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Understand and Analyzing Learning Objects: A Foundation for Long-Term Substantiality and Use for E-Learning

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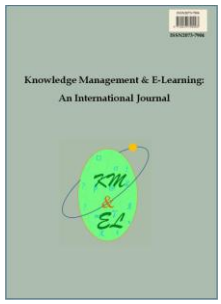

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Understand and analyzing learning objects: A foundation for long-term substantiality and use for e-learning

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Abstract: In this paper, we investigated the genres of learning objects (LOs) within eight e-learning courses that provide boating safety instruction in the United States. Guided by findings from our literature review, five genres of LOs emerged during the analysis, including interactive and non-interactive graphics, interactive and non-interactive animations, and interactive text feedback. We surveyed the use of each genre of LOs within the courses and found that more non-interactive LOs than interactive LOs were adopted. Also, interactive text feedback was the most popular interactive genre available for seven courses. In our discussion, we explore potential management mechanisms of LOs in digital repositories. Our genre analysis provides a foundation for appropriate deconstruction of LOs into components, which can assist with the management of digital repositories. Effective deconstruction of LOs allows instructors and designers to successfully discover LOs that they need and reuse them in new learning units.

Keywords: Learning object; Genre analysis; e-Learning; Boating instruction; Digital repository

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1. Introduction

As e-learning has gained more attention from educators, practitioners, and policy makers, issues related to long-term content management have emerged. The majority of traditional established content, such as instructional or learning materials, is transformed into a digital representation for e-learning without consideration of reusability (Tavangarian, Leypold, Nölting, Röser, & Voigt, 2004). In addition, innovative technologies to support learning in various environments will often influence the types of materials that are generated for these environments. With the evolvement of information and communication technologies (ICTs), Learning Objects (LOs) provide a different form of learning materials. In 2002, the Institute of Electrical and Electronics Engineers (IEEE) approved the *Draft Standard for Learning Object Metadata*. This proposal provides guidelines for managing LOs, which are described as "any entity -digital or non-digital- that may be used for learning, education or training" (IEEE Learning Technology Standards Committee, 2002, p.5). Wiley (2000) defined LOs as any digital resources that could be re-used to support learning. In his definition, Wiley emphasized four attributes of LOs: 1. reusable; 2. digital, 3. resource, and 4. learning. Designers, instructors, and learners purposefully use these attributes to determine appropriate instructional materials.

Tavangarian et al. (2004) implemented an XML (Extensible Markup Language)-based model to ensure the interoperability and reusability of e-learning content. Although the model allows for separation of content by major themes and smaller "chunks" of information, granularity decisions regarding LO size can be complex due to instructivist or constructivist learning perspectives. As the size of the LO decreases, the lack of context and details might decrease its reusability for constructivist design strategies. Malaxa and Douglas (2005) emphasized the importance of metadata to the discoverability of LOs. In their Customizable Learning Object Metadata Authoring Tool (CLOMAT), a metadata tag, *resource type*, was used to facilitate a flexible management approach (Malaxa & Douglas, 2005, p. 157). These projects illustrate the importance of genre studies for the management of learning materials (Päivärinta, 1999; Beghtol, 2001). Specifically, elaborate LOs that represent animations, graphics, and diagrams can be created to support teaching and learning activities. Due to the richness of these elaborate LOs, metadata standards must be able to describe the different types. Genres are important because they support communication between people in specific contexts and environments (Andersen, 2008). As such, management systems for LOs should utilize genres to support the activities of instructors, designers, and learners.

The Open Educational Resources (OER) is another term used by researchers (Downes, 2007; Han, Zhou, & Yang, 2011; Sampson & Zervas, 2013) to reflect the development of the "open" movement in the Web 2.0 era. Atkins, Brown, and Hammond

(2007) defined that "OER are teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or re-purposing by others" (p. 4). Many global academic organizations and government agencies offer free-access to educational resources via their digital repositories.

As a result of the "open" movement, there are many online educational resources available. However, these resources do not always have uniform search interfaces and descriptions that allow users to find desirable LOs for teaching and learning. Such barriers hamper the long-term substantiality, including the re-discovery and re-use, of previously created learning materials.

A clear description regarding LOs' genres or types would build the foundation for users of digital repositories in their efforts to re-discover and re-use LOs effectively and efficiently in the long term. One major problem is that people need to specify the forms of LOs during search tasks. Andersen (2008) suggested that people should first consider information in different forms (as genres), and then genres can support people and their activities in local contexts. Therefore, we advocate the study of LOs based on their genres, and have presented some preliminary results at two conferences. For this paper, we established a research framework, and then applied the framework for a survey of learning object genres within eight online courses that provide boating instruction in the U.S. The purpose of the analysis was to understand the genres and usage of different LOs for e-learning.

2. Literature review

2.1. Learning objects and digital repositories

In addition to the IEEE learning metadata standard, different metadata standards for LOs have been developed worldwide. The *Learning Object Metadata Core* in the United Kingdom (Center for Educational Technology Interoperability Standards, 2008), *CanCore* in Canada (CanCore, 2006), and *ANZ-LOM* in Australia and New Zealand (Education Services Australia, 2012) are some of the examples. The purpose of these metadata standards is to increase re-discovery and re-use of LOs in Learning Content Management Systems (LCMs) or digital repositories (Cohen & Nycz, 2006).

Two of the popular digital repositories in the U.S. are MERLOT (Multimedia Education Resource for Learning and Online Teaching, http://merlot.org) and NSDL (National Science Digital Library, http://nsdl.org). In general, both repositories provide open access to their collections, but there are some differences. MERLOT provides information regarding its 19 types of learning materials and 20 technical formats collected in its collection section. MERLOT's "Technical format" Menu has "Audio" as an option (Fig. 1), which is similar to NSDL's "Audio/Visual" option for their "Resource Type" (Fig. 2). The search and browse functions are two core functions within repositories (Sampson & Zervas, 2013). Thus, the MERLOT and NSDL repositories demonstrate the issue of mixing different material types, technical formats, and resource types for searching activities (Fig. 1 to Fig. 3). For example, an instructor can find a PowerPoint file from MERLOT, but the process of searching for a PowerPoint file on NSDL requires additional steps. In the NSDL, the instructor must check the boxes of several types of resources (Fig. 2), which could produce search results that overwhelm the instructor with many non-relevant file formats. Similar concerns related to accessing

materials in digital repositories were also noted in other studies (Downes, 2007; Han, Zhou, & Yang, 2011; Sampson & Zervas, 2013).

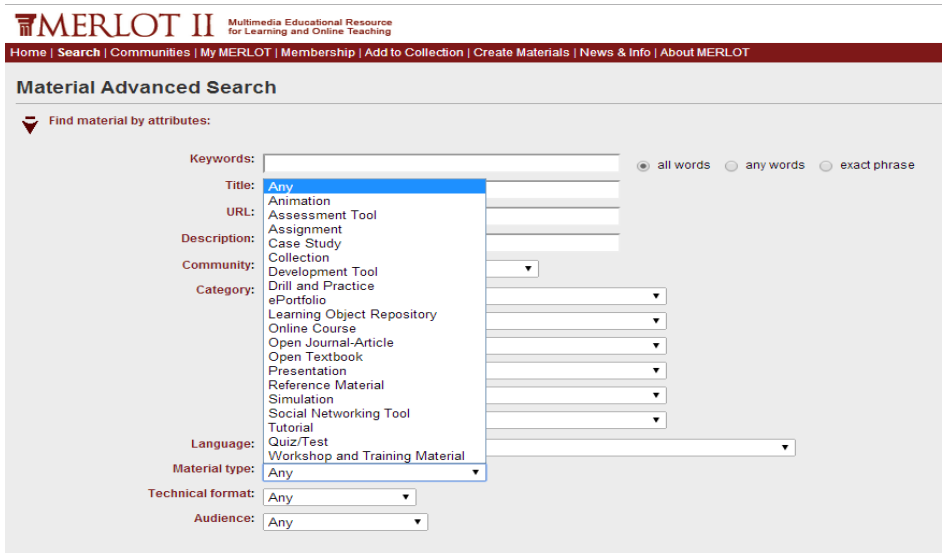

Fig. 1. MERLOT search function (http://www.merlot.org/merlot/advSearchMaterials.htm)

Fig. 2. NSDL search function (http://nsdl.org)

2.2. Beyond discovery: Reusability and reproduction

After instructional designers, instructors, and learners discover LOs from a digital repository, the next step is to integrate the retrieved LOs into their learning projects. However, the adaption process is not always smooth. Common challenges are system/software dependency, as well as language and culture-related content issues. For example, the lack of availability of an object in a desired language can cause adaptation issues. According to Chen and Gilchrist (2013), the majority of videos at YouTube EDU, which is a branch of YouTube that hosts educational videos from higher education institutions and learning organizations worldwide, are in English. The English-only videos can be a barrier to non-English speakers. Similarly, Alebaikan (2013) stated that Reusable Learning Objects (RLOs) are limited in Arabic due to social, cultural, pedagogical, and technical factors.

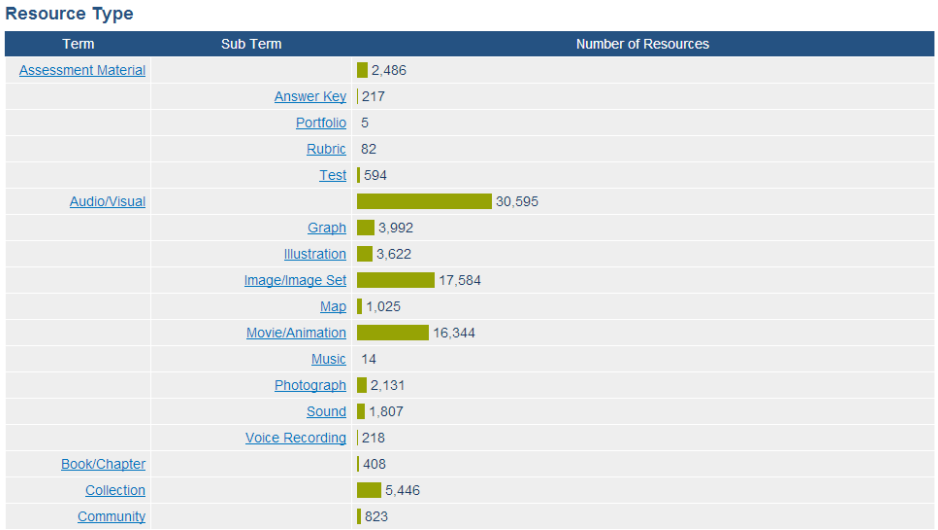

Fig. 3. NSDL resource types (http://nsdl.org/search/resources)

2.3. Evaluation of learning objects

As types of e-learning materials emerge, researchers have proposed various evaluation rubrics to ensure the quality of e-learning courses and materials. Akpinar (2008) implemented a learning object rating instrument (LORI) with the rating scores of 507 K-12 students using 24 LOs. Nine measurement items were validated in his study: *Content Quality*, *Learning Goal Alignment*, *Feedback and Adaptations*, *Motivation*, *Presentation Design*, *Interaction Usability*, *Accessibility*, *Reusability*, and *Standards Compliance*. According to Akpinar's findings, the quality of the description of a LO might affect how instructors and learners select and use the LO in their activities.

Kay and Knaack (2008, 2009) devoted similar efforts to building evaluation rubrics by establishing learning object evaluation metrics (LOEM). They identified *Interactivity*, *Design*, *Engagement*, and *Usability* as key evaluation factors. However, Kay and Knaack (2009) acknowledged the limitations of the use of only 48 LOs and suggested more types of LOs be used in different subject areas and different activities for future studies (e.g., "a learning object used exclusively as a motivational or

demonstration tool, might not have as much an effect as a learning object used to teach a new concept," p. 161). Fig. 4 is an example of one LO used in their 2009 study.

2.4. Genre analysis of learning objects

According to the recommendations in the studies of Akpinar (2008) and Kay and Knaack (2008), the first step in the analysis of LOs is to recognize genres as a starting point and to establish a framework of analysis for a subject domain. Beghtol (2001) noted a genre "…helps structure and interpret texts, events, ideas, decisions, explanations and every other human activity in that domain" (p. 19). As such, the effectiveness and usefulness of digital documents depends on a person's ability to recognize the structure and purpose of a document (Toms, 2001). A genre analysis aids document recognition and facilitates user-document interaction. However, there are many communities on the Web, and each community may recognize and interpret genres differently. These differences present research needs and challenges (Kwasnik, Crowston, Nilan, & Roussinov, 2001).

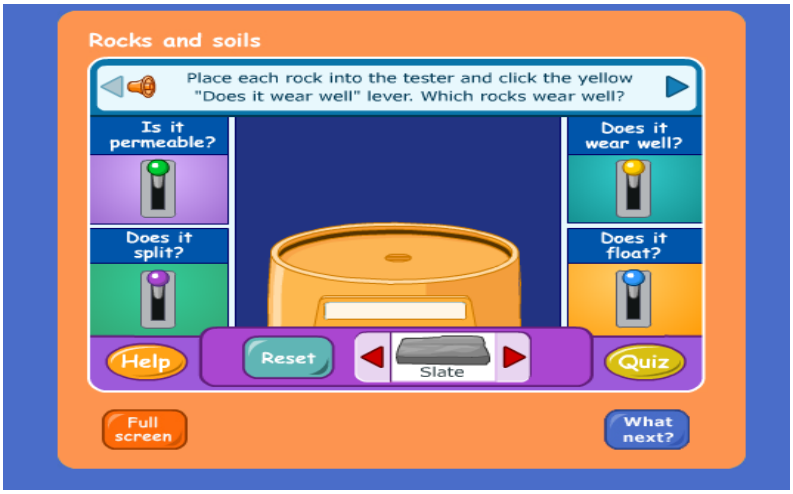

Fig. 4. A learning object used in Kay and Knaack's (2009) study (http://www.bbc.co.uk/schools/scienceclips/ages/7_8/rocks_soils.shtml)

Regarding genres of media objects, Heller and Martin (1995) created a media taxonomy that contains increasingly complicated categories that include computer programs with text, still images, video clips and animations in one screen presentation. In addition, they categorized the expression of media into the categories of elaboration, representation, and abstraction. For example, animations can belong to the motion as well as the representation category. Smaldino, Russell, Heinich, and Molenda (2005) listed six basic types of media widely used in education: text, audios, visuals, motion media, manipulatives, and people. They defined text as "alphanumeric characters that may be displayed in any format" (p. 9). Visuals included still pictures, drawings, charts, graphs, posters, and cartoons. Cartoons adopt "a technique in which the producer takes advantage of persistence of vision to give motion to otherwise inanimate objects" (p. 287).

Kiousis (2002) pointed out that interactivity is both a media and psychological factor that varies across communication technologies, communication contexts, and people's perceptions. Kay and Knaack (2008, 2009) also identified "interactivity" as a key evaluation factor of LOs. In their studies, Kay and Knaack defined interactive

learning materials as learning materials that lead learners to execute actions, allow learners to repeat the actions if needed, and offer various interactions based on educational objectivities.

In summary, the literature review illustrates a scenario in which LOs should be well described by their genre, interactive features, and other metadata information so that they can be re-discovered from digital repositories for re-use or re-production.

3. Research question

Based on the LO literature review, we were interested in the genres and interactive features of LOs and the usage of the LOs in the online boating courses. The following two research questions are the focus of this project:

1) What were the specific genres of LOs used in these online boating education courses?
2) How often were these LOs used?

The findings from this project aim to enhance the design of digital repositories and to support long-term substantiality and use of LOs for e-learning.

4. Data collection

In the 1970s, the National Association of State Boating Law Administrators (NASBLA) developed boating safety education guidelines to promote uniformity and reciprocity among the states. Online boating safety courses are available throughout the U.S., and the National Boating Education Standards provides structure and guidelines for the content. However, the course delivery and presentation vary greatly from course to course. For example, one course included pictures throughout the final exam while another course only included text-based questions and answers (Moore, Chen, Chen, Washburn, 2010).

We surveyed eight online boating safety education courses available online between December 10, 2008 and March 4, 2009 and analyzed the use of LOs:

1. Personal Watercraft (PWC) Safety School.com
2. American Boat Operator Course
3. BoatingBasicsOnline.com
4. BoaterExam.com
5. BoatUS.com
6. BoatUS.org
7. FloridaBoatingCourse.com
8. Florida Boating License and Boat Safety

5. Data analysis

LOs adopted in the above eight courses were analyzed. Based on the principle of exclusivity among categories and overall exhaustivity (Beghtol, 2001) and the above literature review on genres, five genres emerged from the analysis: interactive and non-interactive graphics, interactive and non-interactive animations, and interactive text

feedback. We classified the LOs by form genres instead of content genres (Beghtol, 2001), which means that the LOs were not classified according to the content they conveyed.

LOs were only counted when they were instruction-related. LOs for non-instructional purposes such as logos or buttons were excluded from evaluation in this analysis. When a learning object was repeatedly used, we only calculated it once.

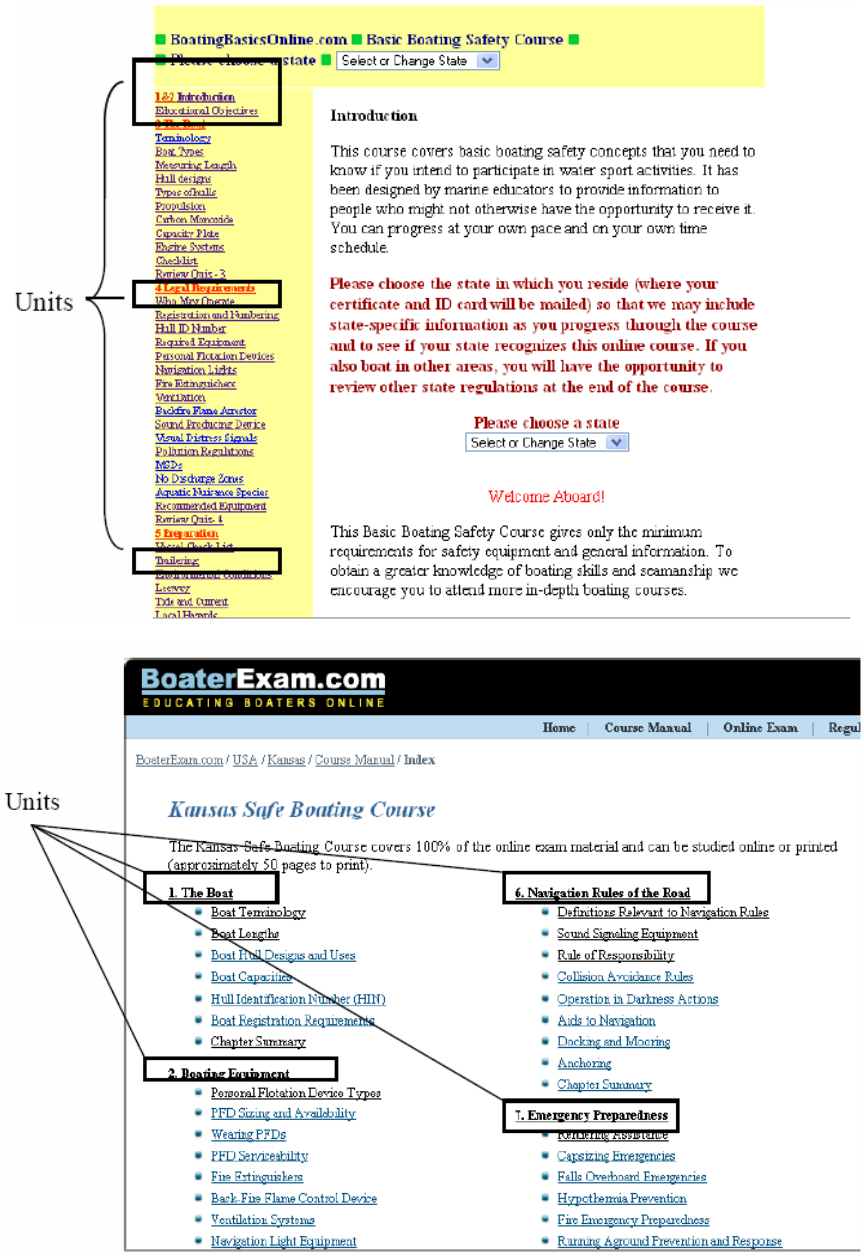

Fig. 5. Learning units

5.1. Learning unit

A learning unit was defined as the first tier of categories on the main navigation page of the course website (Fig. 5). Units may have included introduction sections about state law, course objectives, or concluding units related to continuing education. Final exams and final practice quizzes were not considered as units. Some courses had one or several beginning pages introducing course policy, providing instruction for payments, or sending feedback to the course provider. These pages were not counted as units. Additional course sections that provided state-specific information or glossaries related to boating terminology were not counted as units.

5.2. Interactive graphics

There were two types of interactive graphics serving two different purposes. For the first type, information demonstration, a picture changed, or an annotation appeared when the mouse cursor was moved over the image or object of the interactive graphic. In Fig. 6, an annotation explaining the displacement hull appeared when users hovered their mouse over the associated part of the boat in the graphic. In other situations, a certain object in the picture was highlighted when its name was clicked.

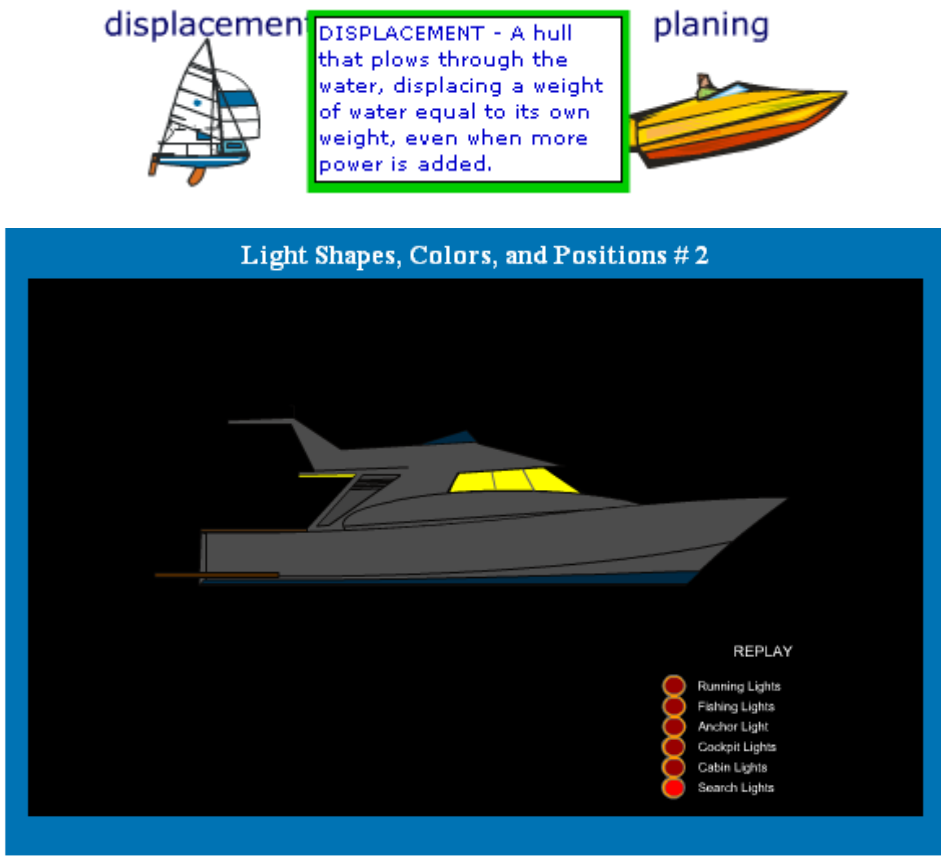

Fig. 6. Interactive graphic (type 1)

The other type of interactive graphic served as practice activities. For example, a user must drag the name of an object to the correct position. As illustrated in Fig. 7, users were asked to drag the terms at the bottom to the blank lines in the graphic. After users placed the term of "Stern" at the right place, "Good" was provided as feedback. Users were able to enlarge some of the graphics in their courses. However, these graphics were not defined as interactive graphics and were calculated under the next category of non-interactive graphics.

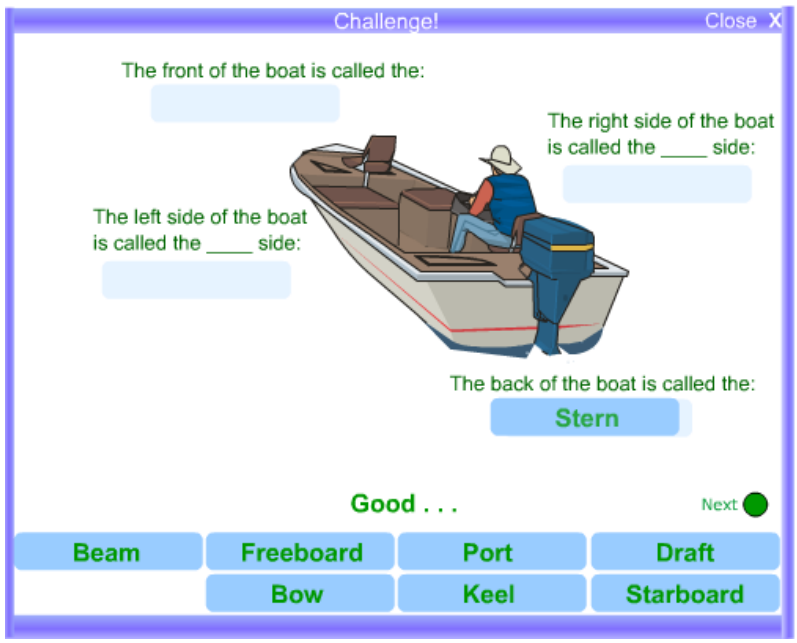

Fig. 7. Interactive graphic (type 2)

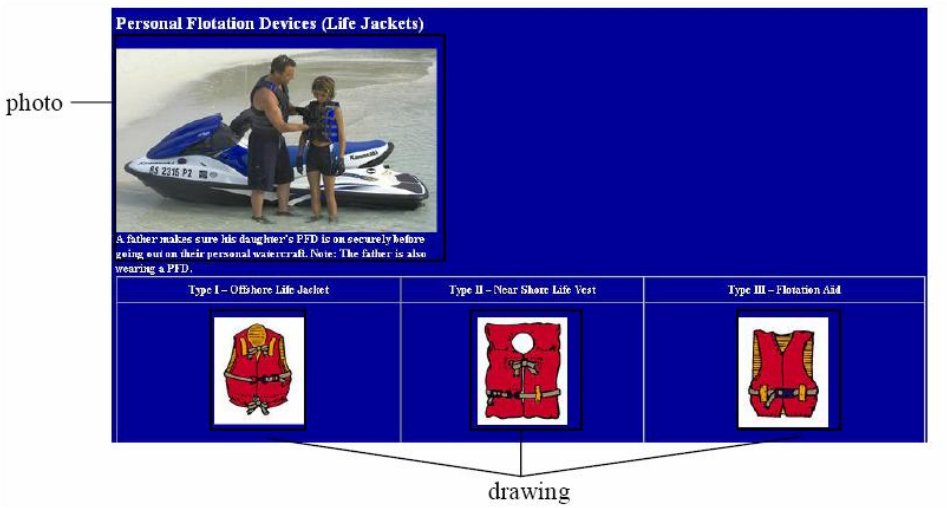

Fig. 8. Non-interactive graphics

5.3. Non-interactive graphics

Non-interactive graphics were counted separately from the interactive graphics discussed in the previous section. Non-interactive graphics included photos of real people, drawings, screenshots of information, or tables of text information that were saved as images (see Fig. 8 for examples). Each of them possessed a unique URL.

As mentioned earlier, graphics that were used as unit or course logos and thus appeared on every page of the same unit or same course were not counted (see Fig. 9). We also excluded buttons from our total. Due to the large number of non-interactive graphics in each course, the number of non-interactive graphics per unit was reported. If the same non-interactive graphic appeared in more than one unit, then we counted that graphic in each unit because of the impossibility of deciding to which unit the graphic belonged. However, if the same picture with the same URL appeared more than once within the same unit, then the picture was computed as only one graphic in that unit.

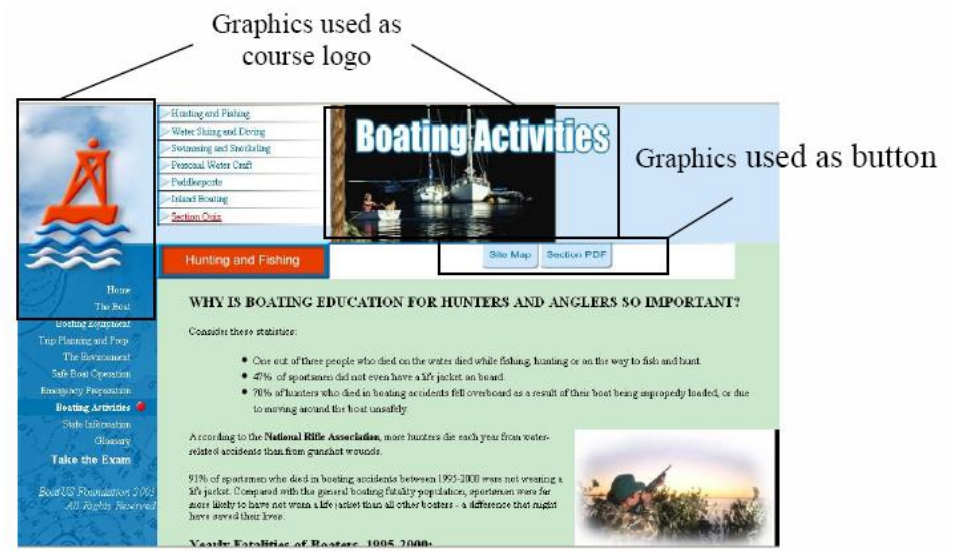

Fig. 9. Graphics that were not counted

5.4. Interactive animation

We defined animations as media that involved movement. Interactive animation, however, allowed users to interact with the course in ways beyond simply stopping, replaying, or moving to the next page. They were associated with exercises for which users were asked to make a selection to demonstrate their understanding and then were provided with a response from the website. Fig. 10 shows "Yes" as feedback after users watched an animation and selected "a power boat approaching head-on" as their response.

5.5. Non-interactive animation

We defined non-interactive animations as LOs that include movement, but no user interaction beyond starting and stopping the animation. The rest of the animations adopted in the eight courses were computed separately from the interactive animations

discussed in the previous section. For example, in Fig. 11, an animation was included in the course demonstrating two power-driven vessels passing each other port-to-port.

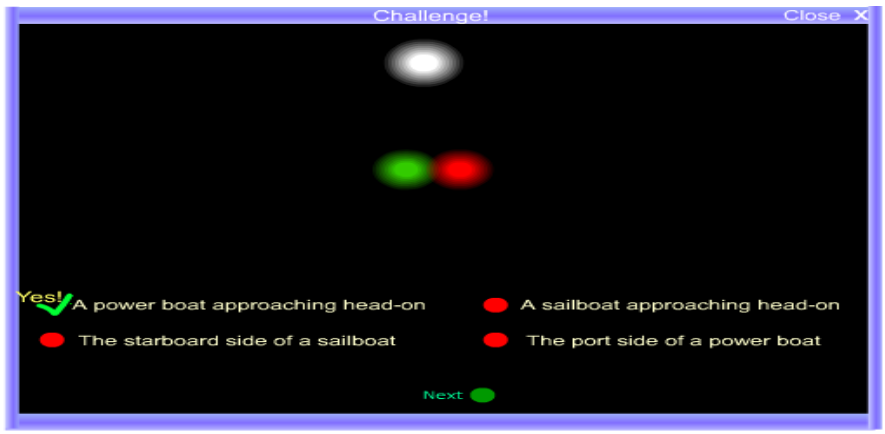

Fig. 10. Interactive animation

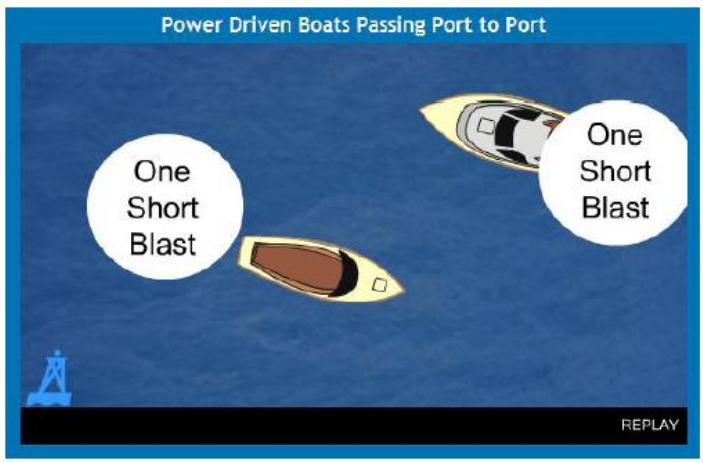

Fig. 11. Non-interactive animation

5.6. Interactive text feedback

Interactive text feedback involved responses from the course website based on a user's input. One form of interactive text feedback was a practice activity in which the users selected an answer to a test item and then the activity provided a response. If a graphic or animation was used in the feedback, then that object was counted as an interactive graphic or animation. The quantity of interactive text feedback was calculated according to the number of test items. In some cases, all test items of an interactive text feedback were presented on one page. Other times, multiple pages were used. Fig.12 represents the latter case, indicating one example of interactive text feedback. After completing one test item, users clicked on "Next" to navigate to the next one.

Another type of interactive text feedback involved the appearance of an explanation when a user clicked certain underlined terminology on the page. For instance,

after users clicked on the term "Ground Tackle," a window popped up providing its definition (see Fig. 13). Their quantity was calculated according to the number of terminologies containing explanations.

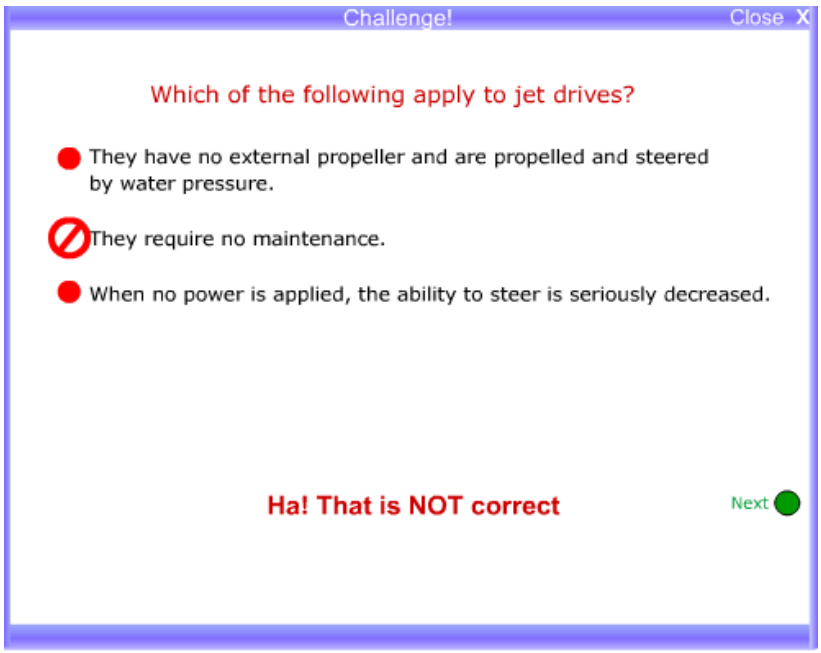

Fig. 12. Interactive text feedback

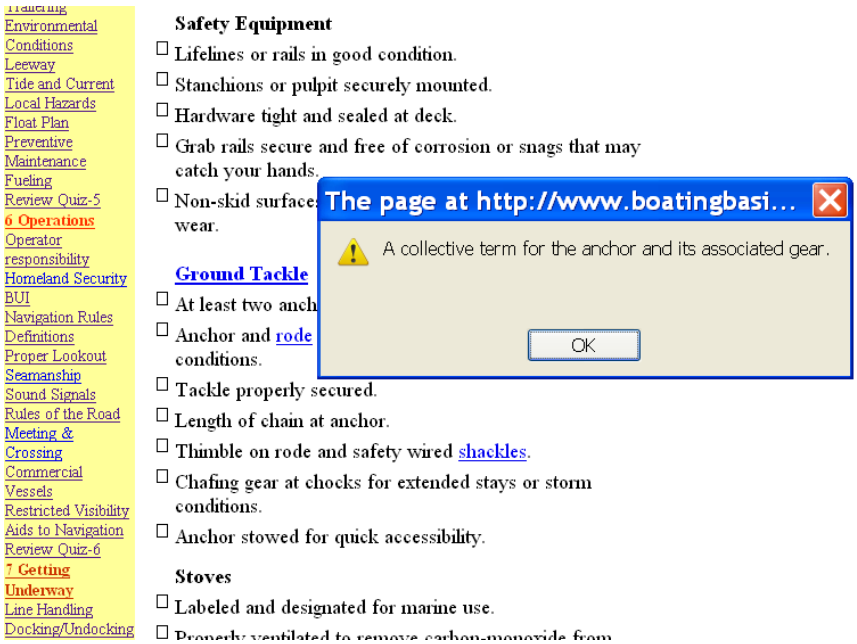

Fig. 13. Interactive text feedback with explanations

6. Results

Table 1 shows the usage of these LOs in the eight online boating courses:

Interactivity: All eight courses adopted more non-interactive LOs than interactive LOs. Course 4 did not have any interactive LOs, while Courses 2 and 7 only offered interactive text feedback. Interactive text feedback was the most popular genre of interactive LOs available for seven courses. Five courses used interactive graphics, but the number was relatively small. Course 8 adopted more interactive LOs than the other 7 courses.

Genre: Non-interactive graphics was the most popular genre. Most courses used more than ten non-interactive graphics in each of their learning units. Interactive text feedback was the second most popular genre followed by non-interactive animation. Interactive animation was the least used genre proceeded by interactive graphic. Courses 3 and 8 contained all five genres of LOs in their learning units.

Table 1
Distribution of the genres of the learning objects

Courses	1	2	3	4	5	6	7	8
Number of learning units	9	7	8	9	7	7	10	6
Total number of interactive graphics	2	0	10	0	2	2	0	9
Number of non-interactive graphics/per learning unit								
1-10	7	3	1	1	3	1	3	0
11-20	2	1	5	2	1	3	4	2
21-30	0	2	0	2	0	0	1	2
31-40	0	0	0	1	1	0	1	0
41-50	0	1	2	2	0	1	0	0
>50	0	0	0	1	2	2	1	2
Total number of interactive animations	0	0	4	0	0	0	0	80
Total number of non-interactive animations	0	0	18	0	18	18	5	31
Total number of interactive text feedback objects	65	64	84	0	70	35	81	69

7. Discussion

This genre analysis indicates that non-interactive graphics were the most frequently used genres of LOs, which is not surprising. Also, interactive text feedback was the most popular interactive genre available for seven courses. Two questions emerged while counting LOs during the data collection process: what is the granularity of a leaning object and how we should count a learning object? For example, Fig. 14 shows multiple images, but most of them share the same URL address. Altogether there were three unique image URLs: a bar (one prolonged blast), a dot (one short blast), and a bell (one

stroke on the bell). We counted them as three graphics observing the rule that each graphic had one unique URL. However, different combinations of the three elements illustrate different boating instructions. Should the three visual elements count as three non-interactive graphics? Or should each combination of the elements in Fig. 14 be count as one graphic, which presents a unique instructional context? These two questions suggest a new research field: the managing mechanism of the LOs in digital repositories. Similar to the concerns noted by Tavangarian et al. (2004), a focus on an image without the appropriate text and/or context can produce meaningless LOs, but the identification and management is less complicated.

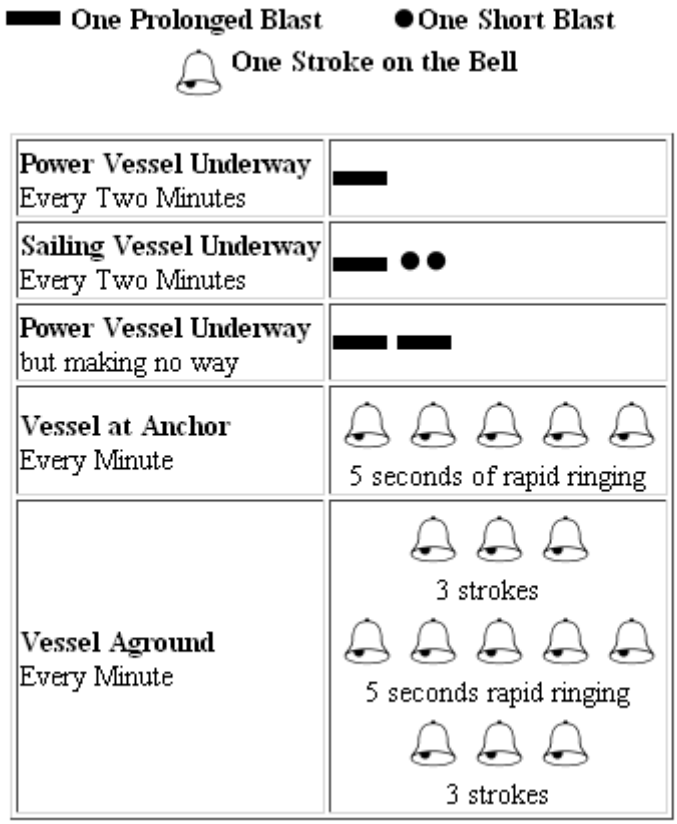

Fig. 14. Counting graphics

Theng, Saputra, Foo, Wei, Raghavan, and Devi (2007) created a prototype of a digital repository, ReLOAMS (Reusable Learning Objects Authoring and Management System) focusing on the reusability of LOs. One unique feature of ReLOAMS is its "deconstructor" module, which "supports the de-construction or decomposition of LOs into smaller units of LO components with a learning objective" (Theng, et al., 2007, p. 1011). Their design approach echoes our observation from this genre analysis, and offers a feasible management mechanism to extract the components of LOs for reuse; to attach contextual information (e.g., learning objective as metadata information) to the components for workflow management; and to reassemble components of LOs for new course units or activities.

Therefore, in order to strengthen the "deconstructor" feature, digital repository designers must be aware of components of various learning object genres. This is necessary for the creation of powerful computational mechanisms to extract meaningful components, assign appropriate metadata information to them, and make LOs reusable.

The results of this genre analysis present a future research agenda on interactivity, design, engagement, and usability identified by Kay and Knaack (2009): how to design interactive LOs to engage learners as well as to create a usability matrix to assess the impact of those objects on learning?

8. Conclusions

This genre analysis illustrates the typologies of the eight boating education courses regarding the genres of LOs. The results indicated that non-interactive graphics were the major learning object genre, and the most popular interactive learning genre was interactive text feedback. Only two courses adopted all the five genres of LOs, and the other six courses did not use any interactive animations. One possibility might be that some course providers had resources to create elaborate animations and interactive features in these courses. The other possibility might be that course developers did not possess sufficient understanding regarding appropriate instructional strategies for using interactive animations. Genres have a direct relationship with instructional design and the impact on the user's comprehension of a specific topic (Kay & Knaack, 2009). In addition, appropriate deconstructing mechanisms of LOs into components affect the management of digital repositories to assist instructors and designers in discovering and reusing LOs in learning units.

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