

Designing Reusable Learning Objects: Matching Delivery Models To Content

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Abstract -- The size and scope of online instruction is rapidly increasing. Instructor time, talent, and resources are potential constraints on instructional quality in the online environment. Reusable learning objects are proposed as a means of simplifying the development of online environments. Past research indicates that for some learners, certain delivery models may be more effective for computer-based environments [1]. This paper discusses three instructional delivery models that intersect six categories of learning with respect to automated learning environments and learning objects. We demonstrate how this can lead to the development of a simple content editor by suggesting a lesson content XML based document type definition.

Keywords: learning objects, delivery models, instructional design

INTRODUCTION

Learning via computers and networks is in a period of great expansion. The United States is gradually moving from an economy based on manufacturing and industry to one based on information. This change carries with it ramifications for the labor force, including the need for adaptable employees who can continuously learn as the work environment changes. Electronic learning (or "e-learning") for students and employees is becoming much more common with the growth of computer networks [2]. However, the completion rate of online courses is significantly lower compared to traditional courses, with perhaps 10 to 20-percentage points difference [3]. Globally, organizations lose approximately \$750 billion annually due to workers wasting time trying to find

and capture information necessary for them to do their jobs [4]. Obviously, "if you present it, they will learn" is not necessarily true. There are still obstacles to utilizing fully the power of computer-mediated instruction [5].

Instruction is more than simply displaying information. Instruction requires an integrated fit that considers the content, the current state of the learner, and the delivery model to achieve success. Further, Ahern suggests that designers need to "choose the most appropriate technologies for a particular instructional task" [6, p.23]. More research on non-traditional delivery methods is necessary to determine the best task-to-technology fit.

DESIGNING INSTRUCTION

As humans, experience is our first teacher. A young child learns the concept of "hot" or "cold" through simple experiential trial and error. Experience, even though it can be very effective, is generally a very inefficient teacher in terms of time and resource requirements. Conversely, in an instructional system the teacher does not have to wait for the experience to happen to the learner, but can intervene by anticipating the learner's need or knowledge gap. Instruction is a systematic process with the goal of eliminating learner deficiencies in cognitive, psychomotor, or affective domains [7].

Instructional systems have three major elements: learner, teacher and content. The system also manages three major interactions: learner with content; teacher with content; and learner with teacher (see Figure 1).

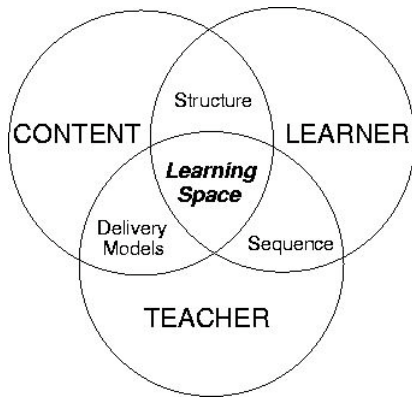


FIGURE 1: instructional system

The elements of content, teacher and student meet within a learning space that defines the instructional environment. Time is a primary constraint on the ability to deliver instruction within the learning space. The teacher (which could be a human or an automated system) mediates between the learner and the content by managing the delivery of content (including activities and experiences) in an appropriate sequence.

The prerequisite skills, development, motives and other learner information determine how the instructional content is organized. For example, if we are teaching children about polygons, a good organizational structure might be to move from concrete examples to rules and concepts that are more abstract. With other types of learners such as adults, an abstract structure may be more appropriate.

The teacher/designer is responsible for developing an effective sequence of learning activities and experiences that align with the developmental level of the learner. Sequencing is "the order in which elements of subject matter, including information, skills, and cognitive strategies are taught during instruction" [8, p. 23]. The teacher/designer not only selects the sequence but also regulates the pacing of the learning experiences and activities. Effectively matching the content with the most appropriate delivery model provides the opportunity for learning to occur.

MATCHING CONTENT TO DELIVERY

Within an instructional system, the teacher/designer must select the most appropriate delivery model for a given set of parameters, such as the nature and structure of the content, the readiness of the student, and so on. This is not a onetime selection,

but rather depends on how these parameters interact during the ebb and flow of instruction.

Delivery models are approaches to instruction with an underlying theoretical framework that are designed to foster a particular type of learning. For example, sometimes the best way of instructing a student is to simply tell the student how to do something. At other times, a student may benefit from a more exploratory approach. Joyce and Weil [9] have described a variety of delivery models and grouped them into four categories: (1) behavioral, (2) information-processing, (3) social, and (4) personal.

We are interested in the first three categories: behavioral, information-processing and social models. Personal models are not discussed as they are beyond the scope of this paper.

Behavioral Delivery Models

Based on the work of Skinner [10], behavioral models take advantage of the human ability to modify behavior in response to stimulus and feedback. This category of instructional models can be used to address a wide variety of learning needs such as computer programming, changing personal habits, and decreasing phobias.

Historically one important application of behavioral systems theory was in the development of instructional systems. Behavioral delivery systems enable learning tasks to be regulated according to the progress of the learner. This allows students to pace themselves for optimal performance. Often these systems organize material into small sequenced instructional modules that are presented to students with assessment of learning embedded in them [9]. Some of these behavioral delivery models include mastery learning (practice with intervention such as in a coaching situation), direct instruction (which can be a simple lecture), or self-training through simulation.

For the teacher/designer, behavioral delivery models are thought to present low instructor demands in terms of time and design expertise. This perception may stem from Skinner's advocacy of teaching machines and instructor-proof delivery of

instruction [11]. Models such as direct instruction and mastery learning are conveniently translated into online study guides that lead the learner step-by-step through the instructional content. Often these materials are organized into instructional modules that can be easily assessed in terms of student achievement [12].

Information-Processing Delivery Models

In contrast to the behavioral delivery models, information-processing models are concerned with how humans acquire, process, and recall information. The aim of these models is to create effective environments for the processing of information. They are designed to increase students' ability to seek and master information, organize it, build and test hypotheses, and make application to the world around them [12].

Some of these models include inductive thinking, concept attainment, memorization, advance organizers, or inquiry training [8].

Social Delivery Models. Social delivery models attempt to capitalize on human nature to enable learning by working collaboratively in small groups [9]. The models range from simple small group discussion to more elaborate models that teach democratic and social organization methods. Social models of instructional delivery are constructed to take advantage of the "synergy" phenomenon -- the collective energy generated by group work. Cooperative learning organizes students to help one another respond to the tasks presented to them.

Learning environments in which students work in pairs or larger groups, tutor each other, and share rewards are characterized by greater mastery of material than the common individual-study and recitation pattern [14]. The shared responsibility and interaction produce more positive feelings toward tasks and others, generate better inter-group relations, and result in better self-images for students with histories of poor achievement. The results generally affirm the assumptions that underlie the use of cooperative learning methods [15]. Social delivery models include partners in learning (dyads), cooperative learning, role playing, and jurisprudential inquiry [9, 14]

Many cooperative learning approaches can be applied to create effective online instructional environments. These include online mentoring, tutor support, informal peer interaction, and expert forums. Online group learning structures include

online seminars, small group discussions, learning partnerships and dyads, learning circles, and teaching and presentations by the learners. Role-playing simulations, online debates, and informal chat areas are also viable instructional environments [14].

DEFINING LEARNING OBJECTS

A learning object (Figure 2) is typically defined as a reusable digital resource that contains both the content and delivery method used to support learning [16]. According to Koper [17], this model of a learning object is consistent with the IEEE definition.

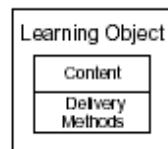


FIGURE 2: LEARNING OBJECT

Learning objects are of great interest to many constituents including business and higher education. Proponents of "learning anywhere at any time" envision learning objects as integral to development of future versions of electronic instructional and/or performance support systems. The promise of the learning object approach is that a business or institution could compile a vast database of digital resources to be catalogued by a learning content management system. The database would contain the resources as well as metadata (data about data) that would help categorize and describe the instructional nature and purpose of each resource.

As a next step in development and sophistication, the system would theoretically be able to automatically assemble learning objects to create learning opportunities and environments "on the fly" for particular learners and situations.

Companies and institutions are scrambling to implement automated networked systems for e-learning and performance that integrate learning objects. The appeal of the learning objects approach is the potential reduction of development cost, time, and resources for instructional delivery. Currently, developing high-quality networked learning environments is a costly venture and is situated in the "craft" mode, as opposed to mass production from an assembly line approach. A major problem in developing learning object systems is that

there is little guidance on how to match the appropriate delivery model with the content.

As indicated above, the current descriptions of learning objects are insufficient for the purposes of creating lesson content and the sequencing of instruction. The current definitions do not provide enough useful information to developers – namely, where the learning object fits into a particular instructional structure. Furthermore, we need better information about the type of delivery model the object requires in order to insert it more effectively into an appropriate lesson sequence. Consequently, in developing learning objects a key question for developers, instructional designers and content experts is how to match the delivery method to the content. Further how can the resulting learning object be matched to the appropriate developmental state of the learner.

CREATING LEARNING OBJECTS

To create a learning object that matches the delivery model to content type, we must be able to classify the content in a consistent manner. Bloom's [19] taxonomy of educational objectives provides an appropriate classification system for this task. The following are categories in the cognitive domain:

- 1) *Knowledge*: specific facts; ways and means of dealing with specifics (conventions, trends and sequences, classifications and categories, criteria, methodology); universals and abstractions in a field (principles and generalizations, theories and structures): Knowledge is defined here as the remembering (recalling) of appropriate, previously learned information.
- 2) *Comprehension*: Understanding the meaning of informational materials.
- 3) *Application*: The use of previously learned information in new and concrete situations to solve problems that have single or best answers.
- 4) *Analysis*: The breaking down of informational materials into their component parts, examining (and trying to understand the organizational structure of) such information to develop divergent conclusions by identifying motives or causes, making inferences, and/or finding evidence to support generalizations.
- 5) *Synthesis*: Creatively or divergently applying prior knowledge and skills to produce a new or original whole.

- 6) *Evaluation*: Judging the value of material based on personal values/opinions, resulting in a product, with a given purpose, without real right or wrong answers.

The learning object developer first analyzes the content and classifies it according to the type of knowledge it represents. The next step is to determine the appropriate student level and then match the delivery model based the type of content and intended outcome. What we suggest is a three-dimensional matrix as illustrated in Figure 3.

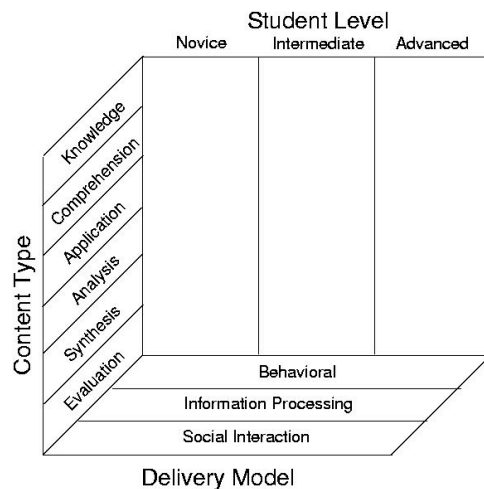


FIGURE 3: Learning object Construction Matrix

The three axes are Student Level (novice, intermediate, advanced); Content Type (Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation) and Delivery Model (Behavioral, Information-Processing, Social Interactive).

According to Forester Research [20], "XML-defined metadata (data that defines data) can embed structured information within data streams that can be used to block in a larger lesson...[It] will facilitate more efficient tagging of content." Therefore, using the matrix as our guide, we designed our own XML Document Type Definition (DTD). The LessonContent DTD (Figure 4) defines a grammar for the legal syntax of learning objects.

```
<ELEMENT source (content)>
<ELEMENT content (name.models)>
<ELEMENT models (direct,cognitive,social)*>
<ELEMENT direct (method)*>
<ELEMENT cognitive (method)*>
```

```

<!ELEMENT social(method)*>
<!ELEMENT method (type,name,data)*>
<!ELEMENT type (#PCDATA)>
<!ELEMENT name (#PCDATA)>
<!ELEMENT data (#PCDATA)>

```

FIGURE 4. LessonContent DTD

The LessonContent DTD includes information about the type of instructional method (direct or cognitive) embodied in each component of the lesson, as well as the type, name, and location of that component. An individual developer can quickly identify different learning objects from a variety of vendors and insert them in the lesson sequence in the appropriate order. This expedites the inclusion of these objects (e.g., URLs, graphic files, formatted text documents, etc.) within the learning space.

The following example (Figure 5) demonstrates the content for an English lesson on sentences and contains the description of two basic elements - nouns and verbs within a sentence. Notice the content description describes the delivery method and the links to the location of the learning objects. Lesson designers will need this information in order to create appropriate learning sequences. In this example, both of the objects were simple web sites, but the DTD is capable of utilizing any type of delivery type as long as it is accessible.

```

<!DOCTYPE source SYSTEM "content.dtd">
<source>
<content>
<name>Sentence Structure</name>
<models>
<direct>
<method>
<type>nominal</type>
<name>Noun definitions</name>
<data>http://faculty.csumb.edu/noun_defs.html</data>
</method>
<method>
<type> nominal</type>
<name>Verb definitions</name>
<data>http://faculty.csumb.edu/verb_defs.html</data>
</method>
</direct>
</models>
</content>
</source>

```

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Figure 5: Sample lesson content

By using the LessonContent DTD, instructional designers are able to better incorporate reusable learning objects within lesson content. Given the metadata within this file a designer is able include this object at the most effective time for a particular lesson and learner.

SUMMARY

The growth of content development and dissemination has outstripped our ability to design and implement computer managed instruction.

Learning objects have been suggested as a possible solution. However, specific implementation guidelines are lacking. The current specifications do not provide developers with enough information concerning the content and delivery intent of the object.

This paper suggests a possible direction for the development of an automated classification methodology using XML. Content developers could create learning objects that are classified not only by the type of knowledge but also which delivery method is best for object in reference to the student. This in turn allows lesson developers to embed the learning object into the most effective lesson sequence.

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