LEARNING OBJECTS IN DECISION SCIENCES AND COMPUTING

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ABSTRACT

We describe the background and construction of Learning Objects and discuss their use in the Decision Sciences and computing curriculum. Data is presented from a sample Learning Object which was given to a college computer science class, generating positive feedback from the learners.

INTRODUCTION

Learning objects (LO singular; LOs plural) divide a topic (such as Introduction to Java Programming or Introduction to Statistics) into small, independent units of information and interactions (including questions). LOs are self-contained and may be used to focus on a particular topic. A general measure of the size of a LO is that it should average between two to fifteen minutes to complete [12]. This paper presents an introduction to the history of LOs, details the creation of a web-based LO, and presents student feedback from the experience of using the LO.

ABOUT LEARNING OBJECTS

Learning Objects came about in the early 1990s as a result of initial work by Wayne Hodgins of Autodesk. In 1992, Hodgins began promotion of the idea of interoperable pieces of learning he called "Learning Objects," realizing his industry was in need of a reusable "plug-and-play" learning strategy. Between 1992 and1995, both the Learning Object Metadata Group (part of NIST, the National Institute of Science and Technology, www.nist.gov) and the Computer Education Management Association (CEdMA, www.cedma.org), began defining issues with Learning Objects such as modularity, database centricity and metadata. Starting in 1994, the IEEE, IMS, and the European group ARIADNE began working toward a standardization of Learning Objects. During that same time frame, the Oracle Corporation recognized that Learning Objects would become a critical part of their future training strategy. Oracle's thinking evolved into the Oracle Learning Application (OLA), an authoring environment using learning objects. [7]

Areas of importance to the Learning Object community today include metadata standards for categorization, the delivery platforms and repositories, the design of learning objects, and measuring the success of learning objects. We will now examine each of these areas in more detail.

1. METADATA. The organization and classification of learning objects is facilitated by metadata. Several metadata standards have emerged over the past several years. Five standards have been particularly important in the development of learning objects.

a. DUBLIN CORE METADATA INITIATIVE. Perhaps first in the area of metadata, the Dublin Core project came out of a brainstorming session in Dublin, OH in 1994 in an effort to provide structure for categorization and retrieval of Web-based library services. DCMI supports the development of metadata registry infrastructure to provide metadata definitions and documentation in the languages of its end users. To date, more than 20 languages are supported. An example of the Dublin Core metadata for the learning object described in this paper may be found in Figure 1, created with the DCdot [5] metadata editor [6].

```
<link rel="schema.DC"
href="http://purl.org/dc/elements/1.1/" />
<link rel="schema.DCTERMS"
href="http://purl.org/dc/terms/" />
<meta name="DC.title" lang="en" content="Java - Casting"
/>
<meta name="DC.creator" content="John Stamey and
Bryan Saunders" />
<meta name="DC.subject" lang="en" content="Casting in
Java; Learn Casting" />
<meta name="DC.description" lang="en" content="This
Learning Object
gives several examples of casting in Java, as well as
programming exercises
at the end." />
<meta name="DC.publisher" content="John Stamey" />
<meta name="DC.date" content="September 15, 2005" />
<meta name="DC.type" scheme="DCTERMS.DCMIType"
content="Text" />
<meta name="DC.format" content="text/html" />
<meta name="DC.format" content="1351 bytes" />
<meta name="DC.identifier" scheme="DCTERMS.URI"
content="http://softwareengineeringonline.com/learningobje
cts/Casting/index.cfm" />
<meta name="DC.language" scheme="DCTERMS.URI"
content="English" />
<meta name="DC.rights" scheme="DCTERMS.URI"
content="John Stamey" />
```

Figure 1

b. INSTRUCTIONAL MANAGEMENT SYSTEM (IMS). Working as a non-profit entity, IMS works with its members to develop and promote the adoption of open

technical standards for interoperable learning technologies. IMS works with all major providers of metadata such as Dublin Core, ADL, and IEEE. (http://www.imsglobal.org/aboutims.cfm)

c. IEEE's LEARNING OBJECT METADATA MODLE (LOM). Originally developed in 2000, nine categories of metadata are defined to describe and categorize learning objects. These include: General Information such as title, language and structure; the Life Cycle including the version of the LO; Meta Metadata describing the metadata used for a LO; Technical Information such as format, length and browser requirements; Educational information such as the objective, type of interactivity, difficulty, audience; Rights including the copyright and any commercial use restrictions; Relation, or the ability for a LO to link to other LOs (Learning Objects); Annotation to provide additional/miscellaneous information about the learning object; and, the Classification, defining the purpose of the LO along with its position within a taxonomy of keywords. (http://ltsc.ieee.org/wg12/)

d. ALLIANCE OF REMOTE INSTRUCTIONAL AUTHORING (ARIADNE) Developed through efforts of the European Union and the Swiss Government, ARIADNE's mission is the development of a truly European knowledge pool for distributed education. They have developed the Knowledge Pool System, or KPS, that promotes sharing and reuse of learning objects. Query tools are available for KPS that allow users to find objects of their choosing that are found in a Local Knowledge Pool. (http://www.ariadne-eu.org/)

e. ADVANCED DISTRIBUTED LEARNING AND SCORM ADL is a joint program of the Department of Defense and the White House Office of Science and Technology. Its purpose is the development of guidelines for large-scale development and implementation of distributed learning. The Sharable Content Object Reference Model (SCORM) is a result of this important initiative. SCORM promotes five ideals of: Accessibility of learning objects from multiple remote locations through the use of meta-data and packaging standards; Adaptability of instructions for the specific needs of individuals and organizations; Affordability through efficiency and enhanced productivity; Durable to allow changes in underlying operating systems without affecting operation; Interoperability over multiple tools and platforms; and, Reusability. (http://www.adlnet.org/)

2. DELIVERY PLATFORMS. Most standards provide for delivery of learning objects over the Internet. For this reason, they are created with technologies ranging from Java applets, HTML, XML, and Flash/Macromedia Authorware. Access to these learning objects comes through aggregations called repositories. Some of the more important Learning Object repositories include Ariadne[1], CAREO[2], CLOE[4], MERLOT[8], SMETE[10], and TALON[11].

3. LEARNING OBJECT DESIGN AND USE. Learning Objects have are described through two aspects. The *domain* consists of disciplinary knowledge, learning theory, and enabling technologies. Each domain may be described through content, presentation, and application [[9]. These relationships are seen in the matrix below (Figure 2):

	Content	**Presentation**	**Application**
Discipline Knowledge	Types Levels	Multimedia Text	Reading Playing Listening Practicing
Learning Theory	Objectives Learning models Contexts	Structure Relationship Naming Pedagogy	Comprehension Analysis Synthesis Evaluation Application
Enabling Technology	Database XHTML XML Authoring tools	GUI	Metadata Ontologies Repositories

Figure 2

In computer science, students are asked to perform learning tasks which emphasize stepping through the code to identify its behavioral characteristics, and recognizing proper use of programming constructs. An additional benefit of the use of Learning Objects is that they can serve as a resource for the students (after their initial use and evaluation period), when they have to apply the concepts learned in programming projects. The data collected from the LO has a number of uses. Figure 3 gives a graphical depiction of the data that may be collected and its uses:

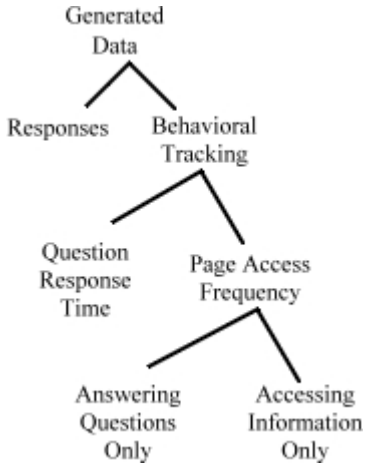

Figure 3

DESIGNING A LEARNING OBJECT

A set of Learning Objects for an introductory course in Java programming (Association for Computing Machinists, CS1 level) were used in a lab course that

provides programming practice and support for the lecture section in fall 2004 at Coastal Carolina University in Conway, SC. We will examine a subject Learning Object entitled "Learning WHILE loops – Part 1." Aspects describing the content of the Learning Object may be see in Figure 4:

TYPE	Vocabulary and process of WHILE loops
LEVEL	Beginning CS1
OBJECTIVES	familiarize students with construction of while loops, emphasize the priming read format, and show examples of use of string objects in the condition statement
LEARNING MODEL	Vocabulary comprehension, application of concepts
PLATFORM	PHP with MySQL database to hold content and store performance data

Figure 4

The subject LO presentation was primarily text-based instructions with code examples to illustrate points and to provide material for the questions. The information presented in the Learning Object was complementary to their CS1 lecture presentation through reading, followed by analysis of the performance and output of programming constructs. Multiple choice questions are used for the evaluation. In total, six HTML pages are presented in the LO, summarized below.

Page 1: Domain knowledge includes:

- Definition of WHILE loops and their general form;
- Naming of parts of the WHILE programming construct;
- Examples to relate the definitions and form with actual code examples.

Student evaluation is based on tracing through a loop to determine the number of times it will execute.

Page 2: Domain knowledge includes:

- Definition of three types of WHILE loops;
- Introduction and explanation of the CONDITION clause;
- Explanation of the != operator for use in the CONDITION clause;

Student evaluation is based on tracing through a SENTINAL CONTROLLED loop to determine the sum of a series of numbers.

Page 3: Domain knowledge includes:

- Introduction of a loop terminating on a GENERAL CONDITION
- Explanation of configuring a WHILE loop to implement a GENERAL CONDITION
- Implementing the CONDITION clause when using a GENERAL CONDITION to terminate the loop

Student evaluation is based on identifying the proper use of a CONDITION CONTROLLED loop to again sum a series of numbers.

Page 4: Domain knowledge includes:

- Introduction the PRIMING READ concept
- Explanation of configuring a WHILE loop to implement a PRIMING READ

Student evaluation is based on identifying the situation for proper use of a PRIMING READ in a WHILE statement.

Page 5: Student evaluation is based on identifying the situation for proper use of a SENTINAL CONTROLLED loop.

Page 6: Domain knowledge includes an example of using the concatenation operator which is frequently used in the CONDITION clause. Student evaluation is based on identifying the output of using a concatenation operator.

An example of the first question of this Learning Object is seen below in Figure 5.

STUDENTS' EXPERIENCE WITH LEARNING OJBECTS

Thirty undergraduate students took part in the experiment. All students were in a wireless classroom setting, and each had a laptop upon which the test, administered over the Internet, was taken. Students signed into the testing system using their email addresses for identification, and answered five questions posed. The following statistics resulted from this experiment: Correct responses and average response time for all questions are seen in Figure 6.

The Learning Object system used herein has immediate reporting capabilities, which provide valuable information for the instructor. The results of using the Learning Object (Figure 6) allow the instructor to immediately pinpoint areas of misunderstanding or lack of understanding at or near the beginning of the lab class. Here, it is clear that students had a problem understanding the PRIMING READ, a traditionally difficult concept with first year students. The low average response time for the PRIMING READ topic further emphasizes that students do not understand the concept. One other measure of the Learning Object performance lets the instructor determine the students that have an overall understand the concepts presented, as well as those who do not.

```
The WHILE statement is one important method
to execute a set of statements multiple
times. Below is an example:

int x = 10;
while (x > 0)
{
       System.out.println(x);
       x--;
}

Here are some important facts about WHILE
loops in general:
    • The statements inside the braces
      execute as long as the CONDITION is
      true.
    • If we initialized x to zero, then
      the first time through the loop,
      the condition (x > 0) would NOT be
      true, so the statements inside the
      braces would NOT EXECUTE.
    • If there is only one statement in
      the loop, you do not need the
      braces. Here is an example of the
      same code, written with only one
      line (and no braces)

int x = 10;
while (x > 0)
       System.out.println(x);

QUESTION:
How many times will the two statements in
the body of this while loop execute?
    • 9
    • ** 10
    • 11
    • None of the Above
```

Figure 5

Question 1	22/30 correct	135.86 seconds
Question 2	22/30 correct	85.3 seconds
Question 3	15/30 correct	81.733 seconds
Question 4	8/30 correct	31.667 seconds
Question 5	19/30 correct	54.556 seconds

Figure 6

Mean	Std.Dev.	Question
3.600	0.723974	Did going through the Learning Object help you (overall) in completing the lab?
3.933	0.583292	In the Learning Object a good reference for you to use in the lab and for the future?
4.000	0.870988	Would you use this Learning Object and similar ones as references for class assignments and to help in studying for tests?
3.933	0.73968	Was the immediate feedback helpful?
4.033	0.718395	Would you like Learning Objects on other topics in this class?

Figure 7

Along with immediate feedback for the instructor, it is important that use of the Learning Object be tracked over time. As students can use the Learning Object to help in test preparation as well as for references as they complete programming assignments, statistics can be kept that will indicate topics that need additional reinforcement throughout the semester.

An additional and important measure of the success of using Learning Objects is based on student perceptions. At the end of the class in which the aforementioned Learning Object was used, a survey was given. The survey used a five-point Likert scale with 5 indicating "Strongly Agree" and 1 indicating "Strongly Disagree" For n=30 students, the results may be seen in Figure 7. These results indicate there was a positive level of quality in the Learning Object presented; students feel positively about wanting more Learning Objects in the course; students think they will provide useful reference throughout the course; and, that the immediate feedback was helpful.

CONCLUSIONS

Learning Objects provide an excellent tool to provide individual tutorial assistance, and can be coupled with a back end evaluation mechanism to record valuable information from the participants. [3] Through this study, a number of advantages of Learning Objects were determined, including:

- Establishment of a goal for training lab session;
- Provision of a tight focus on problems and topics to be presented;
- Application of new knowledge immediately, with feedback provided;
- Measurement of the students' relative performance;
- Immediate identification of problems in understanding; and,
- Easy accessibility as reference material

More Learning Objects will be produced as part of the Decision Sciences and Computing curriculum at Coastal Carolina University in the very near future. More Learning Objects may also be found at http://www.BusinessLearningObjects.com/.

REFERENCES

References available upon request from John Stamey or may be found at http://www.softwareengineeringonline.com/LearningObjects/

REFERENCES
(FOR THE CONVENIENCE OF THE REFEREES)

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