Holzinger, A., Smolle, J. & Reibnegger, G. (2006) Learning Objects (LO): An Object Oriented Approach to Manage e-Learning Content. In: Lazakidou, A. (Ed.) Encyclopedia of Informatics in Healthcare & Biomedicine. Hershey (PA), Idea Group Reference, 89-98. (ISBN 1-59140-982-9)

Learning Objects (LO): an Object-Oriented Approach to Manage e-Learning Content

Andreas Holzinger[1], Josef Smolle[2], Gilbert Reibnegger[3]

[1]Institute of Medical Informatics, Statistics and Documentation (IMI)
Medical University Graz (MUG), A-8036 Graz, Austria
andreas.holzinger@meduni-graz.at

[2]Department of Dermatology
Medical University Graz (MUG), A-8036 Graz, Austria
josef.smolle@meduni-graz.at

[3]Institute for Medical Chemistry and Pregl Laboratory
Medical University Graz (MUG), A-8010 Graz, Austria
gilbert.reibnegger@meduni-graz.at

Abstract:

Learning Objects (LO) are theoretically based on granular, reusable chunks of information. In this paper the authors argues that LOs should consist of more than just content, i.e. they should include pre-knowledge questions on the basis of the concept of the advanced organizer; of self-evaluation questions (assessment) and finally of appropriate metadata. The used metadata concept must be based on accepted standards, such as Learning Object Metadata (LOM) and the Shareable Object Reference Model (SCORM). A best practice example of the realization of these concepts is the Virtual Medical Campus Graz (VMC-Graz), which actually is the realization of an Information System to make a new curriculum digitally accessible.

Keywords: Learning Objects, Reusability, Metadata, Advance Organizer

1. Introduction

We regard Learning Objects (LOs) as having a historically foundation in the object-oriented paradigm of computer science. Object-orientation basically values the creation of components (called *objects*) that can be reused [1], [2].

Cisco [3] defines such a learning object as *"a granular, reusable chunk of information that is media independent."* The term **information chunk** reaches back to [4]; In his sense a chunk is an **information unit,** which can be perceived at one time by the individual into the short term memory (STM); Chunks are generally information units which can be individually complex and intra-individually very different [5].

Generally, the term *media object* is also often used and for the purpose of e-Learning this type of object is further defined as *"digital media designed and/or used for instructional purposes [6]"*. Such objects range from simple text to video demonstrations and interactive simulations [7].

According to Wiley [8], however, the main idea of LOs is to break educational content down into small chunks so that they can be (re)used in various learning environments, in the spirit of object-oriented programming. The Learning Object Metadata Working Group of the IEEE Learning Technology Standards Committee (LTSC) refers to LOs as *any entity, digital or non-digital, which can be used, re-used or referenced during technology enhanced learning* [9]. Some authors use other abbreviations, e.g. they speak of **E-learning objects (ELOs),** e.g. [10], or some speak of **Reusable Learning Objects (RLOs),** e.g. [11].

Within the VMC-Graz we use LOs as a new way of considering and handling learning content. They include at least the following four characteristics (compare also with the center for International Education of the University of Milwaukee [12]): Los is this sense ...

- ... must be much shorter than traditional learning units, typically ranging from 2 minutes to 15 minutes (absolute maximum within the VMC-Graz is 45 minutes);
- ... must be self-containing: each learning object can be used independently;
- ... must be tagged with metadata, which contains descriptive information allowing it to be easily found;
- ... can be aggregated: learning objects can be grouped into larger collections of content, including traditional course structures

2. Instructional Design Theory and Learning Objects

Instructional Design Theories (IDT) describe methods of instruction and the situations in which these methods should be used, the methods can be broken into simpler component methods, and the methods are probabilistic [13]. IDT, or instructional strategies and criteria for their application, play a important role in the application of Learning Objects. Combination and Granularity are two factors which we consider vital:

Combination. Whilst the Learning Technology Standards Committee (LTSC) promote international discussion around the technology standards necessary to support learning object-based instruction and many people are talking about the financial opportunities about to come into existence, there is astonishingly little conversation concerning the instructional design implications of Learning Objects [8].

Granularity. Discussion of the problem of combining Learning Objects in terms of *sequencing* leads to another connection between learning objects and IDT. The most difficult problem facing the designers of learning objects is that of *granularity* [8]. How big should a learning object be?

The IEEE LTSC leaves room for an entire curriculum to be viewed as a single learning object, but such a large object view diminishes the possibility of learning object reusability. Due to the fact that reusability should always be considered as the core learning object notion, this question must be answered cautiously. Luckily, within the VMC-Graz this problem was relatively easy to solve due to the modular and strict logic of the curriculum.

Within the VMC-Graz a LO can have any granularity with the maximum didactical duration of a lecture unit of 45 minutes. In any case, the produced LO must fit into this lecture unit! For example, this is in close accordance with Reigeluth's Elaboration Theory [13]. [8] synthesized this and other IDTs into a learning object specific instructional design theory, called the Learning Object Design and Sequencing Theory.

3. Practical Application of LO's in the VMC-Graz

The Virtual Medical Campus Graz (vmc.meduni-graz.at) general objective is not a new learning platform, but the realization of a tailor-made Information System to make the curriculum digitally accessible and to support the end users in the creation of individual workflows. Consequently, it is not aiming at providing traditional distance learning courses but it contains accompanying material which supports the students before (e.g. pre-readings), during (e.g. hands-on experiments, or simulations) and after the *real lectures* with corresponding material. Thus the system does not replace any lecture but supports every lecture and the system can be used in any learning scenario.

Technically, the departmental knowledge covering the different disciplines is stored in learning objects (LOs) and can be accessed via teaching and learning module catalogs. The target audience of the Virtual Medical Campus Graz is in the region of 4500 students and 600 teachers of the medical university. This high number of users justified a custom-made system, which was specially designed and developed by using a User Centered Development process [14], [15].

The content is developed by medical domain experts in close cooperation with media specialists. The project, as such, should not be regarded in isolation but rather as a part of the development of an e-learning strategy for the whole medical faculty. The solution of didactic problems is central to this type of software project and Multimedia is one of the many possible elements of the solution [16].
An LO within the VMC-Graz consists usually of four parts:

- 1) pre-knowledge questions;
- 2) the learning material (content);
- 3) self-evaluation questions and
- 4) metadata.

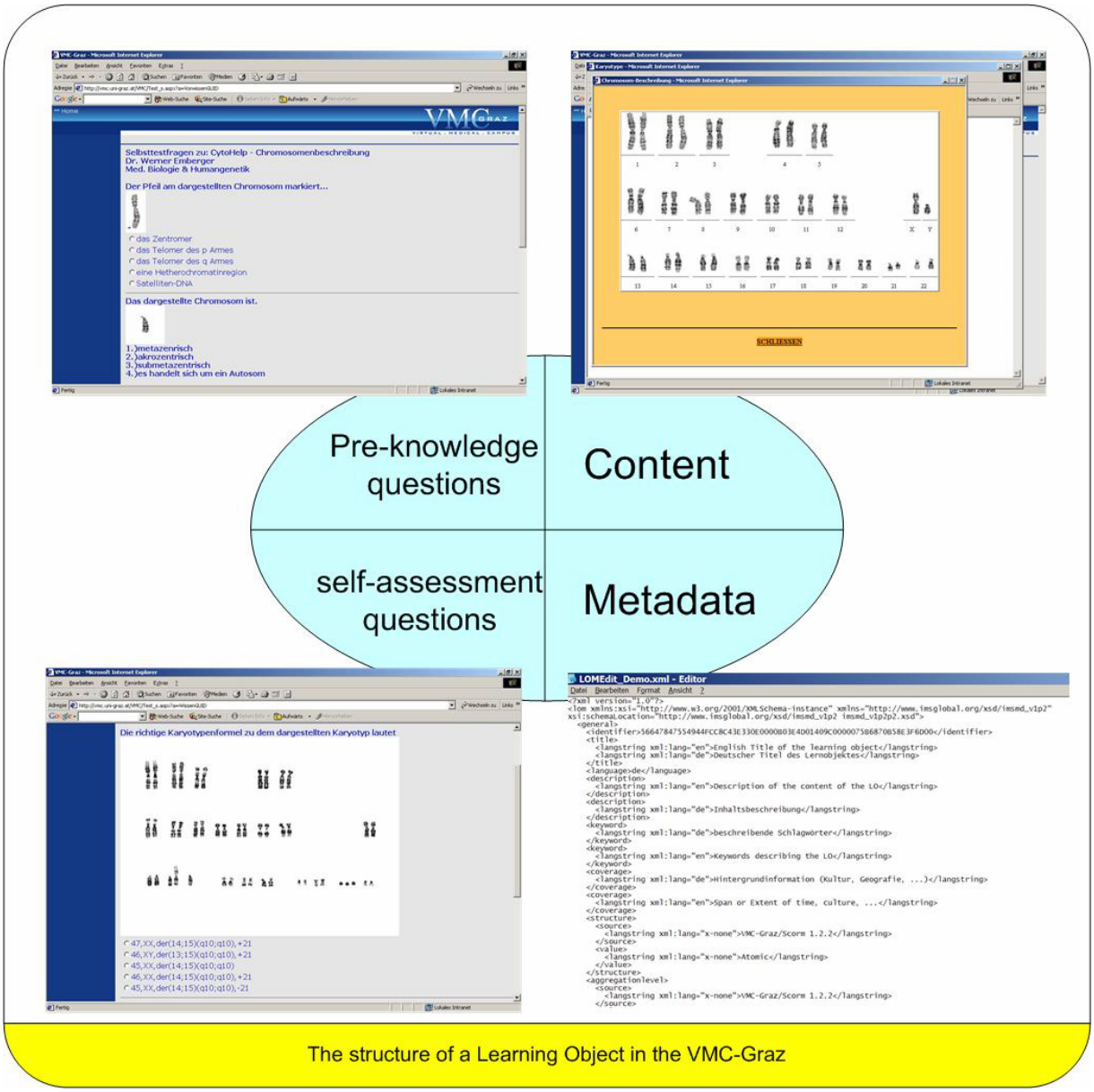

Figure 1 A learning object within the VMC-Graz consists typically of four parts

The LO forms an *atomic unit*. These are grouped within the VMC-Graz in lecture units (45 minute lecture blocks, called lecture hours or lessons), thematic groups (topics, themes) and modules (see figure 3 and figure 4). A LO is technically unrestricted in the amount of data. The only limitation is didactical, i.e. this means that an LO must not exceed a maximum of 45 minutes of didactical *size*, i.e. the longest LO fills one lecture hour with material. However, this didactical length is determined by the lecturers themselves, i.e. they must know which material they wish to supply to the students as support for a 45 minute lecture block.

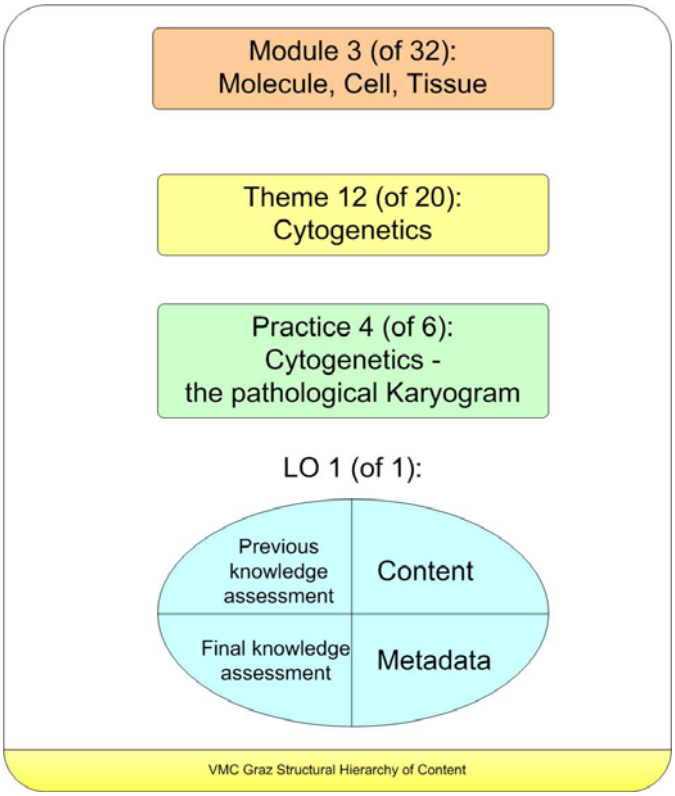

Figure 2 The logical structure of the VMC-Graz: The "atomic unit" is an LO, which is then assembled in lecture hours; an LO can have a maximum didactical size of one lecture hour

3.1. Pre-Knowledge Questions

The pre-knowledge questions serve in our LOs as **advance organizers** which are used as frameworks for helping students to understand what is to be learned. The term *advance organizer* was originally used by [17] to describe a process of linking the upcoming unfamiliar learning material to the learners' previously acquired knowledge. Generally, advance organizers are defined as a kind of appropriately relevant and inclusive introductory material, introduced in advance of the learning material itself and used to facilitate establishing a meaningful set of learning (cf. also with [18], [19], [20]).

Advance organizers are closely related to the *Schema* model of cognitive processing. The schema theory suggests that students learn better when information is presented in an associative

organization. Students build new information on information that is already mastered, thus scaffolding new knowledge on top of old. In other words, learning progresses from what is already known to what is unfamiliar, and then finally, to the relationship between the two. When the prior knowledge is linked to the new material, a connection is made cognitively and the information is processed into long-term memory [21].

Schema theory is a cognitive learning theory that was introduced by [22]. [23] described schemas as the basic building blocks of knowledge and intellectual development. Schemas are extremely interesting in the field of Human-Computer Interaction; for example, to include knowledge structures that store concepts in human memory, including procedural knowledge of how to use concepts [24], [25], [26].

3.2. The Content of a LO

3.2.1. Taxonomy of content

Similar to Bloom's famous taxonomy of educational objectives [27], [8] also developed a taxonomy of LOs and differentiated between five learning object types, which we also used within the VMC-Graz:

- **Fundamental LO** can include as content, either an image (JPEG, GIF or other, in medical education images play an important role!), a document (DOC, PDF, PPT, etc.), a movie (MPEG, AVI etc.); or any other file for example a simple text entry (containing only a literature reference to a hardcopy library book);
- **Combined-closed LO**, e.g. a video with accompanying audio.
- **Combined-open LO,** e.g. an (external) link to a web page, dynamically combining e.g. JPEG and QuickTime files together with extraneously supplied textual material.
- **Generative-presentation LO,** for example, a JAVA applet
- **Generative-instructional LO**, for example, an EXECUTE instructional transaction shell [28], which both instructs and provides practice for any type of procedure;

The purpose of the taxonomy of [8] was to differentiate between possible types of learning objects available for use in instructional design. This taxonomy is not all encompassing, in that it includes only those LO types that facilitate high degrees of reusability. Types of learning objects, which hamper or even prevent reusability (e.g. an entire digital textbook created in a format that prevents any of the individual media from being reused outside of the textbook context), have been purposefully excluded.

3.2.2. The Content

The main content contribution comes from each of the 600 teachers. Mostly, they use their available material, which encompasses written scripts (pdf, doc), transparencies (ppt), images (gif, jpeg, etc.), videos (avi, mov etc.) and any combination of these. For the support of good content development, we provide special training courses, written tutorials, as well as a hotline and a FAQ section, which is based on previous experience. We also make sure that the teachers include their pre-knowledge questions, self-evaluation questions and the proper metadata.

Of course, multimedia content must be designed effectively in order to maximize the true capabilities that multimedia has for enhancing human learning [16]. Within the VMC-Graz, the cooperation of the domain specialists together with media experts ensures the appropriate content development. This functional separation secures qualitatively high-quality contents on the one hand and a professional, media-didactic and technical realization on the other hand.

3.3. Self evaluation questions

Self-evaluation methods make it possible for the learners to check their progress [29]. Due to the fact that multiple-choice has been used at our medical faculty for a long time, we also support all questions in a multiple-choice test style [30], [31]. According to [32] the difficulty of multiple-choice items can be controlled by changing the alternatives, since the more homogeneous the alternatives, the finer the distinction the students must make in order to identify the correct answer. Normally, it takes much longer to respond to an essay test question than it does to respond to a multiple-choice test item. Consequently, students are able to answer many multiple-choice items in the time it would take to answer a single essay question. Teachers can use this

feature to assess a broader sample of the course content in a shorter time. An essential point is grading because multiple-choice accelerates the reporting of test results to the student, so that any follow-up clarification of instruction may be done before the course has proceeded much further [32].

3.4. Metadata

Experience from other projects has generally shown that these are mostly technology driven without enough commitment to content, content management and above all metadata strategies [33]. On the one hand it is necessary to provide all users (in our case students and teachers) with the possibility to find relevant material quickly; on the other hand we aim for interoperability of the learning material within an international context. Consequently, such a project can only be successful when it is fully committed to the implementation of metadata activities. It is not just a project but a strategy, which raises awareness of the possibilities of these metadata.

Correspondingly, our LOs are developed according to accepted standards for international education as a basis for worldwide networking in the form of Reusable Learning Objects (RLO). These LOs are stored in the repository and arranged in lectures, themes and modules by the VMC logic.

We consistently used the *Shareable Content Object Reference Model* (SCORM), Version 1.2. SCORM is a reference model that defines a Web-based learning *content model*, which consists of a set of interrelated technical specifications. In November 1997, the US Department of Defense (DoD) and the White House Office of Science and Technology Policy (OSTP) launched the Advanced Distributed Learning (ADL) initiative, www.adlnet.org [34]. The metadata model of the LOM standard integrated in the SCORM supports the retrieval of learning objects in varying constellations. SCORM denominates the smallest unit which can be administered by an Learning Management System (LMS) as a Sharable Content Object (SCO). An SCO represents so-called assets, which use the SCORM runtime environment to communicate with different systems.

This SCO represents the **lowest level of content granularity,** which can be tracked by any system. An SCO should be principally independent of the learning context and therefore reusable in different learning situations. Moreover, several SCOs can be assembled to form learning or exercise units on a superordinate level. To make a potential reuse practicable, SCOs should be small units. They can be the basis for sharable content repositories which facilitate their exchange. Only an LMS may launch an SCO. An SCO itself is not allowed to launch other SCOs [35].

4. Conclusion and Lessons learned

Generally, the auspicious theoretical concept of Learning Objects was not easy to carry out in practice. It needs a lot of awareness rising amongst the teachers and provision of information as to the advantages of these new concepts. As an incentive, we always pointed out the future advantages, which the successful completion of their learning material will bring.

The handling of the LO Editor proved to be successful, although we weakened our strict concepts (originally teachers were forced to fill in every part) providing pre-filled sections (with default settings) and allowed the postponed production of the pre-knowledge and self-evaluation questions (Although, we personally recommend strictness).

We found that most of the teachers did not like the creation of the pre-knowledge questions. Some even refused to provide any questions. Thus, we had also to weaken our previous concept wherein the creation of pre-knowledge questions was obligatory. We advocate strongly the advantages of the advance organizer concept and provide pay-off possibilities within special VMC-courses. The dislike of the pre-knowledge question section is easy to explain: the teachers, mainly medical doctors, lack the exorbitant time required to construct questions which reflect exactly the content and necessity for assessing the students' understanding of the material. However, once they have created the questions they have gained a deeper understanding of their material and of the knowledge they expect from their students. Consequently, the students benefit from this effort and finally, if the teachers get feedback about possible troubles of the students, eventually they will also get a return on their investment. However, the self-evaluation

questions were regarded as useful and important by every student. The students like to see their own progress and thus are able to reflect about the content.

There is still scientific research to be carried out, including extensive research in the exchange of LOs in an international context, in measuring and benchmarking the quality of the content and in gaining understanding of the optimal granularity of such LOs with the aim to support maximum exchangeability and usability.

5. References

[1] O.-J. Dahl and K. Nygaard, "SIMULA: an ALGOL-based simulation language", *Communications of the ACM*, vol. 9, 9, 1966, pp. 671-678.

[2] G. Booch, *Object-Oriented Analysis and Design with Applications*, Benjamin/Cummings, Redwood City (CA), 1994.

[3] Cisco, "E-learning glossary", Availabe Online: http://www.cisco.com/warp/public/10/wwtraining/elearning/pdf/elearn_glossary.pdf

[4] G. A. Miller, "The magical number seven, plus or minus two: Some limits of our capacity for processing information", *Psychological Review*, vol. 63, 1956, pp. 81-97.

[5] H. A. Simon, "How big is a chunk?" *Science*, vol. 183, 1974, pp. 482-488.

[6] J. B. South and D. W. Monson, "A university-wide system for creating, capturing, and delivering learning objects", Availabe Online: http://reusability.org/read/chapters/south.doc.

[7] A. Holzinger and M. Ebner, "Interaction and Usability of Simulations & Animations: A case study of the Flash Technology", presented at Interact 2003, Zurich, 2003. pp. 777-780.

[8] D. A. Wiley, "Connecting learning objects to instructional design theory: a definition, a metaphor, and a taxonomy" in *The instructional use of learning objects, available at http://reusability.org/read/chapters/wiley.doc*, D. A. Wiley, Ed., Agency for Instructional Technology and the Association for Educational Communications and Technology, New York, 2001. pp. 35.

[9] R. Robson, "IEEE Learning Technology Standards Committee (LTSC)", Availabe Online: http://ltsc.ieee.org

[10] J. A. Muzio, T. Heins, and R. Mundell, "Experiences with reusable E-learning objects; From theory to practice", *The Internet and Higher Education*, vol. 5, 1, 2002, pp. 21-34.

[11] P. R. Polsani, "Use and Abuse of Reusable Learning Objects", *Journal of Digital information, volume 3 issue 4*, vol. 3, 4, 2003, pp.

[12] R. J. Beck, "University of Milwaukee, Center for International Education, Learning Objects," Availabe Online: http://www.uwm.edu/Dept/CIE/AOP/LO_what.html
[13] C. M. Reigeluth, *Instructional design theories and models: A new paradigm of instructional theory*, Erlbaum, Hillsdale (NJ), 1999.
[14] A. Holzinger, "Experiences with User Centered Development (UCD) for the Front End of the Virtual Medical Campus Graz" in *Human-Computer Interaction, Theory and Practice*, J. A. Jacko and C. Stephanidis, Eds., Lawrence Erlbaum, Mahwah (NJ), 2003. pp. 123-127.
[15] A. Holzinger, "Application of Rapid Prototyping to the User Interface Development for a Virtual Medical Campus", *IEEE Software*, vol. 21, 1, 2004, pp. 92-99.
[16] A. Holzinger, *Multimedia Basics, Volume 2: Learning. Cognitive Fundamentals of multimedial Information Systems*, Laxmi, New Delhi, 2002.
[17] D. P. Ausubel, "The use of advance organizers in the learning and retention of meaningful verbal material", *Journal of Educational Psychology*, vol. 51, 1960, pp. 267-272.
[18] D. P. Ausubel, *Educational psychology: A cognitive view*, Holt, Rinehart & Winston, New York, 1968.
[19] C. Kralm and M. Blanchaer, "Using an advance organizer to improve knowledge application by medical students in computer-based clinical simulations", *Journal of Computer Based Instruction*, vol. 13, 1986, pp. 71-74.
[20] A. J. Corkill, R. H. Bruning, and J. A. Glover, "Advance Organizers: Concrete versus Abstract", *Journal of Educational Research*, vol. 82, 1988, pp. 76-81.
[21] R. H. Bruning, R. R. Ronning, and G. J. Schraw, *Cognitive Psychology and Instruction, Third Edition.*, Prentice-Hall, Upper Saddle River (NJ), 1999.
[22] F. C. Bartlett, *Remembering*, Cambridge University Press, London, 1932.
[23] J. Piaget, *On the development of memory and identity*, Clark University Press, Worchester (MA), 1961.
[24] J. W. Satzinger, "The effects of conceptual consistency on the end user's mental models of multiple applications", *Journal of End User Computing*, vol. 10, 3, 1998, pp. 3-14.
[25] A. M. Shapiro, "The relationship between prior knowledge and interactive overviews during hypermedia-aided learning", *Journal of Educational Computing Research*, vol. 20, 2, 1999, pp. 143-167.
[26] P. A. Chalmers, "The role of cognitive theory in human-computer interface", *Computers in Human Behavior*, vol. 19, 5, 2003, pp. 593-607.
[27] B. S. Bloom, *Taxonomy of educational objectives, handbook 1: Cognitive domain*, Longmans Green, New York, 1956.

[28] M. D. Merrill, "Instructional transaction theory (ITT): Instructional design based on knowledge objects" in *Instructional design theories and models: A new paradigm of instructional theory*, C. M. Reigeluth, Ed., Erlbaum, Hillsdale (NJ), 1999. pp. 397-424.

[29] B. S. Bloom, J. T. Hastings, and G. F. Madaus, *Handbook on Formative and Summative Evaluation of Student Learning.*, McGraw Hill, San Francisco (CA), 1971.

[30] P. Gathy, J.-F. Denef, and S. Haumont, "Computer-assisted self-assessment (CASA) in histology", *Computers & Education*, vol. 17, 2, 1991, pp. 109-116.

[31] M. E. McDonald, *Systematic Assessment of Learning Outcomes: Developing Multiple-Choice Exams*, Jones & Bartlett, Sudbury (MA), 2002.

[32] S. J. Burton, R. R. Sudweeks, P. F. Merrill, and B. Wood, "How to Prepare Better Multiple-Choice Test Items: Guidelines for University Faculty"http://testing.byu.edu/faculty/handbooks.asp

[33] A. Holzinger, T. Kleinberger, and P. Müller, "Multimedia Learning Systems based on IEEE Learning Object Metadata (LOM)", presented at ED-Media World Conference on Educational Multimedia, Hypermedia and Telecommunications, Tampere (Finland), 2001. pp. 772-777.

[34] ADLNet, "Advanced Distributed Learning", Availabe Online: http://www.adlnet.org

[35] P. Dodds, "Advanced Distributed Learning, Sharable Content Object Reference Model (SCORM) ADL Version 1.3 Application Profile WORRKING DRAFT 1.0, March 26, 2003, Version 1.2, Release 2001", Availabe Online: http://www.adlnet.org

6. Terms and Definitions

Aggregated Learning Object (ALO) is a combination of learning objects that can be broken down into separate parts without losing the integrity of each part.

Assessment is any process used to systematically evaluate the knowledge level of learners.

Asset, digital is any audio, animation, graphic, photograph, text, or video that may convey information, does not have a learning objective attached, and is not multi-media.

Content Aggregation is any process of building a new learning object from one or more existing objects or assets. For example, if a pre-test reveals that students are missing some key skills or core knowledge an instructor might locate a series of objects and link them using a common interface as a strategy for remediation.

Curriculum is a set of courses, modules, or other organized learning experiences that constitute a complete, cohesive, and coherent program of study.

Granularity is the breadth and depth of an object's content as relates to reusability.

Learning Object is any digital resource that can be reused to mediate learning.

Metadata is descriptive information and is designed to help users and managers locate, organize, access, and use objects effectively.

Module is a grouping of readings, activities, tasks, and assignments that are organized around a central topic or theme. Breaking content into components supports the organization of knowledge and reduces the cognitive load of the learner. See Unit For example, a beginning algebra course includes the following modules:

Multimedia is a combination or text, graphics, audio, animation, video, and/or simulation. Typically, combinations of media can provide deeper explanations or illustrations of content than data presented in one medium.

Reusable means to be placed in different situations, environments, or locations for different purposes or functions, by different end-users.

Shared Content Object Reference Model (SCORM) defines a Web-based learning "Content Aggregation Model" and "Run-Time Environment" for learning objects. The SCORM is a collection of specifications adapted from multiple sources to provide a comprehensive suite of e-learning capabilities that enable interoperability, accessibility and reusability of Web-based learning content.