusability of Learning Objects Enabling Adaptation and Individualised Learning Processes

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Abstract

Learning Objects (LOs) enables an individual and adaptive learning process provided by Learning Content Management System (LCMS) or realised on the micro level by an individual learning object. The adaptive use of LOs sets up demands for LOs; they have to be highly reusable, but still not pedagogically empty or meaningless pieces of content information. Instruction with an adaptive and individual learning process consisting of LOs has to be based on the design of the learner's learning process [1, 2]. Learning objects are linked to a total learning process by the pedagogical interface and pedagogical functions of LOs.

This paper provides the criteria for pedagogical reusability of LOs based on the case analysis of existing LOs and theoretical examination of some existing usability models and evaluation criteria for digital learning materials. The criteria for pedagogical reusability of LOs are needed as a basis for designing adaptive learning systems and learning objects used with an adaptive system or with a LCMS (Learning Content Management System [3].)

1. Introduction

Learning objects offer new opportunities to create individual and adaptive learning processes. Reusable learning objects are emerging paradigm shifts in instructional systems that promise to bring to education the same improvements that it has happened in software development in the form of object-oriented programming [4].

Learning objects are seen as a primal entity of adaptive educational hypermedia (AEH). There are no existing pedagogical reusability criteria for LOs that are independent of the specific pedagogical framework or that may be used as a basis for realising the adaptation of LOs.

Reusability itself is not a new idea. The ground for reusability is found in object-oriented programming

and module based design [5]. However, modularisation is not an answer to creating pedagogically reusable learning objects. Based on our examination and earlier studies [6, 7] LOs can not be used or applied in the learning process in an arbitrary way, like Lego-blocks. The internal structure and the pedagogical interface of the LO identifies an external context and a structure of the learning situation.

This paper provides the pedagogical criteria for the reusability of learning objects that are grounded on sub learning processes. In addition to a development process of reusable LOs used in adaptive systems, these criteria provide an effective tool for designing LO templates.

The criteria are formed based on examination of usability criteria and models and based on the analysis of the twenty LOs developed by the teachers attending the on-service training organised by The Finnish National Board of Education.

2. The Reusable Learning Objects

Currently, there are various definitions of LOs [8]. An LO is defined in this context to be a small piece of learning material (e.g. visualisation, video clip, animation, interactive simulation, interactive exercises) that is a reusable, compact, as well as unitary, entity [7].

The definition or classification of learning objects may be based on the description of the media used or on the description of the LO's "outlook" (e.g. presentations, drills, simulations). However, if the focus is on the pedagogical reusability, the broader context should be considered for the taxonomy and for the definition of the learning objects. The following figure (Figure 1) visualises the taxonomy of different types of learning objects in relation to the learning process.

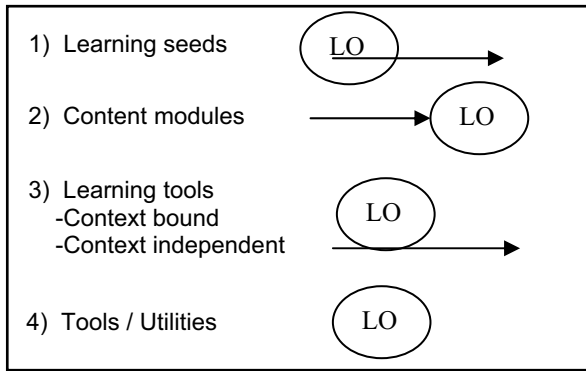


Figure 1. The different types of learning objects described in relation to a learning process [7, 10].

Reusability in the educational context can be generally understood so, that instructional components can be reused a number of times in different learning contexts. LOs are highly reusable components that support learning and may be accessible via a database. Individual LOs can also be combined with each other in various ways to form larger wholes. Similar ideas of reusability may be found in the paradigm of object-oriented programming [9]. Issues like generality, granularity, modularity and scalability have been presented as the features of reusability.

The LOs are pedagogically reusable in the sense that a particular LO may be used in various learning processes and at various stages of a learning process. There are also many different pedagogical functions for a LO in a learning process [7, 10]. Ideally, this enables the adaptive personalisation of learning processes that consist of several learning objects stored in a database. Therefore, learning objects may be easily used in several contexts and for different learners on various levels.

In order to implement LOs in instruction and to design educational technology for the personalisation and adaptation of LOs, the broader context for reusability should be considered (see Figure 2). The reusability of LOs in a learning situation is created by *pedagogical context*, *content context* and *technical context*.

LOs are more reusable if they are not heavily bound to a particular learning theory or a pedagogical model [5]. Although, LOs do not work alone in instruction, they need an environment and a pedagogical framework that defines how they are used in learning processes.

In order to use LOs in various situations (like authentic and informal learning situations) they must work on multiple platforms in addition to the Web (on platforms, like mobile phones or hand held devices).

Therefore, support for multiple platforms also provides an essential element of pedagogical reusability.

If an LO is a tool, like learning tools (e.g. cognitive tools and mind tools [11]) or a utility software, it may be used with various learning contents and in several school subjects. Also the content of the LO that is not bound to particular school subjects or the LO including the multiple presentation of the content, as well as adaptation, increases the reusability of the LO.

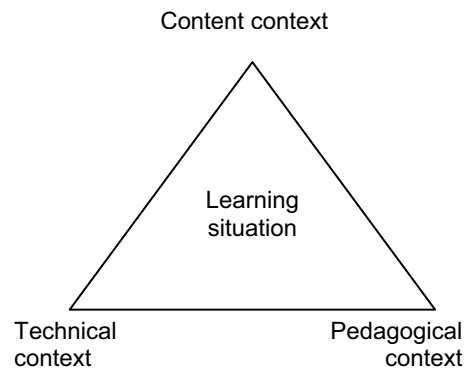


Figure 2. The dimensions of reusability of LOs in the learning situation.

3. From Pedagogical Usability to Pedagogical Reusability

There are several evaluation criteria of digital learning materials (see e.g. [12, 13, 14]). In some criteria, the usability aspect is also taken into consideration and focused on a user and purpose of his or her actions. When developing criteria for reusability that take into account the pedagogical context and characteristics; it is essential to examine various usability models and heuristics that have different views on usability:

- Usability heuristics by Nielsen [15], which estimated the reusability of the object itself,
- Characteristic of the significant learning by Jonassen [16], which is mainly concentrated on the goals of teaching and the reusability of content context,
- Dimensions of the strengths of the computer aided teaching by Reeves [17], which combine both teaching and technology,
- Arvo – an evaluation tool [18] developed by the Finnish Virtual University, which evaluates the pedagogical usability of digital learning material; and VerkkoVelho – a design tool for eLearning courses [19] used by teachers,

- Criteria of pedagogical usability developed by Horila *et al.* [20], in which the evaluation is considered mostly in a technical context.

The evaluation of the usability criteria (presented above) was examined in this study by an inductive analysis [21]. These criteria overlapped each other and ignored the characteristics of new learning materials like LOs or the adaptive personalisation. During the analysis process, the emergent needs for new criteria of pedagogical reusability were found. At the second stage of the analysis procedure the dimensions of reusability presented in Figure 2 were taken as the basis in order to form the new criteria for the pedagogical reusability of LOs.

4. The Analysis of the Learning Objects Produced by Educators

In this case study, twenty LOs designed by teachers attending in-service training organised by The Finnish National Boards of Education, were examined from the point of view of reusability that supports adaptation. Learning object were design by using the method called Learning Process Based Teaching [22]. This educational design method of web-based learning and computer assisted instruction is widely used in Finland. The method enables educators and designers to use different pedagogical models as a ground element, but it puts all the pedagogical interventions and learning materials to work in the context of the learners' learning process.

In addition to the original learning situation for which the LO was developed for use, several alternative learning situations were mapped out by user scenarios done by an individual researcher. The user scenarios modeled the alternative learning processes [22] and the learning situation including the pedagogical functions of the LO [10] and sub learning processes [2] that an LO initiates in a learner.

The learning objects and user scenarios were classified by the type of LO and their features were examined by using the framework (presented in Figure 2) of reusability.

The main result of this quantitative analysis of scenarios was that an individual learning object may be used in various contexts and pedagogical settings, even when the LO originally has been contextually designed to work in a particular learning situation. Therefore, the properties of learning objects were collected in a table, classified and labeled in order to form criteria for pedagogical reusability.

An example of an LO described in Figure 3 illustrates the idea of pedagogical reusability. The type

of LO is interactive simulation, in which various food items are on the plate and their effect on calories is examined. The plate model of nutrition includes the idea of a healthy and well-balanced meal. This LO may be used in several subjects in various learning situations. The LO is pedagogically organised and it guides the students' sub learning process. This learning object may be used, for example, in the following pedagogical functions: activation (cognitive), context creation, a base for setting problems and research questions, and hypothesis / working theory testing that encourage students to draw their own conclusions and think.

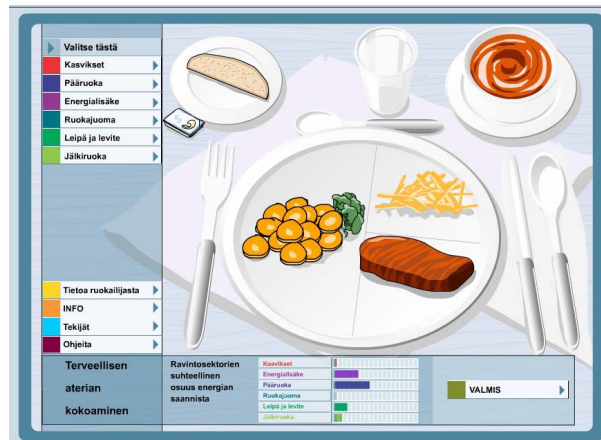


Figure 3. Example of highly pedagogical reusable learning objects that may be used in several pedagogical functions in a learning process. The subject of the learning object is food and nutrition.(see <http://www.edu.fi/oppimateriaalit/terveellinenaterial>)

5. Criteria for Pedagogical Reusability of Learning Objects

We propose the following (see Table 1) as criteria for the pedagogical reusability of learning objects that work as a basis for designing and realising the adaptation of LOs in a personalised learning process (Table 1). These criteria were constructed based on both, the analysis of existing usability criteria and models of usability (presented on the Chapter 3. From Pedagogical Usability to Pedagogical Reusability), and the examination of the twenty learning objects produced by educators (see Chapter 4. The Analysis of the Learning Objects Produced by Educators).

Table 1. The criteria for the pedagogical reusability of learning objects

	Content context	Pedagogical context	Technical context
Criteria	Atomic and independent entity (1)		
	Context independence (2)	Independent of a particular pedagogical model (5)	Support for multiple platforms (7)
	Multiple content presentations (3)	Multiple pedagogical functions and pedagogical interfaces (6)	Usability of user interface (8)
	Updateable / Cumulative content (4)		Provided with metadata (pedagogically descriptive and cumulative) (9)
→	Adaptivity and adaptability of LOs		

The criteria for the pedagogical reusability may also be used in order to create a profile for a learning object. For example, the profile of an individual learning object (The Plate model of nutrition) presented on Figure 4 illustrates coarse the coverage of reusability on the dimensions.

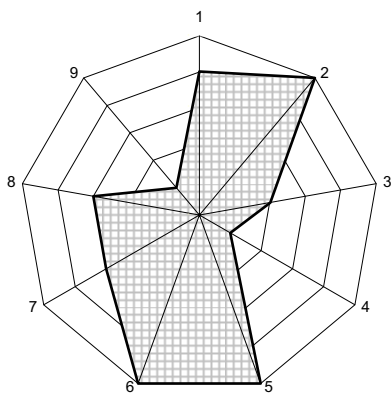


Figure 4. The radar diagram of the pedagogical reusability of an individual LO (The Plate model of nutrition). (The each dimension presents a criterion; see Table 1.)

6. Conclusion and Discussion

The key issue in the use of LOs is how to automatically construct the pedagogically meaningful and individualised learning process consisting of several LOs. This is only possible if LOs are highly reusable. The presented criteria for the pedagogical reusability of learning objects take care of the needs of

adaptation and personalised learning processes in various aspects. The criteria are the missing link needed to describe metadata for LOs and realise the adaptation of LOs based on the user model created by LCMS.

The main result of this quantitative analysis of user scenarios was that an individual learning object may be used in various contexts and pedagogical settings, even when the LO originally has been contextually designed to work in a particular learning situation. This gives us a clue to the contextual design that is based on the sub learning processes and which may be used to develop reusable LOs. If the LO had been bound closely with a particular pedagogical model (instead of a learning process) it would not have had so many pedagogical functions and would not have allowed such high reusability that is needed if LOs are used with an adaptation. The traditional solution for achieving reusability is often to design LOs that are not pedagogically organised (that is just some content information.)

As further work, the criteria for the pedagogical reusability of learning objects should be operationalised and validated. After the operationalisation of the criteria the adaptive LCMS with user modeling can be constructed and adaptive LOs can be developed based on the pedagogical reusability.

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