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ABSTRACT

After analyzing the reuse of learning resources from different pedagogical paradigms, this paper argues that there is a gap between the learning technology community and the education community. The pedagogical paradigms described include: tutorial, drill, and practice; case method; goal-based learning; learning by designing; World Wide Web-based role-play simulation; distributed problem-based learning; critical incident-based computer supported learning; role-based simulation; exploratory learning; cognitive tool; and resource-based learning environment. The terms "learning resource" or "learning object" are not native to the education community. The education community is not interested in issues of reuse, grain size, technical properties, or "learning object." The paper suggests that a way forward is to have a clear demarcation of responsibility between learning technologists, subject matter experts, and instructional designers. (Contains 49 references.) (Author/MES)

# What is a learning object, technically?



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**Abstract** After analysing the reuse of learning resources from different pedagogical paradigms, this paper argues that there is an obvious gap between the learning technology community and the education community. The terms "learning resource" or "learning object" are not native to the education community. The education community is not interested in issues of reuse, grain size, technical properties or even "learning object". This paper suggests that a way forward is to have a clear demarcation of responsibility between learning technologist, subject matter experts and instructional designers.

## Introduction

Wiley (2000) noted that there was confusion with the notions associated with the term "learning object". Ip, as cited in Quinn (2000), expressing the frustration said that he was *"still struggling with an operational definition of a learning object".*

## Current Views

The IEEE Learning Technology Standards Committee (LTSC) defines a learning object as *"any entity, digital or non-digital, that can be used, re-used, or referenced during technology supported learning"* (LSTC, 2000). This is extraordinarily broad. This definition implies learning objects can be documents or software components provided they can be of value in a technology supported learning environment. A more defined view was expressed by Frank Farance at the LTSC meeting (on10th August, 1999) where he described learning objects as the result of the association of learning assets (reusable learning resources) with LOM (learning object metadata). He made the point that a learning object is not an object as defined in object oriented programming.

There are other definitions as well. Computer-based training (CBT) vendor NETg, Inc., uses the term "learning object" but applies a three-part definition: a learning objective, a unit of instruction that teaches the objective, and a unit of assessment that measures the objective. (L'Allier, 1998) NETg's definition limits learning object to be passive "reading material" type resource (excluding the possibility that learning object may be interactive requiring computational support). NETg further limits learning object to a special class of resource. Ip, as cited in Quinn (2000), taking input from Lian and Schuyler, suggests that an learning object must have at least 4 sub-components: content, functions, learning objectives and 'look and feel'. Another CBT vendor, Asymetrix, defines learning objects in terms of programming characteristics: "ToolBook II learning objects - pre-scripted elements that simplify programming ... provide instantaneous programming power". (Asymetrix, 2000) The NSF-funded Educational Objects Economy takes a technical approach, only accepting Java Applets as learning objects. (EOE, 2000) It would seem that there are almost as many definitions of the term as there are people employing it.

In addition to the various definitions of the term "learning object," other terms that imply the general intention to take an object-oriented approach to computer-assisted instruction confuse the issue further. SCORM [SCORM, 2001 #205] use the term "content object". David Merrill uses the term "knowledge objects" (Merrill, Li, & Jones, 1991). Merrill is also writing a book on the topic of object-oriented approaches to instruction to be called "Components of Instruction" (Wiley, 2000), which is sure to introduce yet another term: "instructional component". The ARIADNE project uses the term "pedagogical documents" (ARIADNE, 1999). The NSF-funded Educational Software Components of Tomorrow (ESCOT, 2001) project uses the term "educational software components". The Multimedia Educational Resource for Learning and On-Line Teaching (MERLOT) project refers to them as "online learning materials" (MERLOT, 2000). The Apple Learning Interchange simply refers to them as "resources" (ALI, 2000). Finally, Ip used the term "virtual apparatus" to refer to independent educational components which can be combined on a web-page to produce educationally interesting learning. (Ip & Canale, 1996; Ip, Canale, Fritze, & Ji, 1997; Ip & Canale, 1997b; Fritze & Ip, 1998).

On the other hand, there is no reference to the term "learning object" at all in the IMS Content Packaging specification (v1.1) (Young & Riley, 2000).

## Metaphor Used

Many authors (e.g. Mason, Adcock & Ip, 2000) have used the metaphor of LEGO building blocks to describe Learning Objects. The LEGO metaphor conveys the notion of *"small pieces of instruction (the LEGO blocks) that can be assembled (stacked together) into some larger instructional structure (castle or spaceship)."* (Wiley, 1999). Wiley expressed his reservation of the LEGO metaphor as he observed that a random combination of learning objects may not necessarily produce instructionally-sound course material and not all learning objects can be combined together. Wiley, Gibbons, &

Recker (2000) further introduce the notion of "atoms" as a metaphor because while atoms are the smallest units under chemical combination laws, not all atoms can be combined to produce molecules.

### Granularity

The appropriate size of learning object has been another issue addressed by researchers (Quinn, 2000). As stated above, the Learning Technology Standards Committee's definition leaves room for an entire curriculum to be viewed as a learning object, but such a large object view diminishes the possibility of learning object reuse. Wiley et al.(2000) cite an architectural metaphor originally developed by Brand (1994) to shed some light on the issue. This 6-S sequence consists of

- SITE – The physical location that is there forever;
- STRUCTURE – The building foundation and load-bearing elements which lasts the life of the building.
- SKIN – Exterior surfaces redesigned every 20 years or so.
- SERVICES – These include plumbing, communications, electrical wiring, etc. and are replaced every 7 to 15 years.
- SPACE PLAN – The interior layout can change every 3 years or so.
- STUFF – Furniture and equipment can be changes around daily to monthly.

He notes that good design must allow 'slippage' between the layers so that they can be renewed at the end of their lifespan without destroying the entire structure. Based on this layered concept, Wiley et al. (2000) mapped these characteristics into their description of a learning object as Model, Problem, Strategy, Message, Representation and Media. He argued that while these are independent layers, they may be "compressed" into the learning object. The level of granularity could be analysed by counting the number of layers that were present in the learning object. However due to the potential different rate of the aging of different layers, the more layers are compressed into the learning object, the less robust the learning object may be.

While using different terminology and referring to different semantic systems, Wiley and the IMS Content specification both promote the layered approach. The IMS Content Package specification version 1.1 (Young & Riley, 2000) defines the Package Interchange File is a single file, (e.g., .zip, .jar, .cab) which includes a top-level manifest file and all other physical files as identified by the manifest. A Package Interchange File is a concise Web delivery format, a means of transporting related, structured information. Hence a package represents a unit of usable (and reusable) content. This may be part of a course that has instructional relevance outside of its course structure and can be delivered independently, as an entire course or as a collect ion of courses. The mandatory manifest is a description in XML of the resources comprising meaningful instruction. The resources described in the manifest are physical assets such as web pages, media files, text files, assessment objects or other pieces of data in file form. Resources may also include assets that are outside the package but available through an URL, or collections of resources described by sub-manifests. IMS has deliberately avoided the notion of learning objects and uses the term 'resources'.

### Use of Resources In Different Pedagogical Paradigms

Pedagogical paradigms selected here do not form an exhaustive list of contemporary pedagogical frameworks. Rather, they provide indications of the width and breadth of the technical issues as we attempt to understand the issues of reusing learning object s in virtual learning environment design.

#### Tutorial, Drill and Practice

At one end is "drill and practice". At the other end, a tutorial environment provides a mechanism for presenting a problem to the online learners and provides feedback depending on the answer. When appropriately designed, the feedback mechanism can support Laurillard conversation model of higher learning (Laurillard, 1998).

A reusable unit may be an item (consists of the stem which is the question and responses, feedback and scoring information). IMS Question and Testing Interoperability (IMS QTI) specification (Smythe & Shepherd, 2001) is a good candidate for encoding learning resources for reuse in this paradigm. It is designed to support question and test interoperability between different authors, publishers and other corresponding content developers.

Learning engine (Fritze & Ip, 1998; Fritze & McTigue, 1997) is a richer environment for drill and practice by allowing learners to interact with input/output and visualization device. The learner may response to an item by drawing on a graphing device instead of selecting any pre-drawn graphs. The reusable component is both the resource which determines the graph and the software component which acts as the input/output and visualization device. Another software component, Text Analyzing Object (TAO) (Kennedy, Ip, Adams, & Eizenberg, 1999; Kennedy, Ip, Eizenberg, & Adams, 1998) is also a reusable unit which requires software to use and interpret the resource.

#### Case Method

A teaching case is a story describing, or based on, actual events, that justifies careful study and analysis by students. In other words, a teaching case is a story about the "real world" told with a definite teaching purpose in mind. A teaching case is a way of bringing the real world into a classroom so that students can "practice" on actual or realistic problems under the guidance of their teacher. Case teaching, unlike conventional lecturing, is discussion-based and experiential. The teaching case replaces the lecture as the vehicle for learning, and the case becomes the basis for discussion, exchange of ideas, knowledge and experience among participants (Lynn, 1996; Rangan, 1995).

The case method has been practiced in the United States for many decades. It was made famous, first, by Harvard University's Business School and, later, by Harvard University's John F. Kennedy School of Government. Now cases are widely available from these two schools as well as via the World Wide Web from other sources. Obviously, the learning resources are the teaching cases together with all the discussion questions, teaching guide associated with the cases. Proper metadata tagging will promote the discovery of appropriate cases for specific learning situation and themes.

#### Goal-based learning

Goal-based scenarios (GBS) are essentially simulations in which there is a problem to resolve, or a mission to complete. They require learners to assume the main role in the resolution of the problem or the pursuit of their mission (Schank, 1997; Schank, 1990). Hence, goals in this context refer to the successful completion of t he task at hand, and not the achievement of grades. Much of the information and knowledge that is required to achieve this goal is available in the form of video clips with a talking head telling a story from the prospective of practitioners (see Schank & Cleary, 1995). A GBS serves both, to motivate learners and also provide them with the opportunity to learn by doing, by making mistakes, and receiving feedback.

The description of the scenario is obviously a resource that may be reused in other paradigm such as case method. The major challenge in creating GBS is the just-in-time requirement of providing the learners with appropriate resources. This will imply sophisticated metadata tagging in order for the goal-based learning system to locate relevant learning objects efficiently.

In this paradigm, the learning architecture needs to store the learner profile or previous activities in order to advance to different stages of the scenarios as well as providing the just-in-time resources.

**Learning by designing**

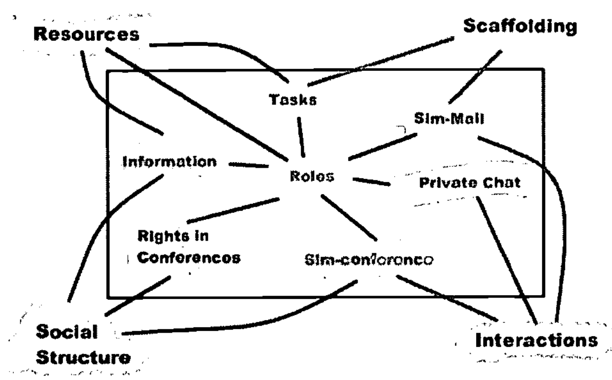
This is an educational context in which the core learning activity is the design of an artifact. Designing as a means for acquiring content knowledge is commonly used in practice-based disciplines such as engineering and architecture (Newstetter, 2000; Hmelo, Holton, & Kolodner, 2000). The obvious benefit of a design task is its inherent situatedness or authenticity. In design-based learning activities, students' understanding is "enacted" through the physical process of conceptualizing and producing something.

When students are creating artifact (digital or otherwise), the learning architecture needs to be able to track the artifacts by automatically applying either embedded or detached metadata for the artifacts. Tanimoto proposed a framework for Distributed Transcripts for Online Learning (Tanimoto, 2001)

Learning objects created by the instructor may not be critical for reuse purposes. The student created artifact may be a source for examples in future run of the course and hence there is reuse value when captured appropriately.

**Web-based role-play simulation**

Role-play simulations are learning situations in which learners take on the role-profiles of specific characters in a contrived educational game. (Linser, Naidu, & Ip, 1999) As a result of playing out roles in a role play simulation, learners are expected to acquire the intended learning outcomes as well as make learning enjoyable. While the underlying belief of web-based role play simulation is similar to goal-based scenario, it differs in both the dynamic nature of the goals during the process as well as the mechanism in supporting learning.




Among other things, stories or cases are used to create an authenticate scenarios. However, other resources, such as specific information provided to different roles to create the information gap among roles, may be specific to this learning environment. Of special interest is the use of real time news (NEF resources (Ip, Morrison, Currie, & Mason, 2000)) or other forms of resources originally created NOT for educational uses. These NEF resources may play an important part in enriching the learning experience. The learning architecture needs to support interchange of information among the learners, especially bi-directional communication capability.

**Distributed problem-based learning**

Problem-based learning (PBL) is an instructional approach that exemplifies authentic learning and emphasizes solving problems in rich contexts. It uses an instructional problem as the principle vehicle. The analysis and study of this problem comprises several phases that are spread over periods of group work and individual study (Barrows & Tamblyn, 1980; Schmidt, 1983; Evensen & Hmelo, 2000). A typical environment (e.g. Liu, Williams, & Pedersen, 1999) that based on PDL will:

(1) Situate the problem in a rich context and allowing learners to engage in scientific inquiries as experts do;
(2) Present the problem with its complexity, yet providing tools to support students in working with complexity;
(3) Provide information in multimedia formats to allow dynamic and interactive presentations that address different learning styles and student needs;
(4) Provide experts' guidance from multiple perspectives to facilitate knowledge acquisition and transfer; and
(5) Emphasize the interrelated nature of knowledge.

Distributed problem-based learning refers to the use of this strategy in a networked computer-supported collaborative environment where face-to-face communication among participants is not essential.
Problems, as learning objects, are resources with specific learning objectives. However, such learning objects would need to be richly linked to other learning objects in order to create the rich context for the problem to have the complexity and authenticity for learners to fully engage in this paradigm. Like web-based role-play simulation, this paradigm requires collaboration support from learning architecture. Unlike web-based role play simulation, most of the current online generic conference features found in LMS will meet the need of this pedagogical design.

**Critical incident-based computer supported learning**

There has been growing interest in building learning environments that focus on supporting groups of learners engaged in reflection on critical incidents from their workplace (Wilson, 1996). A critical incident (from the workplace) presents a learner with a learning opportunity to reflect in and on action. Learners can do this by keeping learning logs which is a record of learning opportunities presented. The critical attribute of the learning log is that it concentrates on the process of learning. It is not a diary of events nor is it a record of work undertaken, rather it is a personal record of the occasions when learning occurred or could have occurred. The learning log also relates prior learning to current practice and is retrospective and reactive in action.

The learning architecture needs to support distributed management of learning logs. Most computer supported collaboration environment would be sufficient to support this type of learning.

**Rule-based simulation**

Microworlds, or computer simulations of restricted environments, are an intuitively appealing way to promote discovery and exploratory learning. Papert (Papert, 1980) called computer supported microworlds "incubators for knowledge" when he described the potential of computer aided learning to encourage exploration and thus self-education by children. His educational philosophies stem from Piaget's work on learning which, simplistically, state that much of children's learning occurs without being taught: children construct their skills and understanding from seeds of knowledge.

Creation of digital microworld for simulation and learning may be one of the most challenging and creative aspect of designing learning objects and learning architecture. Learning objects in this paradigm will be active software component (agent) which interacts with other components in the microworld to model the environment. Efforts in creating interoperability components for use in this environment include Ip & Canale (1996); AgentSheets, E-slate (2000) and ESCOT (2001)

**Exploratory Learning**

Exploratory uses of instructional technology allow students to direct their own learning. Through the process of discovery, or guided discovery, the student learns facts, concepts, and procedures. (Department of Education, 1993) The pedagogical underpinning is closely related to rule-based simulation. The difference is the focus of the exploration. In rule-based simulation, the exploration is restricted within a simulator and the challenge is the creation of the simulation. For exploratory learning, the focus is on information or resource.

In traditional learning environment, the information available to learners (e.g. children in school) have been carefully selected, edited or reworked to meet both the "duty of care" and the learning profiles of the learners. (The school library plays an important role in the selection process.)

However, with the advent of the communication network, resources, including those not originally intended for educational consumption nor for minor, may be available to learners during exploratory learning. (Ip & Naidu, 2001) highlighted the need of rethinking of the issues of availability of material for educational use.

**Cognitive tool**

(Reeves, 1999) suggests two major approaches to using interactive learning systems and programs in education.

First, people can learn "from" interactive learning systems and programs, and second, they can learn "with" interactive learning tools. Learning "from" interactive learning systems is often referred to in terms such as computer-based instruction or integrated learning systems (ILS). Learning "with" interactive software programs, on the other hand, is referred to in terms such as cognitive tools (Lajoie, 1993; Jonassen & Reeves, 1996) and constructivist learning environments. With the use of such "cognitive tools", learners can enter an intellectual partnership with the computer in order to access and interpret information, and organize personal knowledge. Computer-based cognitive tools have been intentionally adapted or developed to function as intellectual partners to enable and facilitate critical thinking and higher order learning.

Typical cognitive tools include databases, spreadsheets, semantic networks, expert systems, concept maps, communications software such as teleconferencing programs, on-line collaborative knowledge construction environments, multimedia/ hypermedia construction software, and computer programming languages.

Learning objects need to be software which support learning. TAO (Kennedy et al., 1999; Kennedy et al., 1998) doubles as a cognitive tool as well.

**Resource-based Learning Environment**

Resource-based Learning Environment (RBLE) emphasizes a transformation of meaning through learner-centered, system-facilitated action. RBLEs support and extend efforts to know, understand, and generate, that is, to reflect, construct, solve problems, and integrate new information for one's own purposes (e.g., curiosity, cognitive dissonance) as well as for others' purposes (e.g., research topic, gain varied perspectives on an issue, solve an assigned problem) (Land & Hannafin, 1996). They provide not only comprehensive collections of highly indexed data, information, and search engines, they help learners to reason, reflect, and assess the veracity of the systems' contents.

Traditionally, special collection of resources in library will provide the starting basic of RBLS. Obviously, indexing and providing efficient discovery of learning resource are of prime importance in this environment.

**Community Gap**

There is an obvious gap between the learning technology community and the education community. We have identified the reuse potential of material in some pedagogical paradigms and used the terms "learning resource" or "learning object" loosely. However, we must acknowledge that such terms are not native to the education community. The issues of reuse, grain size, technical properties or even the basic question of "what is a learning object?" are not central issues in the education community. In the recent years, there are "external" environmental changes (e.g. see Ip & Canale, 1997a) which forced many educators (a lot of them screaming and kicking while some happily embrace) to work in a digital learning environment. While the learning technology community is struggling to understand the issues in the education community, they are also creating new terms attempting to encapsulate the newly acquired understanding, but in the technologist's language. For example, the term "learning object", borrowing from object oriented design paradigm we presume, tries to encapsulate the concept of granularity and reuse of material. Frankly, "learning object" makes no sense to the education community.

Our current understanding of "learning object" is like the three blind men's understanding of the elephant.

Should we focus on discovery of learning material and declare learning object is learning asset plus metadata (LOM) - and ignore the other issues of learning asset?

Should we take an "information shoveling" view on learning and teaching and satisfy ourselves with material which are only to be read, focusing on identifying the sub-structure of such material (e.g. learning objectives, competency levels etc) - and ignore the other issues?

Learning object issues are concerned with developing technical systems to meet education and training needs. On the other hand, any system pertaining to deliver learning and training must express its technical construct in the jargon and concepts of instructional design and pedagogical theories. Unfortunately learning and training are complex environments with many stakeholders including learners, instructors, courseware designers or instructional designers and education managers. Even within the stakeholder group called broadly as instructional designers, the pedagogical paradigms reviewed above show as much gap among the paradigms embraced by the participants as the gap between learning technology community and education community. This presents great difficulty for learning technology community to encapsulate and operationalise any of these concepts (if we are lucky to be able to identify them) in the technical design of a generic learning object framework. Is there ONE learning environment which can satisfy all needs?

There is value in taking a more pragmatic approach. Instead of trying to create a framework to enable interoperability and reuse of learning objects across different pedagogical paradigms, we focus on creating a supporting technical infrastructure to enable interoperability and reuse of resources within specific pedagogical paradigms. We have reviewed the ways educators use resources in different pedagogical paradigms. Summarising, these might include

- specifically written up reading material (e.g. cases in case method teaching, problems in problem-based learning)
- reading resources originally created for other purposes (e.g. initial scenario in web-based role play simulation, resources in exploratory learning and resource-based learning)
- multimedia resource used to supply content and convey authentic situations and a sense of authority (e.g. video clips used in goal base learning)
- structured resources designed to be used in some interactive manners (items in tutorial, drill and practice)
- other structured resources which require special software in order to work in an educationally meaningful context, such as those special questions in text analysis object (TAO) which also acts as like a cognitive tool.

Three observations may be made here.

Firstly, an "information shoveling" model for learning and training is not an acceptable generalised learning model for the informed education practitioners. The paradigms reviewed above indicate quite different technical systems for delivery based on each of the paradigm. One size does not fit all.

Secondly, we need a distinction between learning material and teaching material. Risking of the guilt of stating the obvious, learning material refers to material that is used by the learners and teaching material is material used by teachers. A general framework of educational resources, disregarding the differences between use by learner and by teacher, does not help us much here. While any teaching resource has obvious reuse values, teaching resource deserves a separate technical framework to support interoperability and reuse. In the current paper, we focus on learning resources only.

Lastly, while reading is a major activity, learning resources are more than just reading material. The ability to support appropriate interaction is important. The current finding is in line with a previous work by Ip & Canale (1997). They identified the need of different skills in creating digital learning objects and argued for a clear demarcation of responsibilities among instructional designers, subject matter experts and software designers. They emphasized that content and functionality are two independent, orthogonal concepts and should not be mixed. Content, contributed mainly by subject matter experts, can be encoded as structured and unstructured resources. Unstructured content can be rendered by generic software such as the web browser or popular plug-ins. Functionality is provided by software (referred to as rendering software) which is necessary to take the structured resource and provide interactivity in an educational environment.

By enforcing the distinct nature of content and functionality, Ip & Canale's view supports a two-tier courseware development workflow with a production and consumption relationship. Software developers, who work with bits and bytes, produce rendering software for subject matter expert's consumption. Some generic rendering software can be used by different subject matter experts for unstructured material or some commonly known structured material such as some objective testing resources. On the other hand, for any interactivity, any subject matter expert can choose from a range of rendering software from different developers, or may choose to develop the rendering software themselves if they are willing to invest the effort and time! When sufficient rendering software is available, a significant part of courseware development effort would be reduced to a choose-and-pick exercise and hence will result in a lowering of cost and improvement in quality.

So, what is a learning object? Learning material plus LOM plus optional appropriate rendering software?

## Conclusion

The observation, identification and acknowledgement of the need of specialised rendering software in different pedagogical paradigms force us to re-conceptualise the underlying meaning of the notion of learning object and question the relationship between learning technology community and education community.

Is learning object the rendering software? Is learning object the content? Can we and should we combine the concepts of content and rendering? When we are talking about interoperability, what do we want to interoperable? Rendering software? Content? When we are talking about reuse, do we mean use of the same content (unchanged) by educators coming from different pedagogical paradigms? Or only supporting reuse for those sharing the same pedagogical beliefs?

What are the values underlying the current focus of the learning technology community on issue such as reuse, grain size and technical properties? Are these values driven by economical reasons or desire to improve to learning opportunities and outcomes?

This paper analyses the potential of reuse of learning resources from different pedagogical paradigms Ip & Canale's approach, a clear demarcation of responsibility of subject matter expert, instructional designer and software developer, will empower educators to create more innovative educational courseware.

We started with a question: What is a learning object, technically? It seems that we finish with more questions than we have started.

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