

Connecting learning objects to instructional design theory:

A definition, a metaphor, and a taxonomy

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The purpose of this chapter is to introduce an instructional technology concept known commonly as the “learning object.” First a review of the literature is presented as groundwork for a working definition of the term “learning object.” A brief discussion of instructional design theory is followed by an attempt to connect the learning objects approach to existing instructional design theory, and the general lack of such connective efforts is contrasted with the financial and technical activity generated by the learning objects notion. The LEGO metaphor frequently used to describe learning objects is critically examined and a successor metaphor is nominated. A taxonomy of learning object types is presented as a foundation for continued research in learning objects and related instructional design theories. Finally, the connecting of instructional design theory to the taxonomy is demonstrated and the benefits of this approach are briefly espoused. This introduction should provide the reader with a context for interpreting the remaining chapters of this book.

What is a learning object?

Technology is an agent of change, and major technological innovations can result in entire paradigm shifts. The computer network known as the Internet is one such innovation. After affecting sweeping changes in the way people communicate and do business, the Internet is poised to bring about a paradigm shift in the way people learn. Consequently, a major change may also be coming in the way educational materials are designed, developed, and delivered to those who wish to learn. An instructional technology called “learning objects” (LTSC, 2000a) currently leads other candidates for

the position of technology of choice in the next generation of instructional design, development, and delivery, due to its potential for reusability, generativity, adaptability, and scalability (Hodgins, 2000; Urdan & Weggen, 2000; Gibbons, Nelson, & Richards, 2000).

Learning objects are elements of a new type of computer-based instruction grounded in the object-oriented paradigm of computer science. Object-orientation highly values the creation of components (called “objects”) that can be reused (Dahl & Nygaard, 1966) in multiple contexts. This is the fundamental idea behind learning objects: instructional designers can build small (relative to the size of an entire course) instructional components that can be reused a number of times in different learning contexts. Additionally, learning objects are generally understood to be digital entities deliverable over the Internet, meaning that any number of people can access and use them simultaneously (as opposed to traditional instructional media, such as an overhead or video tape, which can only exist in one place at a time). Moreover, those who incorporate learning objects can collaborate on and benefit immediately from new versions. These are significant differences between learning objects and other instructional media that have existed previously.

Supporting the notion of small, reusable chunks of instructional media, Reigeluth and Nelson (1997) suggest that when teachers first gain access to instructional materials, they often break the materials down into their constituent parts. They then reassemble these parts in ways that support their individual instructional goals. This suggests one reason why reusable instructional components, or learning objects, may provide instructional benefits: if instructors received instructional resources as individual

components, this initial step of decomposition could be bypassed, potentially increasing the speed and efficiency of instructional development.

To facilitate the widespread adoption of the learning objects approach, the Learning Technology Standards Committee (LTSC) of the Institute of Electrical and Electronics Engineers (IEEE) formed in 1996 to develop and promote instructional technology standards (LTSC, 2000a). Without such standards, universities, corporations, and other organizations around the world would have no way of assuring the interoperability of their instructional technologies, specifically their learning objects. A similar project called the Alliance of Remote Instructional Authoring and Distribution Networks for Europe (ARIADNE) had already started with the financial support of the European Union Commission (ARIADNE, 2000). At the same time, another venture called the Instructional Management Systems (IMS) Project was just beginning in the United States, with funding from Educom (IMS, 2000a). Each of these and other organizations (e.g., ADL, 2000) began developing technical standards to support the broad deployment of learning objects. Many of these local standards efforts have representatives on the LTSC group.

The Learning Technology Standards Committee chose the term “learning objects” (possibly from Wayne Hodgins’ 1994 use of the term in the title of the CedMA working group called “Learning Architectures, API’s, and Learning Objects”) to describe these small instructional components, established a working group, and provided a working definition:

Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. Examples of

technology-supported learning include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning (LOM, 2000).

This definition is extremely broad, and upon examination fails to exclude any person, place, thing, or idea that has existed at anytime in the history of the universe, since any of these could be “referenced during technology supported learning.”

Accordingly, different groups outside the Learning Technology Standards Committee have created different terms that generally narrow the scope of the canonical definition down to something more specific. Other groups have refined the definition but continue to use the term “learning object.” Confusingly, these additional terms and differently defined “learning objects” are all Learning Technology Standards Committee “learning objects” in the strictest sense.

The proliferation of definitions for the term “learning object” makes communication confusing and difficult. For example, computer-based training (CBT) vendor NETg, Inc., uses the term “NETg 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). 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. David Merrill uses the term “knowledge objects” (Merrill, Li, and Jones, 1991). Merrill is also writing a book on the topic of object-oriented approaches to instruction to be called “Components of Instruction” (personal communication, March 21, 2000), which is sure to introduce yet another term, “instructional component,” into the instructional design vernacular. The previously mentioned ARIADNE project uses the term “pedagogical documents” (ARIADNE, 2000). The NSF-funded Educational Software Components of Tomorrow (ESCOT) project uses the term “educational software components” (ESCOT, 2000), while the Multimedia Educational Resource for Learning and On-Line Teaching (MERLOT) project refers to them as “online learning materials” (MERLOT, 2000). Finally, the Apple Learning Interchange simply refers to them as “resources” (ALI, 2000).

Depressingly, while each of these is something different, they all conform to the Learning Technology Standards Committee’s “learning object” definition. An in depth discussion of the precise meanings of each of these terms would not add to the main point of this discussion: the field is still struggling to come to grips with the question, “What is a learning object?”

This terminological confusion forces any introductory chapter on the topic to answer the question, “So what is a learning object?” The Learning Technology Standards

Committee definition seems too broad to be useful, since most instructional technologists would not consider the historical event “the war of 1812” or the historical figure “Joan of Arc” to be learning objects. At the same time, the creation of yet another term only seems to add to the confusion. While the creation of a satisfactory definition of the term learning object will probably consume the better part of the author’s career, a working definition must be presented before the discussion can proceed. Therefore, this chapter will define a learning object as “any digital resource that can be reused to support learning.” This definition includes anything that can be delivered across the network on demand, be it large or small. Examples of smaller reusable digital resources include digital images or photos, live data feeds (like stock tickers), live or prerecorded video or audio snippets, small bits of text, animations, and smaller web-delivered applications, like a Java calculator. Examples of larger reusable digital resources include entire web pages that combine text, images and other media or applications to deliver complete experiences, such as a complete instructional event. This definition of learning object, “any digital resource that can be reused to support learning,” is proposed for two reasons.

First, the definition is sufficiently narrow to define a reasonably homogeneous set of things: reusable digital resources. At the same time, the definition is broad enough to include the estimated 15 terabytes of information available on the publicly accessible Internet (Internet Newsroom, 1999).

Second, the proposed definition is based on the LTSC definition (and defines a proper subset of learning objects as defined by the LTSC), making issues of compatibility of learning object as defined within this chapter and learning object as defined by the LTSC explicit. The proposed definition captures what the author feels to be the critical

attributes of a learning object, “reusable,” “digital,” “resource,” and “learning,” as does the LTSC definition. With that compatibility made explicit, the proposed definition differs from the LTSC definition in two important ways.

First, the definition explicitly rejects non-digital (by dropping the word and dropping the idea of a learning object being simply "reference"-able) and non-reusable (by dropping the phrase "used or" which seems to imply the acceptance of single use) resources. The definition of learning object presented in this chapter does not include actual people, historical events, books (in the traditional sense of the term), or other discrete, physical objects. The definition also drops the phrase "technology supported" which is now implicit, because all learning objects are digital.

Second, the phrase "to support" has been substituted in place of "during" in the LTSC definition. Use of an object "during" learning doesn't connect its use to learning. The LTSC definition implies that nothing more than contiguity of an object's use and the occurrence of learning is sufficient, meaning that a banner advertisement atop an online course web page would be a legitimate learning object. The definition adopted for this chapter emphasizes the purposeful use (by either an instructional designer, an instructor, or a student) of these objects to support learning.

Armed with a working definition of the term learning object, the discussion of the instructional use of learning objects can proceed.

Instructional design theory and learning objects

Instructional design theories have been overviewed frequently in the literature (Dijkstra, Seel, Schott, & Tennyson, 1997; Reigeluth 1983, 1999b; Tennyson, Schott, Seel, & Dijkstra, 1997). Reigeluth (1999a) defines instructional design theory as follows:

[I]nstructional design theories are design oriented, they describe methods of instruction and the situations in which those methods should be used, the methods can be broken into simpler component methods, and the methods are probabilistic. (p. 7)

Reigeluth's current definition of design theory as prescriptive theory follows earlier definitions of design theory (Simon, 1969; Snelbecker, 1974; Reigeluth, 1983). Because the very definition of "theory" in some fields is "descriptive," design theories are commonly confused with other types of theories that they are not, including learning theory and curriculum theory (Reigeluth, 1999a).

Instructional design theory, or instructional strategies and criteria for their application, must play a large role in the application of learning objects if they are to succeed in facilitating learning. This statement echoes Reigeluth and Frick's (1999) call, "more [instructional design] theories are sorely needed to provide guidance for ... the use of new information technology tools" (p. 633). The following discussion takes a step in this direction, by recasting two of the largest issues in the learning objects area – combination and granularity – in instructional design terms.

Combination. While groups like the Learning Technology Standards Committee exist to 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 around the instructional design implications of learning objects.

Indicative of this lack of thought about instructional design is item 7(d) of the Learning Objects Metadata Working Group's (a working group of the Learning

Technology Standards Committee) Project Authorization Request (PAR) form (LTSC, 2000b). The PAR is the mechanism by which IEEE projects are officially requested and approved, and must contain statements of the project's scope and purpose. Section 7 of the PAR deals with the purpose of the proposed project, and item (d) in the Learning Objects Metadata Working Group's PAR (LOM, 2000) reads as follows:

To enable computer agents to automatically and dynamically compose personalized lessons for an individual learner.

As the Learning Object Metadata standard neared finalization in early 2000, some questions were raised regarding the current standard's ability to achieve this purpose. Apparently no one had considered the role of instructional design in composing and personalizing lessons. If the reader will pardon a brief digression, at this point a brief discussion of metadata, the focus of the Learning Object Metadata Working Group's efforts, is necessary.

Metadata, literally "data about data," is descriptive information about a resource. For example, the card catalog in a public library is a collection of metadata. In the case of the card catalog, the metadata are the information stored on the cards about the Author, Title, and Publication Date of the book or resource (recording, etc.) in question. The labels on cans of soup are another example of metadata: they contain a list of Ingredients, the Name of the soup, the Production Facility where the soup was canned, etc. In both the case of the library book and the can of soup, metadata allow you to locate an item very quickly without investigating all the individual items through which you are searching. Imagine trying to locate *Paradise Lost* by sifting through every book in the library, or looking for chicken soup by opening every can of soup in the store and inspecting their

contents! The Learning Objects Metadata Working Group is working to create metadata for learning objects (such as Title, Author, Version, Format, etc.) so that people and computers will be able to find objects by searching, as opposed to browsing the entire digital library one object at a time until they find a satisfying one.

The problem with 7(d) arose when people began to actually consider what it meant for a computer to “automatically and dynamically compose personalized lessons.” This meant taking individual learning objects and combining them in a way that made instructional sense, or in instructional design terminology, “sequencing” the learning objects. It seemed clear to some that in order for a computer to make sequencing or any other instructional design decisions, the computer must have access to instructional design information to support the decision-making process. The problem was that no instructional design information was included in the metadata specified by the current version of the Learning Objects Metadata Working Group standard.

The lack of instructional design discussion at this standards-setting level of conversation about learning objects is disturbing, because it might indicate a trend. One can easily imagine technology implementers asking, “if the standards bodies haven’t worried about sequencing, why should we?” Once technology or software that does not support an instructionally-grounded approach to learning object sequencing is completed and shipped to the average teacher, why would he or she respond any differently? This sets the stage for learning objects to be used simply to glorify online instruction, the way clip-art and dingbats are used in a frequently unprincipled manner to decorate elementary school newsletters. Wiley (1999) called this “the new CAI – ‘Clip Art Instruction’” (p.

6). Obviously, instructionally grounded sequencing decisions are at the heart of the instructionally successful use of learning objects.

Granularity. Discussion of the problem of combining learning objects in terms of “sequencing” leads to another connection between learning objects and instructional design theory. The most difficult problem facing the designers of learning objects is that of “granularity” (Wiley, et al., 1999). How big should a learning object be? 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. Reuse is the core of the learning object notion, as generativity, adaptivity, and other –ivities are all facilitated by the property of reuse. This is why a more restrictive definition has been proposed in this chapter.

Lest the answer seem too straightforward, because learning objects commonly require the creation of metadata (which can mean filling out a form of twenty-some odd fields like “Semantic Density”), designating every individual graphic and paragraph of text within a curriculum a “learning object” can be prohibitively expensive. From an “efficiency” point of view, the decision regarding learning object granularity can be viewed as a trade-off between the possible benefits of reuse and the expense of cataloging. From an instructional point of view, alternatively, the decision between how much or how little to include in a learning object can be viewed as a problem of “scope.” While reality dictates that financial and other factors must be considered, if learning is to have its greatest chance of occurring, decisions regarding the scope of learning objects must also be made in an instructionally grounded, principled manner.

Viewed in this manner, the major issues facing would-be employers of learning objects, granularity and combination, turn out to be perhaps the two considerations known best to instructional designers: scope and sequence. There are a number of existing instructional design theories that provide explicit scope and sequencing support that, while not intended to be, are applicable to learning objects. Reigeluth's Elaboration Theory (Reigeluth, 1999b), van Merriënboer's Four-component Instructional Design model (van Merriënboer, 1997), and Gibbons and his colleagues' Work Model Synthesis approach (Gibbons et al., 1995) come to mind, among others. Wiley (2000) recently synthesized these and other instructional design theories into a learning object-specific instructional design theory, called Learning Object Design and Sequencing Theory.

Interest in the learning objects idea

Even without a strong commitment to instructional principles on the part of standards bodies, there has been a considerable investment in the idea of learning objects. The IMS Project, which develops and promotes compliance with technical specifications for online learning, was until recently funded by memberships. The highest level of participation, "Contributing Member," was associated with an annual fee of \$50,000, retroactive to the project's beginning. Over 30 vendors, universities, and other organizations belonged to this program (IMS, 2000b) whose membership list reads like a who's who of software developers and high-powered organizations: Microsoft, Oracle, Sun, Macromedia, Apple, IBM, UNISYS, the U.S. Department of Defense, the U.S. Department of Labor, the California State Universities, International Thompson Publishing, and Educational Testing Service, to name a few. The next level of

membership down, the “Developers Network,” has over 200 members, most of which are universities.

Additionally, a report released by investment banking firm W. R. Hambrecht contains more than the common predictions for the future of online learning, for example, that the online learning market will reach \$11.5 billion by 2003 (Urdan & Weggen, 2000). As evidenced in the report, even brokers are talking about learning objects and encouraging investors to make sure that the e-learning companies they buy rely on the technology:

[Online learning content] development cycles are predicted to shorten by 20% every year to two or three weeks by 2004. This imperative will drive more template-based designs and fewer custom graphics. Learning objects will be created in smaller chunks and reusable formats. As a consequence, the industry will become more efficient and competitive... We are convinced that the move to defined, open standards is crucial to the continuing successful adoption of e-learning, especially as it begins to transition beyond early adopters into the rapid growth phase of the market. Authoring tools will need to operate across different platforms and communicate with other tools used to build learning systems.

Content and courseware must be reusable, interoperable, and easily manageable at many different levels of complexity throughout the online instructional environment. Enterprise learning systems have to accommodate numerous and varied learner requirements, needs, and objectives. Corporate customers need to be able to easily track content created by multiple content providers through one training management system and search vast local or distributed catalogs of

content to identify learning objects or modules on a particular topic. The race for education technology standards is on (Urduan & Weggen, 2000, p.16).

Whether or not the learning object paradigm is grounded in the best instructional theory currently available, there can be little doubt that the United States and the world (the ARIADNE coalition has a similar list of European members) are about to be flooded with learning object-based tools. Microsoft has already released a toolset it touts as “the first commercial application of work being delivered by the Instructional Management System (IMS) Project” (Microsoft, 2000). Recognition, adoption, and the potential for future support for the learning objects idea is significant, and includes some of the biggest players in software, higher education, and even investment. Learning objects seemed to be poised to become *the* instructional technology of online learning. However, technical standards and venture capital are not enough to promote learning. In order to promote learning, technology use should be guided by instructional principles.

The post-LEGO learning object

From its genesis, the learning object community has used metaphors to explain the learning objects concept to the uninitiated. Learning objects and their behavior have been likened to LEGOs, Lincoln Logs, and other children’s toys in a twofold effort to (1) communicate the basic idea and (2) put a friendly, familiar face on a new instructional technology. These analogies continue to serve their intended purpose of giving those new to the idea an easy way of understanding what we are trying to do: create small pieces of instruction (LEGOs) that can be assembled (stacked together) into some larger instructional structure (castle) and reused in other instructional structures (e.g., a spaceship). Unfortunately, the metaphor has taken on a life of its own. Instead of serving

as a quick and dirty introduction to an area of work, this overly simplistic way of talking about things seems to have become the method of expression of choice for those working at the very edge of our field -- even when speaking to each other. This point was driven home recently at a conference of a professional educational technology organization, where the LEGO metaphor was referred to in every presentation on learning objects, and even those on related topics such as metadata.

The problem with this ingraining of the LEGO metaphor is the potential degree to which it could control and limit the way people think about learning objects. Consider the following properties of a LEGO block:

- Any LEGO block is combinable with any other LEGO block.
- LEGO blocks can be assembled in any manner you choose.
- LEGO blocks are so fun and simple that even children can put them together.

The implicit assumption, conveyed by the metaphor, that these three properties are also properties of learning objects is needlessly restricting some people's views of what a learning object could potentially be and do. It is the author's belief that a system of learning objects with these three properties cannot produce anything more instructionally useful than LEGOs themselves can. And if what results from the combination of learning objects is not instructionally useful, the combination has failed regardless of whatever else it may do. The recommendation of another metaphor seems necessary.

Instead of making something artificial (like a LEGO) the international symbol for learning object, let us try something that occurs naturally, something about which we already know a great deal. This should jump start our understanding of learning objects

and the way they are put together into instructionally meaningful units. Let us try the atom as a new metaphor.

An atom is a small "thing" that can be combined and recombined with other atoms to form larger "things." This seems to capture the major meaning conveyed by the LEGO metaphor. However, the atom metaphor departs from the LEGO metaphor in some extremely significant ways:

- Not every atom is combinable with every other atom.
- Atoms can only be assembled in certain structures prescribed by their own internal structure.
- Some training is required in order to assemble atoms.

The implications of these differences are significant. The task of creating a useful, real-world learning object system is complicated enough without the requirement inherited from LEGO-type thinking that each and every learning object be compatible (or combinable) with every other learning object. This requirement is naïve and oversimplistic, and if enforced may keep learning objects from ever being instructionally useful.

The task of creating a useful learning object system is also hindered by the idea that learning objects need to be combinable in any manner one chooses. (According to <http://www.lego.com/>, six of the standard 2x4 LEGO blocks can be combined in 102,981,500 ways.) This is what is currently touted as "theory neutrality." Software vendors and standards bodies describe their learning object related work as being "instructional theory neutral." Were this the case all would be well in learning object land. Problematically, a more accurate description of their products is "instructional

theory agnostic,” or in other words, “we don't know if you're employing an instructional theory or not, and we don't care.” As stated above, it is very likely that the combination of learning objects in the absence of any instructional theory will result in larger structures that fail to be instructionally useful.

Finally, the task of creating a useful learning object system is stuck in the idea that anyone should be able to open a box of learning objects and have fun assembling them with their three-year-old. While the assembly of learning objects should not be made any more difficult than necessary, the notion that any system developed should be so simple that anyone can successfully use it without training seems overly restrictive. It prevents learning objects-based instructional design research from reaching Simon's (1969) ideal of being “intellectually tough, analytic, formalizable, and teachable.” It seems to prevent the field from making any cumulative, scientific progress.

Worse yet, the three “LEGO properties” of learning objects point toward a possible trend: the tendency to treat learning objects like components of a knowledge management system (perhaps the term “information objects” would be appropriate). While no two people may ever reach a common definition of instruction, most would agree that instruction is more than information, as Merrill is so fond of reminding us. This type of thinking manifests itself as people equate learning objects with “content objects” to the exclusion of “logic objects” and “application objects,” for example.

If we take atoms as the new learning object metaphor, questions that were once difficult to answer become transparent. For example, take the question mentioned previously, “what degree of granularity is the most appropriate for instructionally effective learning object combination?” One answer can be found by examining the atom

metaphor more closely. (While pushing a metaphor is risky business, because all metaphors break down at some point, it can be useful as a properly contextualized educational exercise.)

It is commonly accepted that atoms are not the smallest bits of stuff in the universe. Atoms are, in fact, combinations of smaller bits (neutrons, protons, and electrons), which are combinations of smaller bits (baryons and mesons), which are combinations of even smaller bits (quarks, anti-quarks, and gluons), etc. It is the particular manner in which these top-level bits (neutrons, protons, and electrons) are combined in an individual atom that determines which other atoms a particular atom can bond with. In other words, it is the structure of the combination that determines what other structures the combination is compatible with, much the way the shape of a puzzle piece determines where in the puzzle it may be placed.

Applying this to learning objects, it seems that smaller bits (i.e., learning objects of a finer grain size) may be combined into structures that promote one learning object's combination with a second, while the same structure prevents the first object's combination with a third. One answer to the question, "what degree of granularity is the most appropriate for instructionally effective learning object combination?" suggested by the atom metaphor is, then, the level of aggregation at which the learning objects display this structural bonding characteristic. From a constructivist point of view, which promotes learning within a rich context (Duffy & Cunningham, 1996), this could be interpreted as meaning that learning objects should be internally contextualized to a certain degree – a degree that promotes their contextualization (combination) with a

closed set of other learning objects, while simultaneously preventing their combination with other learning objects.

Atomic bonding is a fairly precise science, and although the theories that explain it are well understood (albeit probabilistically) at the macro-level of neutrons, protons and electrons, they are understood less well at the levels of the smaller bits. While the smaller bits are an area of curiosity and investigation, this does not prevent fruitful work from occurring at the macro-level. Similarly, instructional design theories function probabilistically at a high level, while less is understood about the exact details of the smaller instructional bits. Here again, however, fruitful work continues to occur at the higher level while lower level explorations are being carried out. It should be obvious at this point that a person without understanding of instructional design has no more hope of successfully combining learning objects into instruction than a person without an understanding of chemistry has of successfully forming a crystal. Rather than thinking about LEGOs or Lincoln Logs, perhaps our minds should be pointed toward something like a "learning crystal," in which individual learning objects are combined into an instructionally useful, and to some degree *inherent*, structure.

The role of taxonomy development

The discussion of learning object characteristics, such as sequence, scope, and structure, leads one to consider what different types of learning objects might exist. In other words, can types of learning objects be meaningfully differentiated? Taxonomy development has historically accompanied instructional design theories (Bloom, 1956; Gagne, Briggs, and Wager, 1992), and is recommended by Richey (1986) and Nelson (1998) in their instructional design theory development approaches. According to Richey

(1986), the development of conceptual models such as taxonomies serves to “identify and organize the relevant variables; defining, explaining, and describing relationships among the variables” (p. 26-27).

While object categorizations exist specific to particular instructional design theories, such as Merrill’s (Merrill, Li, and Jones, 1991) sets of process, entity, and activity classifications, a general learning object taxonomy compatible with multiple instructional design theories does not exist. The lack of such a broadly applicable taxonomy significantly hinders the application of the learning object to existing instructional design theories, as current practice has been to create theory-specific taxonomies to support each implementation (Merrill, Li, and Jones, 1991; L’Allier, 1998), considerably increasing the time, resource, and effort necessary to employ learning objects. The rest of this chapter will present a general taxonomy of learning object types.

A taxonomy learning object types

All learning objects have certain qualities. It is the difference in the degree to which (or manner in which) they exhibit these qualities that makes one type of learning object different from another. The following taxonomy differentiates between five learning object types. Examples of these five object types are given below, followed by the taxonomy, which explicates their differences and similarities.

- *Fundamental* - For example, a JPEG of a hand playing a chord on a piano keyboard.
- *Combined-closed* - For example, a video of a hand playing an arpeggiated chord on a piano keyboard with accompanying audio.

- *Combined-open* - For example, a web page dynamically combining the previously mentioned JPEG and QuickTime file together with textual material “on the fly.”
- *Generative-presentation* - For example, a JAVA applet capable of graphically generating a set of staff, clef, and notes, and then positioning them appropriately to present a chord identification problem to a student.
- *Generative-instructional* - For example, an EXECUTE instructional transaction shell (Merrill, 1999), which both instructs and provides practice for any type of procedure, for example, the process of chord root, quality, and inversion identification.

Distinguishing between the learning object types is a matter of identifying the manner in which the object to be classified exhibits certain characteristics. These characteristics are critical attributes and are stable across environmentally disparate instances (e.g., the properties remain the same whether or not the learning objects reside in a digital library). Table 1 presents the taxonomy. The purpose of the taxonomy is to differentiate possible types of learning objects available *for use in instructional design*. This taxonomy is not exhaustive in that it includes only learning object types that facilitate high degrees of reuse. Other types of learning objects that hamper or practically prevent reuse, (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. Finally, the taxonomy's characteristics' values (such as High, Medium, and Low) are purposefully fuzzy, as the taxonomy is meant to facilitate inter-object comparison, and not to provide independent metrics for classifying learning objects out of context (such as file size in kilobytes). Table 1 is followed by a more in

depth discussion of each of the characteristics of learning objects and a discussion of the learning object types themselves.

Table 1. Preliminary Taxonomy of Learning Object Types.

Learning Object Characteristic	Fundamental Learning Object	Combined-closed Learning Object	Combined-open Learning Object	Generative-presentation Learning Object	Generative-instructional Learning Object
Number of elements combined	One	Few	Many	Few - Many	Few - Many
Type of objects contained	Single	Single, Combined-closed	All	Single, Combined-closed	Single, Combined-closed, Generative-presentation
Reusable component objects	(Not applicable)	No	Yes	Yes / No	Yes / No
Common function	Exhibit, display	Pre-designed instruction or practice	Pre-designed instruction and / or practice	Exhibit, display	Computer-generated instruction and / or practice
Extra-object dependence	No	No	Yes	Yes / No	Yes
Type of logic contained in object	(Not applicable)	None, or answer sheet-based item scoring	None, or domain-specific instructional and assessment strategies	Domain-specific presentation strategies	Domain-independent presentation, instructional, and assessment strategies
Potential for inter-contextual reuse	High	Medium	Low	High	High
Potential for intra-contextual reuse	Low	Low	Medium	High	High

Learning object characteristics. The characteristics in Table 1 are described below.

- *Number of elements combined* – Describes the number of individual elements (such as video clips, images, etc.) combined in order to make the learning object.
- *Type of objects contained* – Describes the type of learning objects that may be combined to form a new learning object.
- *Reusable component objects* – Describes whether or not a learning object's constituent objects may be individually accessed and reused in new learning contexts.
- *Common function* – Describes the manner in which the learning object type is generally used.
- *Extra-object dependence* – Describes whether the learning object needs information (such as location on the network) about learning objects other than itself.
- *Type of logic contained in object*– Describes the common function of algorithms and procedures within the learning object.
- *Potential for inter-contextual reuse* – Describes the number of different learning contexts in which the learning object might be used, that is, the object's potential for reuse in different content areas or domains.
- *Potential for intra-contextual reuse* – Describes the number of times the learning object might be reused within the same content area or domain.

Learning object type definitions. The five types of learning objects have been exemplified and their characteristics have been described. While the creation of strict

definitions for these types is an ongoing effort, the author's current best thinking with regard to definitions of each type is captured below.

- *Fundamental* – An individual digital resource uncombined with any other, the fundamental learning object is generally a visual (or other) aid that serves an exhibit or example function (Wiley & Nelson, 1998).
- *Combined-closed* – A small number of digital resources combined at design time by the learning object's creator, whose constituent learning objects are not individually accessible for reuse (recoverable) from the Combined-closed learning object itself. A video clip exemplifies this definition, as still images and an audio track are combined in a manner which renders these constituent pieces unrecoverable (or, at least difficult to recover). The Combined-closed learning object may contain limited logic (e.g., the ability to perform answer sheet-referenced item scoring) but should not contain complex internal logic (e.g., the capacity to intelligently grade a set of item forms or case types) since this valuable capability would not be reusable in other learning objects. Combined-closed learning objects are generally single purpose, that is, they provide either instruction or practice.
- *Combined-open* – A larger number of digital resources combined by a computer in real-time when a request for the object is made, whose constituent learning objects are directly accessible for reuse (recoverable) from the Combined-open object. A webpage exemplifies this definition, as its component images, video clips, text, and other media exist in reusable format and are combined into a learning object at request-time. Combined-open learning objects frequently

combine related instructional and practice-providing Combined-closed and Fundamental objects in order to create a complete instructional unit.

- *Generative-presentation* – Logic and structure for combining or generating and combining lower-level learning objects (Fundamental and Combined-closed types). Generative-presentation learning objects can either draw on network-accessible objects and combine them, or generate (e.g., draw) objects and combine them to create presentations for use in reference, instruction, practice, and testing. (Generative-presentation learning objects must be able to pass messages to other objects with assessment logic when used in practice or testing). While Generative-presentation learning objects have high intra-contextual reusability (they can be used over and over again in similar contexts), they have relatively low inter-contextual reusability (use in domains other than that for which they were designed).
- *Generative-instructional* – Logic and structure for combining learning objects (Fundamental, Combined-closed types, and Generative-presentation) and evaluating student interactions with those combinations, created to support the instantiation of abstract instructional strategies (such as "remember and perform a series of steps"). The transaction shells of Merrill's Instructional Transaction Theory (Merrill, 1999) would be classified as Generative-instructional learning objects. The Generative-instructional learning object is high in both intra-contextual and inter-contextual reusability.

Connecting learning objects to instructional design theory

The main theme of this chapter has been that instructional design theory must be incorporated in any learning object implementation that aspires to facilitate learning. The taxonomy of learning object types presented in this chapter is instructional design theory-neutral, making it compatible with practically any instructional design theory. (The taxonomy's explicit references to domain-dependent and domain-independent presentation, instruction, and assessment logic, which must come from somewhere, keep it from being instructional theory agnostic.)

Wiley (2000) posited and presented three components of a successful learning object implementation: an instructional design theory, a learning object taxonomy, and “prescriptive linking material” that connects the instructional design theory to the taxonomy, providing guidance of the type “for this type of learning goal, use this type of learning object.” In addition to providing a worked example of this process, Wiley (2000) also presented design guidelines for the five learning object types.

Previously, any person or organization who wanted to employ learning objects in their instructional design and delivery was required to either create their own taxonomy of learning object types or work in an *ad hoc*, frequently higgledy-piggledy manner. Taxonomy development requires significant effort above and beyond normal instructional design and development, and is certainly one cause of the current poverty of instructionally-grounded practical applications of learning objects. However, any instructional designer may potentially connect the instructional design theory of their choice to the theory-neutral taxonomy presented in this chapter via the creation of “prescriptive linking material,” a considerably simpler exercise than the creation of a new

taxonomy. It is the author's desire that the development of the learning object taxonomy presented herein will (1) speed the practical adoption of the learning object approach, (2) allow the simplified application of any instructional design theory to the learning object approach, and (3) provide a common ground for future research of the instructional technology called "learning objects." Application of the "prescriptive linking material" approach and scrutiny of the taxonomy will help both improve significantly over time.

Conclusion

Like any other instructional technology, learning objects must participate in a principled partnership with instructional design theory if they are to succeed in facilitating learning. This chapter has presented a possible partnership structure. If learning objects ever live up to their press and provide the foundation for an adaptive, generative, scalable learning architecture, teaching and learning as we know them are certain to be revolutionized. However, this revolution will never occur unless more voices speak out regarding the explicitly *instructional use of learning objects* – the automated or by-hand spatial or temporal juxtaposition of learning objects intended to facilitate learning. These voices must penetrate the din of metadata, data interchange protocol, tool/agent communication and other technical standards conversations. While instructional design theory may not be as "sexy" as bleeding-edge technology, there *must* be concentrated effort made to understand the instructional issues inherent in the learning objects notion. The potential of learning objects as an instructional technology is great, but will never be realized without a balanced effort in technology and instructional design areas. *We need more theorists.*

Acknowledgements

The development of this chapter was funded in part by the Edumetrics Institute and NSF grant #DUE-0085855.

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