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# Learning Objects Update: Review and Critical Approach to Content Aggregation

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## ABSTRACT

The structure and composite nature of a learning object is still open to interpretation. Although several theoretical studies advocate integrated approaches to the structure and aggregation level of learning objects, in practice, many content specifications, such as SCORM, IMS Content Packaging, and course authoring tools, do not explicitly state the aggregation level or granularity of learning content. The aim of this paper is to review, compare, and amalgamate different content models for learning objects into a single and coherent learning content hierarchy. To fulfil the objectives of this study, a substantive body of literature was reviewed and analysed to identify current issues in the field of learning objects, and more specifically, learning object content models.

## Keywords

Learning object content models, Content packages, Content structure, Granularity, Hypermedia

## Introduction

The structure and composite nature of a learning object is still open to interpretation (Metros, 2005; Knight, Gašević, & Richards, 2005). Most of the definitions are shaped around general principles that govern the learning object concept, such as reusability, learning intent, and context-independence. A typical example of such a definition is provided by Polsani (2003), who defined a learning object as "an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts."

Downes (2003) considers the size of a learning object to be important and provides debate about this. Cisco Systems, one of the pioneers in the field of learning objects, tried to address this particular issue by suggesting that five to nine information objects (collections of raw data such as text, video, images, and photos) can be combined to form a learning object (Barron, 2002). Other authors approach the issue of the size of a learning object from an instructional, time-based angle, suggesting that its size can be defined in terms of instructional time ranging from a 15-minute to a two-hour learning experience (Downes, 2003; Mortimer, 2002). In contrast to the above approaches, however, Currier and Campbell (2005) and Polsani (2003) argue that neither learning time, nor the physical size (in terms of bits and bytes) is a valid criterion for determining the size and granularity of a learning object. They suggest that the logical size rather than physical size is the appropriate concept for defining the size of a learning object.

Other researchers have tried to approach the structure of the learning object by defining its contents or its constituent parts. Most definitions are influenced by instructional design theory. According to Metros (2005, p. 12), in order for a digital source to be considered as a learning object it "must include or link to: 1) a learning objective; 2) a practice activity, and 3) an assessment." A similar definition has been provided by Mortimer (2002), who argues that a learning object should include metadata, a learning objective, and the actual content, as well as activities and assessments that support the specified objective. Finally, Macromedia MX suggests that the main components of a learning object should include the existence of content, metadata, and interoperability mechanisms that facilitate its exchangeability across authoring tools and virtual learning environments (VLEs) (Gallenson, Heins and Heins, 2002; Heins and Hilmes, 2002; Johnson, 2003).

In addition to the above theoretical and sometimes ambiguous conceptualizations, many content packaging specifications, such as SCORM, IMS Content Packaging, and course authoring tools, do not explicitly state the level of aggregation or granularity of a learning object. The lack of concrete specifications can impede one of the most vital aims of a content packaging specification, which is to support interoperable exchange of content packages (such as collections of learning objects which are annotated with metadata and organised in a specified way) between different authoring systems/tools and runtime environments (such as VLEs) (IMS, 2004). Some research on ontologies has been conducted to address this issue. An ontology can be represented as a structured vocabulary of concepts related to each other forming the conceptualization of a domain (such as a thing, an activity, a phenomenon, or a subject domain) (Staab and Studer, 2004; Fensel, 2001). The ALOCoM and Course ontologies represent two attempts by which researchers tried to provide an explicit vocabulary and a conceptualisation of the structure and aggregation level of learning content (Stojanovic, Staab, & Studer, 2001; Verbert and Duval, 2004, p. 207; Verbert, Gašević, Jovanovic, & Duval, 2005). Both ontological approaches, however, address discrete portions of a learning content hierarchy. For example, the ALOCoM ontology defines a learning object as a collection of content fragments and content objects, but it does not specify the role and position of a learning object in the learning content hierarchy. On the other hand, the Course ontology identifies the components of a whole course (as a collection of atoms and modules) but it does not expose the specific nature of a learning object. No theoretical work has been conducted as a means for defining holistically and exposing the nature and logical position of a learning object within the learning content hierarchy.

The purpose of this paper is to review and compare different content models for learning objects. This study, however, differentiates itself, in terms of breadth and scope, from previous similar attempts to compare learning object content models, such as the comparative study conducted by Verbert and Duval (2004). In particular, the present study updates the previous one by taking into account more content models as specified by various organisations, research projects, and researchers world wide. In addition, the study is not limited to the identification of the constituent parts of a learning object but covers the whole spectrum of the hierarchical structure and relations of learning content (from raw data to information to learning objects to whole courses). Finally, this paper approaches the granular size of the learning object from two different angles, the objectivist perspective and the relativist perspective.

## Review of content models

Content models provide a framework for defining the structure, that is, the level of aggregation/granularity of learning objects, and include the SCORM Reference Model (ADL, 2004), the aggregation levels defined by the IEEE LTSC LOM standard (IEEE LTSC, 2002), the Cisco Systems RLO (Cisco Systems, 2003a,), the Learnativity content model (Wagner, 2002), the content model defined by Schluep, Ravasio, and Sissel-Guttormsen Schar (2003) for their prototype LCMS (learning content management system), and finally, the DNER & LO model (Currier & Campbell, 2005) (Figure 1). This section provides an overview of the different aggregation levels of learning content.

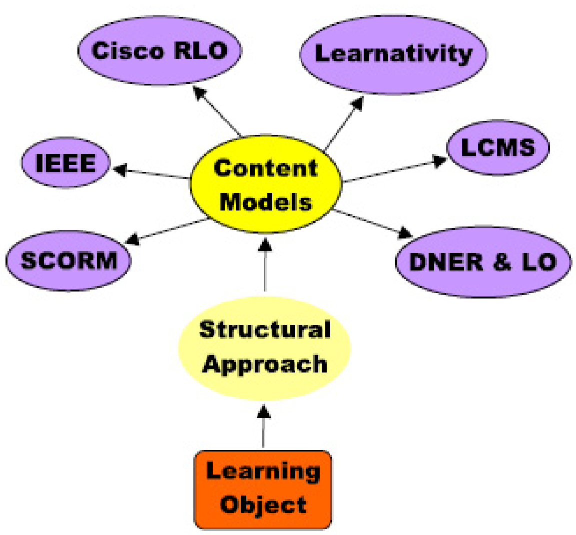


*Figure 1.* Content models for learning objects

The Reusable Learning website (2004), sponsored by the U.S. National Science Foundation (NSF), defines the aggregation level as "the degree to which a digital learning resource is made up of other digital learning resources. The higher the aggregation level the deeper the hierarchical structure." Similarly, on the same website, the sibling term "granularity" is defined as "the size, decomposability and the extent to which a resource is intended to be used as part of a larger resource. More granular digital learning resources are larger and are composed of smaller pieces" (Reusable Learning, 2004).

## The SCORM content model

SCORM (sharable content object reference model) is a collection of related specifications and standards aimed at the creation of interoperable, accessible, durable, affordable, and re-usable learning content (ADL, 2004). What is particularly important about SCORM is the fact that it does not introduce new specifications or standards, but it co-ordinates and refers to already established technical standards, specifications, and guidelines introduced by other international organisations committed to e-learning standardization, such as the IMS, the IEEE LTSC, ARIADNE, and AICC. This further justifies the wide acceptance and significant impact of SCORM on the e-learning industry world wide. SCORM is defined by three separate but not mutually exclusive pieces of documentation: the content aggregation model, runtime environment, and navigation and sequencing. From the three strands of the SCORM documentation, the content aggregation model most relevant to this study as it defines the content components used for creating a learning experience as well as the way these components can be aggregated into units of learning. The main components of the SCORM content model include:

- assets
- sharable content objects (SCOs)
- content organisations (ADL, 2004).

An asset represents the smallest re-usable piece of learning content. Many assets can be aggregated to build other assets and SCOs. The basic difference between a SCO and an asset is that the SCO communicates with a virtual learning environment using an application programming interface. A content organisation presents a structured map of the learning resources. In this case content organisation is restricted to a hierarchical tree structure that acts as a table of contents. More sophisticated learning experiences for learners can be defined by the use of activities that specify the way content components such as assets and SCOs are used in a given instructional environment. It is worth mentioning that sequencing and navigation rules and behaviours are embedded in the activities and not in the SCOs or assets (such as the physical resource files) (ADL, 2004, p.25). This is of significant importance for SCOs' and assets' re-usability, because they are not bound to specific sequencing and navigation rules and thus are not dependent on a particular instructional approach or learning theory. SCORM uses the IMS content packaging specification as a means for incorporating its various components: assets, SCOs, activities, content organisation, and metadata within a single content aggregation (or unit of learning).

SCORM does not prescribe the actual size of a SCO or even the size of a whole content aggregation (or unit of learning). In addition, although SCORM provides the opportunity for authors to represent the different levels of the structure of learning content hierarchically, it does not specify any particular formal taxonomy, vocabulary, or heavyweight ontology for representing the structure of contents, for example, as a course, module, or lesson. On the other hand, the size of a SCO depends on a synthesis of educational and organisational criteria, such as the scope of instruction, learning objectives, and affordability (in terms of time, cost, human resources, etc.).

## The IEEE LTSC LOM aggregation metadata model

The IEEE LTSC defines a content model that consists of four aggregation levels or levels of functional granularity. These include:

- "Level 1: The smallest aggregation level, such as raw media data or fragments.
- Level 2: A collection of Level 1 learning objects, such as a lesson.
- Level 3: A collection of Level 2 learning objects, such as a course.
- Level 4: The largest level of granularity, such as a collection of courses."

(IEEE LTSC, 2002, p. 15)

What is of particular importance about the aggregation levels defined by the IEEE LTSC is that these levels are being used by the learning object metadata (LOM) standard for describing the functional granularity of learning objects.

It should be mentioned, however, that these aggregation levels are general and vague. For example, they do not specify or describe explicitly the various aggregation levels. Moreover, according to Friesen (2004), the lack of explicit definitions and explanations regarding the use of the general aggregation level and general structure elements and their corresponding LOM vocabularies makes the specific metadata elements and values difficult to use by metadata creators.

### Cisco's reusable learning object content model

In 2003, Cisco Systems published a strategy and authoring guidelines for reusable learning objects as part of its e-training program. The aim of Cisco's RLO (reusable learning object) strategy was the creation of small objects that can be aggregated in order to meet specific training needs (Cisco Systems, 2003b, p. 5). For this purpose, Cisco Systems proposed five aggregation levels for structuring learning content: 1) subtopic, 2) topic or RIO (reusable information object), 3) lesson or RLO (reusable learning object), 4) module, and 5) course.

A course is comprised of a collection of modules, which in turn include collections of lessons. A lesson can be reusable in multiple courses and learning contexts. A lesson or reusable learning object consists of a single learning objective, an overview, a summary, and a collection of topics (or RIO), as well as practice activities, assessment, and metadata. In particular, five to nine reusable information objects can be combined to form a learning object (Barron, 2002). A topic is a self-contained reusable information object that consists of subtopics (such as small chunks of information of various types such as definitions, examples, tables, guidelines, etc.), assessment, practice activities, and metadata. Topics are grouped into five category types, including concepts, facts, procedures, processes, and principles. Both RLO and RIO components (such as content, activities, and assessment) can be represented in various media formats such as text, audio, animation, videos, Java code, applets, and other delivery media (Cisco Systems, 2003b; 2003a). It is worth mentioning, however, that although Cisco initially treated a single lesson as a learning object, for the purpose of terminological simplicity, Version 4.5 of the strategy regards each aggregation level (from topics to courses) as a learning object (Cisco Systems, 2003b). This revision, however, broadens the scope of a learning object and does not specify its exact position in the course hierarchy as it did previously.

### Learnativity content model

The Learnativity Alliance (2005) created a conceptual specification of a content model that represents the different levels of organisation and granularity involved in the creation of digital learning content in both e-learning and knowledge management initiatives. According to Wagner (2002), the basic components of the Learnativity content model include:

- *Content assets*. Content assets include raw data such as photographs, audio and video files, java applets, and animation.
- *Information objects*. Information objects represent the most granular form of content. There are various types of information objects, including concept, fact, process, principle, command reference, exercise, and procedure.
- *Learning objects*. Learning objects are combinations of information objects that serve a specific learning objective or job task.
- *Learning components*. Collections of learning objects can be further organised and sequenced to form a learning component. There are various types of learning components, such as lessons and courses.
- *Learning environment*. A combination of learning components with communication tools and/or other features that facilitate an e-learning experience can be aggregated into a learning environment (e.g., VLEs and MLEs).

Although the Learnativity content model is more prescriptive in terms of content granularity and aggregation than the aforementioned models, it does not provide a framework for aggregating, structuring, and sequencing content, as in the case of the SCORM model, which prescribes the development of such as framework. In addition, unlike Cisco Systems' RLO strategy, the Learnativity content model does not provide details regarding the logical size of a learning object or the instructional components included in each content component. The conceptual content model, however, declares the trade-off relation between re-usability and contextualization of content components. For example, content assets or information objects are more context-independent and thus more re-usable for multiple instructional situations. On the other hand, learning components or learning environments are less re-usable because they are more context-dependent entities.

The Learnativity content model was influential for many subsequent learning content models produced by Academic ADL Co-Lab and Autodesk. Table 1 provides a summary of all these Learnativity-based content models (Brown, 2002; Hodgins, n.d).

*Table 1.* Summary of Learnativity-based content models

| **Learnativity Content Model** | **Academic ADL Co-Lab Modular Content Hierarchy** | **Autodesk Content Model** |
|---|---|---|
| Content Asset | RawData | RawContent Items |
| Information Object | Information Objects | Reusable Information Object |
| Learning Object | Learning Objects | Reusable Learning Object |
| Learning Component (e.g. lesson, course) | Lesson | Lesson |
| | Course | Course |
| Learning Environment | | |

**Other proposed content models**

In addition to the above content models, many researchers and research bodies have proposed other similar levels of aggregation of learning content. For example, Schluep, Ravasio, & Sissel-Guttormsen Schar (2003) define three levels of aggregation for their learning content management system (LCMS). These include assets, learning objects, and learning units. Learning objects may contain one or more assets, while learning units consist of collections of learning objects. Although no details are provided about the logical size of a learning object, the authors suggest that learning objects should be small and self-contained as a means for facilitating reusability. Another taxonomy of various levels of aggregation for learning objects was proposed by the DNER & LO project. The DNER & LO project was a JISC-funded research initiative that ran until June 2002. The DNER & LO project concentrated on the creation, sharing, reusability, re-purposing, and interoperability of learning content and learning objects across the UK higher education. As part of this study, Currier and Campbell (2005, p. 91–92) proposed seven levels of aggregation of learning content. These are:

1. *Information objects* (raw data, such as an image, reference or text file, with no learning objective);
2. *Information resources* (collections of information objects, such as an e-book or e-journal, with no educational objective);
3. *Learning objects* (aggregations of information resources that serve a specific learning objective and may facilitate the execution of a learning activity, assessment, etc);
4. *Unit of study* (an aggregation of learning objects and information resources or objects, such as a lesson);
5. *Module* (an aggregation of units of study and learning objects);
6. *Course* (an aggregation of units of study, modules, or other learning objects and resources);
7. *Collection* (an aggregation of modules and courses, with no educational objective assigned and merely serving as a searchable database for learning objects.

The authors further divided these content components between components developed for addressing a learning objective (learning objects, units of study, modules, and courses) and those components serving informational rather than learning purposes (information objects, information resources, collections).

## Discussion

The above section provided an overview of different aggregation levels. In this section the aggregation-granularity level of a learning object is discussed from two main perspectives, the objectivist perspective and the relativist perspective. The objectivist approach classifies the cases in which an explicit, measurable, and standard type of learning object is defined, while the relativist approach symbolizes the "open" approaches that treat any level of granularity as a learning object, for example, from raw data to a whole course certification.

### The objectivist approach to learning objects

There are few studies that provide comparative data about content aggregation levels for learning objects. Verbert and Duval (2004), presented a comparative study of four different content models (the Learnativity content model, SCORM, Cisco's RIO/RLO, and Netg). Their study provided a theoretical framework for the identification of the main levels of aggregation upon which the development of the ALOCoM content structure ontology was based. Table 2 presents how Verbert and Duval (2004) mapped the various levels of aggregation of the four content models against their proposed model, while Table 3 summarizes the main levels of aggregation for learning objects based on the results of the present study.

*Table 2.* The ALOCoM ontology

| Learnativity | SCORM | Cisco | Netg | ALOCoM |
|---|---|---|---|---|
| Raw Data | Assets | Content Items | | Content Fragments |
| Information Object | | RIO | | Content Objects |
| Learning Object | SCO | RLO | Topic | Learning Objects |
| Aggregate Assemblies | Content Aggregation | | Lesson | |
| Collections | | | Unit | |
| | | | Course | |

*Table 3*. Summary of different content models

| | SCORM | IEEE LTSC LOM | Learnativity | Cisco RIO/RLO | The LCMS | DNER & LO |
|---|---|---|---|---|---|---|
| Low Level of Aggregation | Assets | Raw–Data Level 1 | Content Assets | Sub-Topic | Assets | Information Objects |
| | SCOs | Aggregation Level 2 (Lesson) | Information Objects<br>Learning Objects | Topic (RIO)<br>Lesson (RLO) | Learning Objects | Information Resources<br>Learning Objects |
| High Level of Aggregation | Content Aggregation (e.g. Lessons, Courses) | Aggregation Level 3 (Courses)<br>Aggregation Level 4 (Certification Course) | Learning Component<br>Learning Environment | Module<br>Course | Learning Unit | Unit of Study<br>Module<br>Course<br>Collection |

A learning object, SCO, or RLO can be defined as an aggregation of different kinds of information (RIO or information objects) or data (assets, content assets, raw data, or sub-topics) (see Table 3). Most of the content models reviewed do not specify the amount of information and data that constitute a learning object. This does not hold true, however, for the Cisco model, which proposed the creation of learning objects from ± 7 reusable information objects (Barron, 2002). In addition, several authors have proposed that the logical size of a learning object should be small enough to better support its reusability (Schluep, Ravasio, & Sissel-Guttormsen Schar, 2003; Conlan, Dagger, & Wade, 2002; ADL, 2004). Both the Learnativity and Cisco content models specify that a learning object should serve a specific learning objective or job task (the latter holds in the case of e-training programs developed at the workplace). According to Currier and Campbell (2005) the existence of a learning objective differentiates learning objects from information sources. Furthermore, Cisco's RLO is instructional design-dependent and includes additional features such as activities, assessments, content overviews, and summaries that serve the assigned learning objective. Table 3 also reveals the relationship between the level of aggregation/granularity and the different types of learning content. In this manner, raw data are characterized by a low level of granularity and aggregation, while in the case of modules or courses the level of aggregation increases.

Figure 2 represents a typical learning content model pyramid as specified in the results of this study. A learning object may be either a concentration of raw data, as in the case of SCORM, the LCMS developed by Schluep et al. and the IEEE LTSC LOM standard, or an aggregation of information objects (i.e., collections of learning objects), as in the case of the DNER & LO, Cisco, and Learnativity models, or a combination of both raw data and information objects. Aggregations of learning objects define modules or courses respectively, depending on the learning objectives of the organisation or tutor. There is some debate, however, regarding the relationship between a learning object and a lesson. The Cisco content model, for example, uses the terms "reusable learning object" and "lesson" as synonyms. A similar approach has been adopted by the IEEE LTSC LOM standard. On the other hand, this does not hold true in the case of the content models proposed by the DNER & LO project (in which "unit of study" equals "lesson"), SCORM CAM (in which "content aggregation" equals "lesson"), and the Learnativity content model (in which "learning component" equals "lesson"). In addition, according to Table 1, both the Academic ADL Co-Lab modular content hierarchy and the Autodesk molecular content model differentiate between a lesson and a learning object.

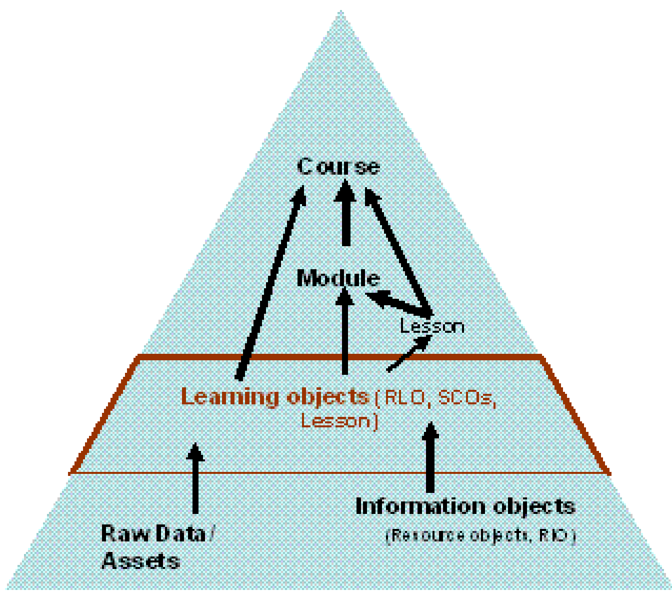


*Figure 2.* The learning content pyramid

For the purpose of this analysis, the learning object concept has been flexibly defined as either a lesson or as a component of a lesson. This flexible definition does not offer a political solution to this debate, but one of instructional scope. For example, it has been quite frequently argued that instructional design principles should guide the design of learning objects (Wiley, 2000; Longmire, 2000). From an instructional design perspective, Gagne, Briggs, and Wager (1992) identified four basic elements that should be taken into account for lesson planning. These are:

1. "A statement of the objective of the lesson […];
2. A list of instructional events to be employed;
3. A list of the media, materials, and activities by which each event is to be accomplished;
4. Notes on the teacher roles and activities […]"

(Gagne, Briggs, & Wager, 1992, p. 237).

These elements of lesson planning as defined by Gagne, Briggs, and Wager (1992) are very close to the way Cisco approaches the concept of a learning object, that is, as a container of the learning objective, activities, and content. A similar approach to learning object design has been also adopted by Macromedia (Gallenson, Heins, & Heins, 2002; Johnson, 2003). Finally, Plodzien, Stemposz, and Stasiecka (2006), based on a "model of effective learning," identified four broad categories of a learning object's structure: introduction, main content, summary, and evaluation. These categories were further used as measures for evaluating the quality of learning objects. The researchers concluded that the presence of such instructional components within a learning object had a positive impact on the way users evaluated its quality. Thus, in this case, a learning object has many design similarities with a lesson plan as specified by Gagne, Briggs and Wager (1992). On the other hand, instructional design-agnostic learning objects that lack a cohesive pedagogical structure may be further aggregated into instructionally meaningful lessons. In that case, a learning object forms part of a lesson and it is not considered as a lesson itself.

From a technical point of view, the most appropriate way for structuring and sequencing the contents of an instructionally oriented learning object is through the use of a learning design language, such as the IMS Learning Design, developed by the IMS (2003) or the Educational Modelling Language (EML), developed by the Open University of Netherlands (Hermans, Manderveld, & Vogten, 2003). The conceptual structure of a learning design language is based on a set of concepts or building blocks that support the interaction among roles, activities, environments, and learning design methods. For example, in the case of the IMS Learning Design, each person may be assigned a role (either a learner or staff). Based on the assigned role and the specified learning outcomes, each person performs an activity (either a learning or support activity) within a specific environment that consists of content, services, and sub-environments (Koper & Oliver, 2004).

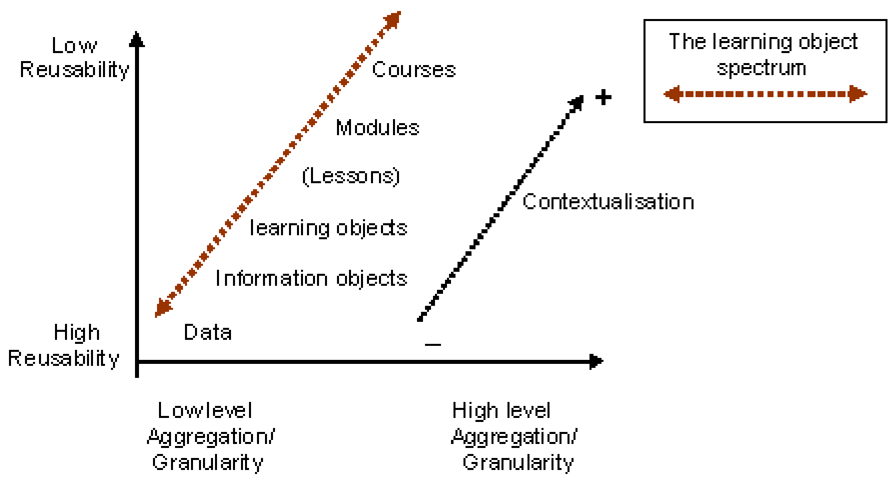


*Figure 3.* The learning object spectrum

**The relativist approach to learning object's granularity and level of aggregation**

While the review of the content models revealed that a typical learning object consists of small collections of raw data and information, there is another trend arising within learning technology standardization communities and corporate training departments, and among individual researchers, regarding the identity of a learning object in terms of its granularity and level of aggregation. In this manner, both the IEEE LTSC LOM draft standard (2002, p. 15) and version 4.5 of Cisco's strategy for reusable learning objects (2003b) support the notion that any aggregation level maybe regarded as a learning object. A similar approach has been adopted by Verbert and Duval's model. According to Table 2, Verbert and Duval mapped their learning object concept to a broad spectrum of learning content aggregation levels, including learning objects, collections of learning objects, or even courses. In addition, Song (2002) argued that a learning object can represent a wide variety of learning content such as "a course, a book or a seminar." Friesen (2002) adopted a similar approach to the concept of a learning object as well. Such a broad specification of the learning object phenomenon frees the concept of a learning object from more specific and objectivist approaches. In this case, a learning object does not have a standard and measurable granularity or aggregation level value. Furthermore, like Figure 3 indicates, a relativist learning object can be positioned at any level in the trade-off relation between reusability and aggregation level as presented by the learning object spectrum. Figure 3 reveals the learning object spectrum according to which as the level of granularity-aggregation increases, the learning object content becomes more context dependent and its potential reusability decreases. The relationship between the aggregation/granularity level, the level of contextualization, and the reusability value has been graphically conceptualized by the Learnativity model (Wagner, 2002).

**Barriers for defining an explicit and objectivist specification of a learning object**

The relativist approach to the term "learning object" may be attributable to the following factors:

- Lack of a shared, explicit, and measurable definition of a learning object. Even widely adopted technical standards for learning objects like the IEEE LTSC LOM (2002) provide vague definitions of the nature and granularity of a learning object.
- Lack of shared ontologies. Research on ontologies has resulted in some data models that define the various types of learning content components, as in the case of the Course, ALOCoM, and LOV ontologies. However, unlike IMS CP and SCORM, these ontologies have not been officially integrated to existing content packaging specifications. In addition, the proposed ontological conceptualisations are far from being regarded as shared and commonly agreed-upon vocabularies among different communities. Further work and research in the field should be undertaken, particularly from those organisations responsible for learning technology standardization and interoperability.
- Misconceptions related to the adoption of the term "object" from the object-oriented programming. Object-oriented programming at a higher level of abstraction is based on the definition of classes and objects that can be further reused in multiple software codes (Wu, 2005). This object orientation can be an intrinsic property of each content component within the learning content hierarchy (data objects, information objects, learning objects, lesson objects, module objects, and course objects) but with different degrees of re-usability in each case. Thus, object-orientation is not a unique property of what is defined as a learning object in the various learning content models. In many cases, however, the term learning object is commonly used to excess in order to denote the object-oriented and reusable nature or property of any learning component.
- Lack of explicit and identifiable instructional components of a learning object. Although the instructional design of learning objects has been identified as an important condition for their success (Wiley, 2000), in theory such an instructional foundation of a learning object does not exist. Useful specifications like the IMS Learning Design specification and the Educational Modelling Language have been developed for enhancing learning content with pedagogically meaningful activities. These specifications, however, have not yet been widely implemented by existing learning content authoring tools (Britain & Liber, 2004). It is worth mentioning, however, that LAMS (Learning Activities Management System) is an authoring tool that permits the creation and sequencing of learning activities that can be integrated within e-learning systems such as Moodle and Blackboard.

## Conclusions

This paper presents a review and comparison of different theoretical accounts of the aggregation level of learning objects from both an objectivist and a relativist perspective. It does not propose a new definition of a learning object. On the contrary, it outlines the ambiguity with which the concept is used in the literature in terms of its aggregation level and granularity. An objectivist and instructional design-based approach to learning objects can provide a more concrete understanding of the contents of a learning object by both humans and machines (such as authoring tools and e-learning systems). More work, however, needs to be undertaken to provide a standard specification of a learning object and its aggregation level. Such a standard specification would address several issues, including:

- standardization of the process of packaging, sharing and exchanging learning objects;
- development of standard quality metrics for evaluating learning objects;
- identification of the position and role of a learning object in the learning content hierarchy and its positioning in the electronic information environment in general;
- improved management and administration of learning object repositories;
- planning for future development of learning objects.

The optimal condition for reaching a common consensus of a definition of a learning object should involve collaboration among learning content providers, researchers, and e-learning practitioners. Thus, future research should be initiated for investigating the opinions, beliefs, and perceptions of e-learning practitioners and researchers with the concept of a learning object, its components, and its relationship with the concept of a lesson.

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