Multiple Metrics Besides Estimating the Effectiveness of Reusing Learning Objects

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Abstract: Developing perception systems with the ability to provide semantic information is one of the most challenging aspects of modern learning technology. Due to these changes, numerous learning objects are now available in learning object repositories. These materials have been deemed more beneficial than traditional books due to their high potential for reusability. The goal of this study is to investigate the extent to which these learning objects can be reused for various purposes. A case study methodology was employed to examine this phenomenon in a specific context. However, selecting unsuitable learning objects may be less effective than creating the Learning Objects System (LOS) from scratch. Evaluating the usability of these LOS has become increasingly significant, as the number of LOS in repositories continues to grow. This evaluation aids in determining the reusability of LOS.

Keywords: Learning Objects; Technology integration; Design; Classification; Representations; Presentation object; Practice object; Simulation object; Conceptual model object; Information object; Contextual representation object.

1. INTRODUCTION

The popularity of Learning Objects (LOS) is on the rise, as evidenced by the recent surge in the number of learning object repositories (Sultan et al., 2014). LOS can be effectively utilized by multiple users for the same or different purposes in various contexts (Sampson & Papanikou, 2009). An increasing number of students are pursuing higher education online (Stedman & Adams, 2014). The reusability of LOS can lead to economic benefits from educational technology by saving time and improving the quality of learning. However, in cases where unsuitable LOS are chosen, it may be more beneficial to create the LOS from scratch. LOS can facilitate the development and adaptation of content and systems (Sanz et al., 2008).

The purpose of this study is to investigate "Reusable learning objects" in the context of current literature and practice. This includes identifying what works and what does not, and making recommendations for improvements. The study begins with a definition of learning objects and a review of the literature. It then explores the life cycle of learning objects, including their creation, modification, delivery, and reuse. A set of qualities that make sharing and reuse easier and more effective are introduced, with a focus on Software Engineering and Entrepreneurship courses.

1.1. Importance of using learning objects

The most significant advantages of employing learning objects include:

Cost-effectiveness: The prices of textbooks nearly tripled from 1986 to 2004. Using learning objects can save money as LOS developed once can be reused in multiple situations (Kinzie, 2006). Some LOS can be reused multiple times for different objectives in different courses or even across fields (Smith, 2004).

Novelty: Learning objects provide new methods of understanding, visualizing, presenting, and communicating complex issues (Silveira, 2004).

Focus on learning goals: Learning objects direct learners' attention to specific goals, provide instructional activities, and offer opportunities to assess their knowledge.

Ease of modification: Learning objects allow for straightforward course modification, whether for an entire organization or an individual learner.

Integration with Learning Management Systems (LMS): LOS can be linked to and maintained in a course using an LMS, allowing publishers to adjust their work with ease (Smith, 2004).

Advanced functions: Learning objects aid teachers in performing advanced functions such as assigning new skills and topics, improving current skills, supporting the learning process by providing new ways to present learning material, and clarifying complex concepts that are challenging to describe using standard practices. They enable learners to engage in new types of learning that are not available in a traditional classroom setting and promote active learning through motivational activities (Haughey & Muirhead, 2005).

1.2. The Importance of Evaluating Learning Objects

The surge in the number of learning objects and learning object repositories has amplified the need for evaluating learning objects. This allows users to swiftly identify appropriate learning materials (Haughey & Muirhead, 2005).

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Since users often seek LOS with specific features to fulfill a particular role, it is crucial to evaluate learning objects beforehand to ensure the selected LOS can meet the stipulated requirements.

1.3. The Learning Objective's Life Cycles

According to Collis B., Strijker, A. (2004), the LOS process is divided into six steps:

Obtaining: The first step in the LOS process involves obtaining or creating a LOS.

Labeling: This refers to classifying the LOS obtained in the first step.

Offering: The LOS is then stored in a Learning Object Repository where others can find and retrieve it.

Selecting: At this stage, users begin searching the Learning Object Repository for LOS suitable for their needs.

Using: Once the LOS has been selected, it is ready for use.

Updating or Deleting: After using the LOS, we have three options: reuse it, update it in the Learning Object Repository, or remove it from the repository (Sampson & Papanikou, 2009).

1.4. Reusability Effectiveness of Learning Objects

LOS can extend their effectiveness to include new users, multiple learning contexts, and online environments over time. Reusability is influenced by technical, educational, and social factors (Austerweil et al., 2017).

1.5. Framework of Learning Objects Reusability (LOS)

The framework of LOS is described through the following steps:

Identifying Needs: The requirements needed to support learning activities using LOS are defined.

Searching: Users search the Learning Objects Repository for the identified needs.

Creating: New LOS that meet the given parameters are created.

Metadata Creation: Data describing the newly created learning objects are generated.

Approval: Before being made available to users, the provided learning objects in learning object repositories are reviewed.

Modification: If the chosen LOS do not meet the requirements mentioned in the first stage, they are modified.

Disaggregation: The chosen LOS are divided into fundamental elements, with the relevant components for the learning activity identified.

Adaptation: The identified LOS are adapted to match the learning activity's requirements.

Aggregation: The LOS are combined with others, which could come from a repository search or be newly created.

Integration: The LOS are incorporated into the learning system's environment, ready for use by teachers or students.

Evaluation: At this stage, users evaluate the learning objects by providing feedback.

2. METHODOLOGY OF EVALUATION

The reusability of object-oriented software can be assessed through the following stages (Sanz et al., 2008):

Stage 1: Identifying and analyzing the components of learning objects that influence the software's reusability.

Stage 2: Analyzing metadata, the structure of learning objects, and standards to define metrics quantifying the aspects of reusability identified in the first stage.

Stage 3: Creating an appropriate model for evaluating learning objects by combining multiple models based on their capacity to assess learning object reusability.

Stage 4: Evaluating the model in the final stage.

2.1. Reusability Factors Analysis

Several factors influence the reusability of a learning item; these factors could be structural or contextual challenges. Reusable learning items must be:

Self-contained: It is important to understand that reusability can be hindered if there are links to other resources (Sampson & Papanikou, 2009).

Modular: Reusable learning objects should be modular, meaning they can connect to other items to construct composite structures. To support reusability, they should be of the right size and have a specific learning aim.

Traceable: Reusable learning objects should be easily identifiable and traceable through accurate metadata.

Modifiable: Reusable learning objects should be adaptable enough to be adjusted and recast in a different context than the one they were originally created for.

Usable: The interactive interface elements of reusable learning objects should be intuitive.

Standardized: A reusable learning object must comply with a common specification or standard.

These attributes are integrated into factors to determine the efficiency of technical and pedagogical learning objects. The probability of reusing a learning item increases when all these features are enhanced. The reusability of learning objects will be maximized if all these features are improved (Austerweil et al., 2017).

2.2. Technical Features

Learning materials should be easy to download and upload. All files relevant to the required learning object should be compressed. Learning objects should be self-contained and not rely on external elements to function. If the learning object is to be shared, it should be clear how it operates, and a user guide with all necessary information should accompany it.

Affordance: A guide should accompany LOS materials, providing information on how to use them. Whether or not LOS affordance is acceptable depends on the interface and navigation architecture.

Interoperability: To be interoperable, LOS should process data from the repository, adapt to their new environment, and return the relevant data to repositories as needed.

Modifiability: LOS should be flexible enough to serve several users in a range of situations. Therefore, they should be modified to meet their new purpose.

2.3. Educational Features

Independence: LOS should be independent of time and date, not relying on external events.

Location-agnostic: LOS should not be tied to a specific location.

Generality: LOS should be generic and applicable to any subject or discipline. They should differentiate content and outcomes at various levels of education.

Pedagogical neutrality: LOS should be usable in any educational setting and with any pedagogical approach (Austerweil et al., 2017).

Reuse, Re-tasking, and Repurposing: Reuse refers to the process of repurposing a learning object for a different purpose from the one it was created for. Re-tasking refers to the process of applying a learning object in a different environment for different aims. Repurposing is the process of modifying a learning object for use in a different purpose setting (Zimmermann et al., 2007).

3. Classification of Learning Objects in the Learning Objects Repositories

Users must conduct an effective search in learning object repositories before collecting and assessing Learning Objects (LO's) (Sampson & Papanikou, 2009). In libraries, collections are arranged according to their themes. When expanded to various levels, it was necessary to create a classification system to organize by subject matter.

A classification system is a method of organizing all sources of knowledge into basic categories called "classes" and subcategories named "divisions" and "subdivisions." Each subcategory is more specific than the one before it (Rebekah, 2021).

3.1. Fundamental Combined Closed

In his taxonomy, five categories of learning objects are differentiated, which are Combined-open, Generative-presentation, and Generative-instructional. They are classified into three types of knowledge units: Internally interactive knowledge units, receptive knowledge units, and cooperative knowledge units. Their applicability depends on the degree of communication and involvement between the user and the learning products, and also between other learners (Wiley, 2000).

3.2. Types of Learning Objects:

Presentation Objects, Practice Objects, Simulation Objects, Conceptual Models, Information Objects, and Contextual Representations are the six types of learning objects (Churchill, 2007).

3.3. DDC Categories

"Dewey Decimal Classification" is the most widely used classification system. Knowledge is divided into ten categories, each of which is further divided into ten sections, according to DDC. The first numeral represents the class, the second digit represents the division, and the third digit represents the section, with two numbers following the decimal point denoting more specific degrees (DDC, 2007).

4. METRIC OF EVALUATING LEARNING OBJECTS

The metrics apps listed below estimate the reusability of learning objects:

4.1. Learning Object Review Instrument (LORI)

LORI is a tool for assessing learning objects, provided as a service by the website (www.elera.net), which evaluates multiple learning items in repositories (Nesbit & Li, 2004). LORI's evaluation standards are divided into nine categories: Content Quality, Alignment of Learning Goals, Adaptation and feedback, Motivation, Presentation design, Interaction usability, Accessibility, Reusability, Compliance with standards. Every element described is assigned a number from one to five by reviewers; reviewers also provide comments. They can mark the LORI as "not applicable" to the criterion if they believe it is irrelevant.

When a group of reviewers engages in reviewing one LORI, the averages of their evaluations for each element are calculated, creating a cumulative average for all the LORIs. The reviewers' comments are also provided.

4.2. Multimedia Education Resource for Learning and Online Teaching (MERLOT):

MERLOT (www.merlot.org) is one of the most well-known learning object repositories. Some of the learning objects in MERLOT are evaluated and appear first in the results, with the highest rating. The unevaluated learning objects are listed at the end. The MERLOT evaluation criteria are separated into three categories.

The first category is content quality. Reviewers appraise the Learning Object's (LOS) quality level (Amin et al., 2019). They do this based on personal experience and the application of a few concepts.

The guidelines emphasize the need for the original domain with which the learning object is related. The ability to understand the LOS data without external introductory material is deemed more challenging than the others due to its effectiveness as a teaching-learning tool. Students and teachers should employ the LOS in real-life scenarios. Reviewers are guided by a set of questions to determine if the LOS supports learning and teaching processes when used by professors and students.

More questions are provided to reviewers to assess whether the LOS would be useful in future learning scenarios. The questions consider which stage is employed to achieve the LOS objective and the characteristics of the learners who would benefit from the LOS.

The third and final part is Ease of Use. This section assesses the ease with which teachers and students can use the LOS. Reviewers answer questions about the buttons, text, menus, labels, and layout. Reviewers are asked if the instructions for using the LOS are clear, along with any comments on how to use them. The reviewers are also asked about flexibility, documentation, teaching, technical assistance, familiarity, and appeal (Amin et al., 2019).

4.3. The Convergent Participation Model

This metric is an extension of the previously mentioned metric (LORI), as it requires experts to evaluate the LOS using LORI's criteria. These evaluation experts meet in an online conference to discuss their various evaluations and comments about the learning objects. They begin with the learning items with the most variation in evaluation, then move on to the learning items with less variation. Before the end of the conference, reviewers perform a reevaluation of the learning objects and answer a questionnaire regarding the study's goals (Nesbit et al., 2002).

4.4. Digital Library Network for Engineering and Technology DLNET

In DLNET, there are two review processes: peer review, which occurs immediately after a learning object is submitted to the library, and public review, which happens over time based on comments from users who have used the learning object (Rahman et al., 2011).

4.5. Peer Review

The peer-review procedure follows the order listed below: When a learning object is submitted to DLNET, reviewers are notified via email. They are contacted in one of two ways: if they agreed to assess learning objects by registering, or if a learning object submitter recommends them. The object is evaluated using ET criteria by reviewers. Finally, the reviews determine whether the learning object is publishable.

User Review: This is feedback from users who have downloaded and used the learning object. This review form can be found on the website and is distinct from the review form used by reviewers. The review results assign a 5-star rating to the learning object.

The Co-operative Learning Object Exchange (CLOE) is a university collaboration in the development, sharing, and reuse of learning objects. This system uses a peer-review mechanism to analyze all submitted learning objects. The editor-in-chief reviews the learning object to ensure that it is technically sound. If it is not accepted, it is sent back to the author for editing. CLOE reviews are based on three factors: 1. Content quality; 2. Efficacy as a teaching/learning tool; 3. User-friendliness (http://www.cloe.on.ca).

4.6. Learning Objects Reusability Effectiveness Metric (LOREM).

LOREM provides a thorough evaluation of learning objects in repositories. To do so, it adheres to strict evaluation standards that allow only reviewers to evaluate each item (Sultan et al., 2014).

The evaluation criteria are divided into eight categories. Reviewers are divided into three groups, each with different types of reviewers. Guidelines assist reviewers in providing reliable assessments. The systems leverage the principles of authorization and authentication to allow reviewers to analyze LOS only in their expert areas, thereby increasing the reliability of the evaluation process and ensuring a high degree of accuracy.

The first group of reviewers is academic, which includes only two types of reviewers: instructors and subject matter experts (SMEs).

The second group is technical, which includes three types of reviewers: Learning Objects Developer, Learning Objects Designer, and Instructional Designer. The third and final category has only one type of reviewer: students.

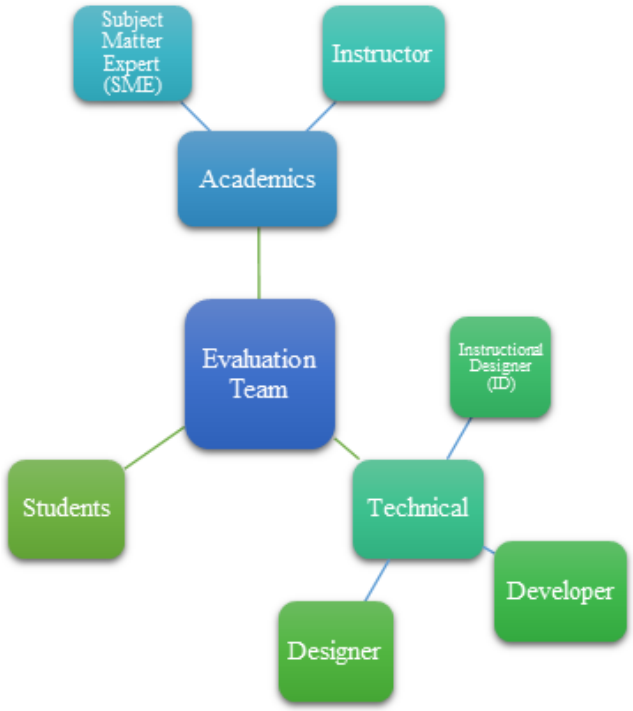

Fig. (1). Hierarchy of Evaluation Team.
Source: (Sultan et al., 2014).

There are three different methods for assessment according to the category: the first is a check box, the second is a five-level rating scale, and the third involves three radio buttons. The system design requires reviewers to leave a comment if they rate an item lower than the acceptable value.

The eight categories are:

1- Retasking & Repurposing: This category aims to measure the possibility of the LOS being reused in a new learning environment and its capability to be customized to meet learning goals.

2- Gender: LOREM enables reviewers to determine if the LOS is more suitable for one gender than the other or is equally suitable for both males and females.

3- Accessibility: This category focuses on the possibility of people with three types of disabilities (sensory, deaf, and blind) using the LOS.

4- Appropriateness: Measures the suitability of the LOS to the topic where it is used and to the target users.

5- Content quality: Covers aspects that measure the LOS quality such as clarity, accuracy, and architecture.

6- Metadata: Measures the quality of metadata which should provide enough information about the LOS.

7- Motivation: This category measures five points to evaluate the LOS's capability to motivate students.

8- Usability: Assesses the ease of using learning objects without any other software and the clarity of the instructions provided.

9- Challenges of Reusing Learning Objects.

5. CHALLENGES OF REUSING LEARNING OBJECTS

It is vital to evaluate the problems associated with reusing learning objects to estimate the effectiveness of their reuse. Therefore, we are focusing on the key challenges to reusing LOS.

5.1. Granularity

Learning object elements can be combined and reassembled in different contexts to satisfy individual needs because reusability is important (Moore et al., 2008). However, if the learning object is too small, managing the pieces will require significant effort.

5.2. Intellectual Property

According to Metros, S. (2005), faculties often do not have the right to use many learning objects. They benefit from them by uploading them to their servers; on the other hand, faculties use the same intellectual property rights and rarely allow for learning object sharing outside of their official publishing model. Academic staff often do not want to upload their learning objects for public use, preferring to maintain control (Koppi et al., 2005).

CONCLUSION

In the field of learning technology, and due to the continuously increasing number of LOS in the repositories, the need for evaluating the usability of these LOS has become more apparent. By collecting and analyzing well-known learning objects metrics and the criteria used to evaluate LOS, we can achieve the following:

- Understand the extent to which learning objects (LOS) are reusable to achieve economic benefits.
- Assist teachers in performing their duties, save costs, and facilitate the evaluation process.
- Develop standards for high-quality learning objects, considering their viability as teaching tools and ease of use.

FUTURE WORK

There is still much work to be done. The methodology presented in this study has a lot of potential because it has only been shown to be valuable anecdotally. However, more research and measurement are needed before solid conclusions can be drawn. Here are some questions to consider for future research:

- What role do the principles outlined in this paper play?
- What courses, disciplines, and teaching styles are the best matches for this methodology?
- Is the technique outlined here effective in increasing teacher productivity and satisfaction?
- What kind of teachers and instructional styles will benefit the most from the application?

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AUTHOR CONTRIBUTION

Dr. M. Alsaigh was responsible for conducting the literature search and study selection. He formulated the research question and wrote the paper.

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No conflicts of interest have been declared by the author.

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