Constructing Web-Based Courses with Content Objects, Didactic Objects and Didactic Situations

Laura Maria Coutinho
Central Coordination for Distance Learning
Pontifícia Universidade Católica do Rio de Janeiro, Brazil
laura@ccead.puc-rio.br

Gilda Helena B. De Campos
Central Coordination for Distance Learning
Pontifícia Universidade Católica do Rio de Janeiro, Brazil
gilda@ccead.puc-rio.br

Claudia L. R. da Motta
Electronic Computing Nucleus
Universidade Federal do Rio de Janeiro, Brazil
claudiam@nce.ufrj.br

Marco A. Casanova
Department of Informatics,
Pontifícia Universidade Católica do Rio de Janeiro, Brazil
casanova@inf.puc-rio.br

Abstract: This paper proposes a collection of concepts that facilitates structuring Web-based courses, thereby improving reuse of the material already developed and reducing production cost. The proposal is based on the idea that one can profitably specialize learning objects into content objects and didactic objects. Then, a course is formalized as a didactic situation, defined as an aggregation of content and didactic objects with specific properties. To illustrate the concepts, the paper also includes a small set of representative examples.

Keywords: Learning Objects, Web-based courses, Learningware, Object reuse.

1. Introduction

The term 'course' typically recalls a series of expositive classes, intertwined with exercises and quizzes, whereby the teacher verifies how much the student learned. There are notorious variants such as courses structured as sequences of case analysis.

The definition of alternative strategies to structure courses becomes a central question when one investigates how to design Web-based learningware. However, it is not uncommon to see Web-based learningware designed as a mere transposition of course notes into HTML pages. In other words, oral exposition, backed up by class notes, is substituted by HTML pages.

This simple substitution is neither necessary, nor desirable. The Web offers the possibility of interaction and is an instrument for autonomous content search. If used appropriately, the Web facilitates the definition of more sophisticated learningware strategies where the student becomes an

active player that creates and modifies the content, that is, he or she becomes a co-author of the learning process, guided by his tutor.

Motivated by this brief discussion, we propose in this paper a collection of concepts that facilitates structuring Web-based courses, thereby improving reuse of the material already developed and reducing production cost. Our proposal is based on the idea that one can profit by separating content from didactics or, more precisely, by specializing learning objects into content objects and didactic objects. Then, we formalize a course as a didactic situation, defined as an aggregation of content and didactic objects, with specific properties. To illustrate the concepts, we also include in this paper a small set of representative examples.

Briefly, a learning object is "a collection of materials that can be used to present and support a single learning objective" (Jacobsen, 2001), or "a small instructional component that can be used to support learning in different environments" (NUS/CIT, 2004a), "any digital resource that can be re-used and that can be helpful in the learning process" (Willey, 2004), or still "any (physical) entity, digital or non-digital, that can be used for learning, education or training" (IEEE LTSC, 2002a). A small instructional component is a module or lesson that covers a specific concept, fact, procedure, process or principle (Sosteric, 2001). Different environments imply that a learning object can be used in distinct learning management systems – LMS – or learning content management systems – LCMS (Magalhães, 2004). For example, a module or learning object developed to teach the use of vowels in German can be made accessible through IVLE (Integrated Virtual Learning Environment) (NUS/CIT, 2004b) and then ported to other LCMSs, such as BlackBoard (BLACKBOARD, 2004), WebCT (WEBCT, 2004) or Aulanet (Lucena, 1999).

Learning objects typically have a set of descriptors, or metadata, that facilitate retrieving them from an object repository (Porto, 2003). Metadata usually adhere to standards (IEEE LTSC, 2002a). For example, Learning Object Model (LOM) (Tarouco, 2003), developed by the IEEE Learning Technology Standards Committee addresses the question of metadata for learning objects (IEEE LTSC, 2002b). Other projects also address the definition of metadata for learning objects, such as the ARIADNE Project (ARIADNE, 2003) and the IMS Learning Resource Meta-data (Anderson, 2001).

This paper is structured as follows. Section 2 introduces the new classes of learning objects proposed in the paper. Section 3 presents simples examples of the new objects, whereas Section 4 covers more complex examples. Finally, Section 5 contains the conclusions and directions for future search.

2. Specializations of Learning Objects

2.1 Content Objects, Didactic Objects and Didactic Situations

As a first step towards facilitating learningware development, we propose to explicitly separate content from didactic indications about how to use the content, by introducing a richer set of object classes. We refer the reader to sections 3 and 4 for examples of these concepts.

As usual, we build more complex objects by aggregation of other objects. We distinguish two forms of aggregation – partial orders and total orders. A partial order is an aggregation O of objects equipped with a reflexive, transitive and anti-symmetric relation $R \subseteq O \times O$; a total order is a partial order such that, for any two objects o_1 and o_2 in O, either $(o_1,o_2) \in R$ or $(o_2,o_1) \in R$, but not both. In both cases, if $(o_1,o_2) \in R$ then we say that o_1 *precedes* o_2 in R.

In more detail, we define:

- a *content object* (CO) has one or more *content attributes* whose types are of any of the usual media types – text, image, video, etc.... and whose values are pieces of material that the student must consume;

- a *didactic object* (DO) has one or more *didactic attributes*, also of the usual media types, but whose values contain instructions for the student of a purely didactic nature;
- an *elementary didactic situation* (EDS) is either a content object or a didactic object;
- a *complex didactic situation* (CDS) is an aggregation (a partial or total order) of didactic situations;
- a *didactic situation* (DS) is an elementary or a complex didactic situation.

Note that we do not use the term learning object to avoid confusion with the published literature. Indeed, we reserve the term learning object to refer to examples outside our context.

Although similar in format, content and didactic objects differ on the way they should be understood and used. The learningware designer is responsible for defining the classes of content and didactic objects he will work with, which involves indicating which are the content attributes or didactic attributes of each class. Alternatively, the implementation of the learning objects management system may determine these details.

A didactic situation describes, with the help of the didactic objects it contains, how the student must consume the content objects it includes. A didactic situation models "a set of relations explicitly or implicitly established between a student and a group of students, a given environment and an educational system, whose purpose is to help students acquire knowledge" (Brousseau, 1996). What characterizes a didactic situation is therefore its intention, that is, the fact that it was defined with the purpose of modeling a learning process.

Didactic situations typically reflect epistemological presuppositions. For example, the major characteristics of didactic situations that adhere to the constructivism approach are: (1) students are responsible for organizing themselves, and for taking decisions, in order to solve the problem that was proposed; (2) students must organize their activities to obtain a result that was previously made explicit or that they may identify themselves; (4) students may resort to different strategies to solve the problem that was formulated; (5) students may establish several social relations – information exchanges, debates, negotiations – with other students or the teacher (Lins, 1996).

2.2 Syllabus and Course

We now introduce additional object classes that formalize the notions of syllabus and course.

We first model a *syllabus* as a partial order of terms, or *concepts*, taken from a given vocabulary. If c_1 precedes c_2 in S, we say that c_1 is a *pre-requisite* of c_2. Figure 1 schematically illustrates the notion of syllabus. Informally, a syllabus is a set of related concepts that represents a conceptual cut of some knowledge area.

A *course* is a triple $C = (D, S, r)$ where D is a didactic situation, S is a syllabus and r is a relation that maps components of D into components of S. We say that D *belongs to* C. We say that a component d of D is a *component* of C and that d *covers* a concept c of S iff r relates d and c. Note that a component may cover more than one concept, or even none, and that a concept may be covered by more than one course component. Intuitively, a course is just a didactic situation covering a syllabus, that is, it indicates which components of the didactic situation cover which concepts of the syllabus.

We say that a course $C = (D, S, r)$ is *consistent* iff, for every pair of concepts c_1 and c_2 of S such that c_1 is a pre-requisite of c_2, if d_2 is a component of D that covers c_2, then there is a component d_1 of C that precedes d_2 in C and that covers c_1 in C. We also say that a course $C=(D, S, r)$ is *complete* iff, for every concept of S, there is a component of C that covers it. Figure 2 schematically illustrates the notion of course. Note that the course in Figure 2 is consistent and complete with respect to the syllabus of Figure 1.

Assume that there exists a repository populated with content objects, didactic objects and didactic situations, perhaps constructed cooperatively by content specialists and instructional designers. Briefly, course construction can be divided into three major stages. Initially, a content specialist will prepare the syllabus by selecting a consistent set of concepts. Next, an instructional designer will start course construction by selecting and combining didactic objects, content objects and didactic situations that cover the concepts expressed in the syllabus and that follow the learning theory adopted. Lastly, the designer will construct the final didactic situation (the major component of the course) by defining the order, or possible orders, that the students may follow to consume the didactic situations constructed in the second stage. Such possible orders must be coherent with the syllabus so as to produce a course that is consistent and complete.

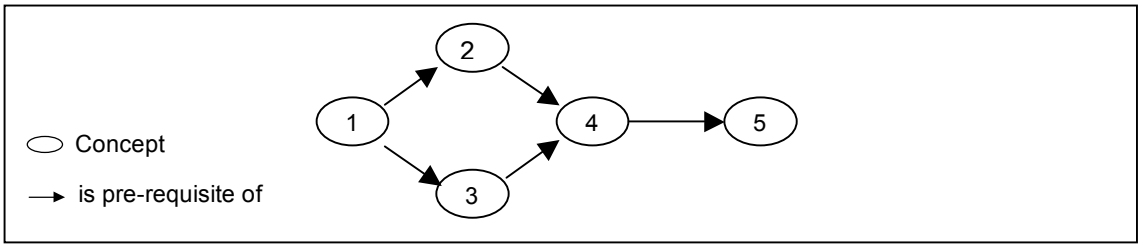


Figure 1: Schematic example of a syllabus.

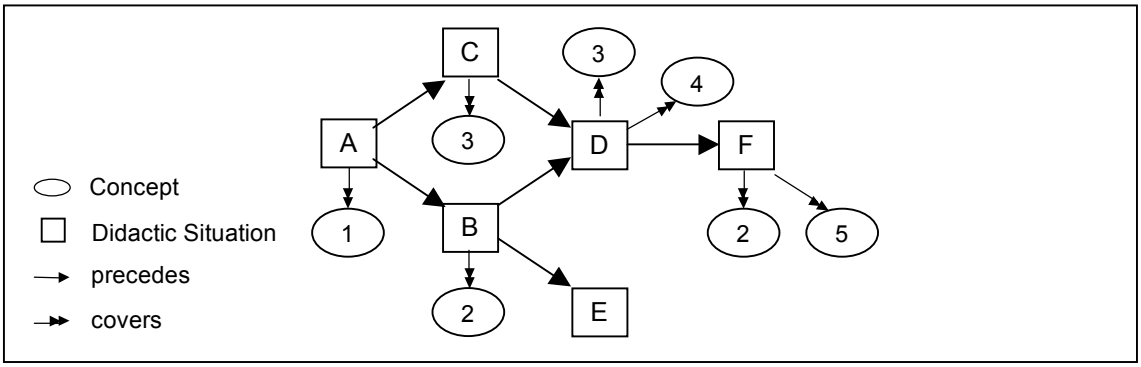


Figure 2: Schematic example of a course.

3. Examples of Didactic Situations Following Distinct Pedagogical Approaches

3.1 Didactic Situation: "Reading Assignment"

The didactic situation "Reading of Text 1", schematically presented in Figure 3, describes a reading activity based on a given text. It provides a very simple example of the instructional approach. The didactic object "Reading Assignment", shown in Figure 3a, has two attributes, "Objective" and "Description", whose meaning is immediate. This object captures a generic didactic event where text is exposed to the student. The content object "Text 1", shown in Figure 3b, has two metadata attributes, "Author" and "Language", and a content attribute, "Content", of type "text" (the first few lines of the "Lusíadas"). The didactic situation "Reading of Text 1" is then defined as an aggregation (a total order) of the didactic object "Reading Assignment" and the content object "Text 1". Figure 3c illustrates this aggregation as a table, with an indication of the sequence of objects, and Figure 3d, as a tree. Note, from Figure 3c, that this aggregation is a total order, where "Reading Assignment" precedes "Text 1".

We may indeed create a more complex didactic situation, "Reading of Two Texts", which illustrates object reuse, albeit in a simple form. This didactic situation, schematically presented in Figure 4, is defined as an aggregation (a total order) of 5 objects. The object "Reading of Text 1" was defined in Figure 3. The object "Reading of Text 2" is similarly defined as an aggregation again of the didactic

object “Reading Assignment”, but with a second text (omitted here for brevity). The objects “Pre-Test 1”, “Reading Comprehension 1” and “Test 1” are elementary didactic situations constructed from the (generic) didactic objects, “Pre-test”, “Reading Comprehension” and “Test”, respectively, and specific content objects related to the texts in question (all again omitted for brevity).

Reading Assignment	
Objective	improve reading skills
Description	read the document

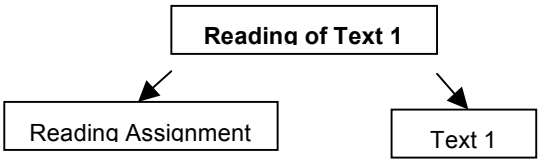
(a) Didactic object “Reading Assignment”

Text 1	
Author	Luiz de Camões
Language	Portuguese
Content	“As armas e os barões assinalados que da ocidental praia lusitana em perigos e guerras esforçados...”

(b) Content object “Text 1”

Reading of Text 1		
	1	Reading Assignment
	2	Text 1

(c) Elementary Didactic Situation “Reading of Text 1” (tabular format)

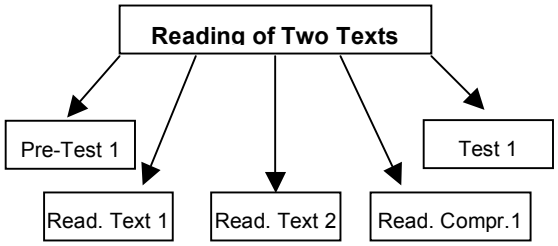


(d) Elementary Didactic Situation “Reading of Text 1” (tree format)

Figure 3: Examples of objects.

Reading of Two Texts		
	1	Pre-Test 1
	2	Reading of Text 1
	3	Reading of Text 2
	4	Reading Compr. 1
	5	Test 1

Tabular representation



Tree Representation

Figure 4: Didactic Situation “Reading of Two Texts”.

3.2 Didactic Situation: “Project Assignment”

The didactic situation “Project Assignment” exemplifies the constructivist approach. It is defined by multiple aggregations of didactic objects, with no content object involved. The didactic objects used have an intentional character that emphasizes the role of the students as knowledge seekers, rather than the role of the tutor as a provider of answers and solutions (Fagundes, 1999).

The nested tables in Figure 5 schematically indicate the aggregations used to construct “Project Assignment”. That is, for example, the didactic situation “Research”, labeled “4”, is an aggregation of 5 didactic objects, labeled “4.1” through “4.5”. Figures 6 to 11 detail some of the didactic objects used in “Project Assignment”.

Intuitively, a project assignment is defined much like a script. It starts with the definition of a theme, proposed by the student or the tutor. The theme may reflect a question to be explored or it may be the starting point of a process that encourages connecting phenomena, for example. Once the theme is defined, an initial assessment of the situation must be carried out, which means answering two fundamental questions: what is unknown and what is already known about the theme. The next step is to design a conceptual map that decomposes the initial theme into simpler concepts. These activities correspond to the didactic objects shown in Figures 6 to 8. The rest of the activities are likewise formalized.

Project Assignment	**1**	**Presentation**	1.1	Presenting the theme		
	2	**Planning**	2.1	Assessing previous knowledge		
			2.2	Elaborating hypotheses		
			2.3	Preparing a conceptual map		
	3	**Contract**	3.1	Knowing roles and tasks		
			3.2	Choosing the coordinator and the editor		
	4	**Research**	4.1	Gathering Information		
			4.2	Analyzing Information		
			4.3	Selecting Information		
			4.4	Expanding the conceptual map		
			4.5	Presenting the information selected		
	5	**Production**	5.1	Discussing the information selected		
			5.2	Summarizing the information selected		
			5.3	Organizing the information sources		
			5.4	Publishing the results	5.4.1	Preparing a presentation
					5.4.2	Writing a report
	6	**Evaluation**	6.1	Summarizing the script followed		

Figure 5: Didactic Situation "Project Assignment"

Assessing previous knowledge	
Skill	Compare
Description	assess what is already know about the theme
Result	a list of what is already known about the theme
Interaction	use of a discussion forum

Figure 6: Didactic Object "Assessing previous knowledge".

Elaborating hypotheses	
Skill	Identify
Description	identify which are the doubts about the theme
Result	a list of the doubts about the theme
Interaction	use of a discussion forum

Figure 7: Didactic Object "Elaborating hypotheses".

Preparing a conceptual map	
Skill	correlate concepts
Description	prepare a conceptual map relating the known concepts
Result	publication of the concept map

Figure 8: Didactic Object "Preparing a conceptual map".

4. Additional Examples of Didactic Situations

The published literature and reference Web sites on learningware design provide innumerous examples of learning objects, complete courses and best practices. We therefore selected two widely different examples to illustrate how they can be profitably reinterpreted in our conceptual framework. CISCO's Reusable Learning Object Strategy could also be likewise reinterpreted (CISCO Corp., 2001; CISCO Corp., 2003), as discussed in (Coutinho et al., 2004).

4.1 An Example from RIVED

This section translates, to our concepts, one example taken from RIVED, the "Experiment with Theodolites" learning object. RIVED stands for *Red Internacional Virtual de Educación* (RIVED, 2004; SEED, 2004) and is a partnership program involving several Latin American countries to develop learning objects, involving animation and simulation. It currently focuses on the teaching of Sciences and Mathematics for High School.

The "Experiment with a Theodolite" learning object simulates measuring the width of a lake with the help of a theodolite. The student should point the (virtual) theodolite towards an object A he knows the distance from his position O, and then towards a point B he wishing to measure the distance from his position. The theodolite accurately measures the angle α between these two directions. By constructing a triangle, with the angle α he just measured and the known distance from O to A, he is able to determine the distance from O to B (Nunes, 2003).

We model this learning object as follows. We first define a separate content object, "Description of the experiment with a theodolite", that describes the specific (virtual) experiment (Figure 12). Then, we define a didactic object, "Problem-situation, modeled using virtual reality", that captures the essence of using computer simulations in a learning process (Figure 13). Finally, we define a didactic situation, "Problem-situation: Experiment with a Theodolite", by aggregating these two objects (Figure 14).

Description of the experiment with a theodolite	
Author	RIVED Project
Content	(A description of the virtual experiment with a theodolite, as in (Nunes, 2003))

Figure 9: Content object "Description of the experiment with a theodolite".

Problem-situation, modeled using virtual reality	
Ability	Mobilization of resources to solve a given problem-situation
Activity 1	Given a problem situation, modeled using virtual reality, identify a solution

Figure 10: Didactic object "Problem-situation, modeled using virtual reality".

Problem-situation: Experiment with a Theodolite	1	Problem-situation, modeled using virtual reality
	2	Description of the experiment with a theodolite

Figure 11: Didactic situation "Problem-situation: Experiment with a Theodolite".

4.2 Example of a Web-Based Course

This section translates, to our concepts, a Web-based course developed at CCEAD/PUC-Rio - Coordenação Central de Educação a Distância da Pontifícia Universidade Católica do Rio de Janeiro (CCEAD, 2004). The course is about Constitutional Law, at the extension level, and covers: the purpose and importance of Constitutional Law; the organization of the Brazilian government; the Brazilian Constitution of 1988; the fundamental rights and guarantees.

The course is organized as a sequence of 4 groups of 4 activities. Moreover, the didactics of the groups is regular, in the sense that the i^{th} activities of each group, for i=1,…,4, contain the same instructions for the students. Ignoring the syllabus, this course is easily re-interpreted as a didactic situation C aggregating 4 didactic situations, G_1 G_2 G_3 G_4. For i=1,…,4, the didactic situation G_i is again defined as an aggregation of 4 didactic situations, $SD_{i,1}$ $SD_{i,2}$ $SD_{i,3}$ $SD_{i,4}$. Each didactic situation $SD_{i,j}$ is in turn the aggregation of one content object $C_{i,j}$ and one didactic object D_j. Note that D_j is the same didactic object for all four groups, for j=1,…,4. Figures 15, 16 and 17 illustrate how SD_{11} is defined.

Knowledge Assessment	
Ability	Assess information, making analogies and associations with previous knowledge and raising new doubts
Activity	List all points you know about the topic and all points you are in doubt. This knowledge assessment is important since it will help you search for new information to answer your doubts, as well as to consolidate your knowledge about the topic.

Figure 12: Didactic Object "Knowledge Assessment".

Doubts and Certainties about Constitutional Law	
Author	PUC-Rio
Content	(Doubts and Certainties about Constitutional Law)

Figure 13: Content Object "Doubts and Certainties about Constitutional Law".

SD_{11}	Knowledge assessment
	Doubts and Certainties about Constitutional Law

Figure 14: Didactic Situation SD_{11}.

5. Conclusions

Although technology is an important issue, the development of Web-based courses should focus on the learner needs. The investigation of alternative ways to conduct or structure courses therefore becomes a central question, moderated by other equally important concerns, such as production time and cost.

These observations motivated us to introduce specializations of learning objects, that we called content objects and didactic objects. We then modeled a course as an aggregation of these objects,

covering a syllabus. Separating content from didactics facilitates course structuring and reuse of the learning objects.

As directions for future research, we may indicate defining an ontology for didactic objects and the specification of a learning objects management system that offers an interface to define content and didactic objects and to map them into dynamic HTML pages.

Reference List

Anderson, T. & McKell, M. (2001). "IMS Learning Resource Meta-data – version 1.2 Final Specification", IMS Global Learning Consortium.http://www.imsproject.org/metadata/imsmdv1p2/imsmd_infov1p2.html (last accessed on 03/26/2004).

ARIADNE (2003). http://ariadne.unil.ch (last accessed in 11/2003).

BLACKBOARD (2004). http://company.blackboard.com (last accessed on 03/26/2004).

Brousseau, G. (1996). Didática da Matemática. Porto Alegre, Artmed, 1996.

CCEAD (2004) http:// www.ccead-puc.rio.br (last accessed on 03/26/2004).

CISCO CORP. (2003). Reusable Learning Object Strategy: Designing and Developing Learning Objects for Multiple Learning Approaches. White Paper.

CISCO CORP. (2001). Reusable Learning Object Strategy: Designing Information and Learning Objects through Concept, fact, Procedure, Process and Principle Templates. White Paper.

Coutinho, L. M., Campos, G. H. B., da Motta, C. L. R., Casanova, M. R., "Learning Objects: Separating Content from Didactics"(submitted for publication).

Fagundes, L. C. (1999). "Aprendizes do futuro: as inovações começaram!". In: Cadernos de Informática para a mudança em educação. Brasília: MEC/SEEC/PROINFO.

Hernandez, F. (1998). A Organização do Currículo por Projetos de Trabalho. Porto Alegre, Artmed.

IEEE LTSC (2004). http://ltsc.ieee.org (last accessed on 03/26/2004).

IEEE LTSC (2004). "IEEE Standard for Learning Object Metadata", New York: Institute of Electrical and Electronics Engineers, Inc. http://ltsc.ieee.org/wg12/par1484-12-1.html (last accessed on 03/26/2004).

Jacobsen, P. (2001). "Reusable Learning Objects: What does the future hold?". LTI Magazine. November 1, 2001. http://www.ltimagazine.com/ltimagazine/article/articleDetail.jsp?id=5043 (last accessed on 03/26/2004).

Lucena, C. J. P. , Fucks, H., Milidiu, R., Laufer, C., Blois, M., Choen, R., Torres, V. & Dafon, L. (1999). "AULANET: Helping Teachers to do their Homework". In: Multimedia Computer Techniques in Engineering Workshop, Graz, Austria.

Lins, M .J. S. C. (1996). "Piaget: Da Epistemologia Genética a uma Teoria da Aprendizagem". In Piaget: Teoria e Prática. Proc. of the IV Simpósio Internacional de Epistemologia Genética, São Paulo.

Magalhães, L. P., & Ricarte, I. L. M. (2004). "Informação estruturada na World Wide Web". http://www.proenca.uel.br/ia368f/tema-05/informacao (last accessed on 03/26/2004).

NUS/CIT (2004b). Courseware Development, National Univ. of Singapure, Centre for Instructional Technology, Edtech. http://courseware.nus.edu.sg/Standards/rlo.asp (last accessed on 03/26/2004).

NUS/CIT (2004b). http://ivle.nus.edu.sg/ivle/background.com. (last accessed on 03/26/2004).

Nunes, C. A. A. (2003) "Objetos de Aprendizagem". São Paulo (unpublished manuscript).

Pereira, L. A. M., Porto, F. A. M. & Melo, R. N. (2002). "Objetos de Aprendizado Reutilizáveis (RLOs): Conceitos, Padronização, Uso e Armazenamento". Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

Perrenoud, P. (2000). Novas Competências para Ensinar. Artmed, Porto Alegre.

Porto, F., Moura, A. M. C., Fernandez, A. P., Fernandes, A., Campos, G. H. B. & Coutinho, L. (2003). "ROSA: A Data Model and Query Language for E-Learning Objects", Proc. PGL Research Conference, Rio de Janeiro.

RIVED (2004). http://www.rived.proinfo.mec.gov.br (last accessed on 03/26/2004).

Santanche, A. (2002). "ANIMA: Representando e Integrando Objetos Educacionais na Web". M.Ba. Dissertation presented to the University of Salvador, Salvador.

SEED (2004). http://www.mec.gov.br/seed (last accessed on 03/26/2004).

Sosteric, H. (2001). "Objetos de aprendizagem "http://www.ead.unicamp.br/php_ead/boletim.php?bolt=43 (last accessed on 03/26/2004).

Tarouco, L. M. R., Fabre, M. J. M. & Tamusiunas, F. R. (2003). “Reusabilidade de Objetos Educacionais”. RENOTE: Revista Novas Tecnologias da Educação.

WEBCT, Inc. (2004). http://www.webct.com (last accessed on 03/26/2004).

Willey, D. A. (2004). “Learning Object Design and Sequencing Theory”. http://www.reusability.org (last accessed on 03/26/2004).