Knowledge Objects and Learning Objects: Birds of a Feather or Different Species Altogether?

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Abstract

Learning objects (LOs) are essential building blocks of Sharable Content Object Reference Model (SCORM)-conformant training and performance support systems, and have been the subject of extensive research, development, and application efforts. A close relative to the LO is the knowledge object (KO) which is undergoing a semantic and structural identity crisis. Some practitioners consider KOs equivalent to LOs; others see KOs as structural components of LOs; still others see KOs and LOs to be ill-defined, unrelated entities. In short, there has been a diversity of opinion about the defining characteristics of KOs, their essential components and structure, and their relationship to LOs. Merrill and his colleagues provided insights on KOs during the exposition of his Instructional Transaction Theory in the 1990s. There has been a recent increase in interest in KOs, evidenced by theoretical and application issues addressed in the International Journal of Knowledge Objects and Learning Objects and related publications, as well as in less formal treatises on the Internet. The premise of this paper is that there is a need for a better understanding of, and utilization guidelines for, KOs used in training and performance support. Specifically, there is a need to address key KO issues such as how to: 1) achieve free-standing KOs, 2) make KOs usable across multiple contexts; 3) define an appropriate tagging standard, 4) standardize KO terminology, presentation tone, and keywords, and 5) facilitate the contextualization of content. In this paper we provide a critical review of KOs and LOs, address KO issues, and make practical recommendations for their effective use. To provide real-world context, we briefly reference ongoing work by the U.S. Defense Ammunition Center to develop and implement KOs in the operational domains of ammunition safety hazardous materials transportation.

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Nina Deibler is a Principal Consultant in the Learning Solutions business unit of SI International, Inc. She has over 12 years of experience designing and developing learning solutions for clients in academia, industry, and government. She earned an MA from Abilene Christian University, an MAS from Embry-Riddle Aeronautical University, and a BA from Grove City College. From 2000 to 2006, Nina was part of the Learning Systems Architecture Lab (LSAL) at Carnegie Mellon University where she co-authored several SCORM related publications including the "SCORM Best Practices Guide for Content Developers." She designed and co-led a successful series of workshops to assist content developers and programmers implementing SCORM-conformant instructional materials. Nina served as a senior instructional designer on the Boeing C-17 Aircrew Training System designing and developing computer, instructor, and simulator-based training for pilots and loadmasters for four years. Nina is currently evaluating and designing instruction and supporting the knowledge management efforts of DAC and the Advanced Distributed Learning (ADL) Initiative.

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INTRODUCTION

Background

Learning objects (LOs) are essential building blocks of reusable training and have been the subject of extensive research, development, and application efforts. LOs comply with the Advanced Distributed Learning (ADL) Initiative's Sharable Content Object Reference Model (SCORM). SCORM encourages the reuse of content in multiple systems and contexts. A close relative of the LO is the knowledge object (KO), which similarly can be considered an essential building block of performance support systems and knowledge management (KM) programs.

The characteristics of KOs, however, are not well understood. Furthermore, there is only modest agreement about the relationship between KOs and LOs as types of digital objects. Some practitioners consider KOs equivalent to LOs; others see KOs as structural components of LOs, while still others see KOs and LOs as ill-defined, unrelated entities. Yet KOs play a critical role in enterprise KM systems (Wiley, 2000a).

Because of their potential impact on KM programs, the learning and knowledge management communities need to thoroughly understand the characteristics of KOs, their essential components and structure, and their relationship to LOs. In addition, practical guidelines for their effective use are needed.

Research Questions

The research reported in this paper was part of a larger knowledge management support program being conducted for the U.S. Defense Ammunition Center (DAC). DAC is responsible for developing and implementing training and performance support in the operational domains of ammunition safety and hazardous materials transportation (HAZMAT). The purpose of this research was to provide a better understanding of LOs, KOs, and their inter-relationships in supporting a KM program. We addressed four key research questions:

RQ #1. What are the defining characteristics of and practical differences among information objects (IOs), KOs, and LOs?

RQ #2 Are there validated techniques for converting KOs to LOs (and vice versa), or do new techniques need to be developed?

RQ #3 How can the lessons learned, best practices, and guidelines identified from previous research on LOs be directly applied to KOs?

RQ #4 How can work being done to develop LOs for courseware be best leveraged to produce KOs for KM programs?

METHODOLOGY

Literature Review

Using the Internet as our primary search tool, we conducted a focused review of the literature on LOs and KOs. Sources included authoritative texts, scientific and technical papers, and professional journals. They are listed under References.

Personal Interviews

In addition to the Literature Review, at a DAC KM Summit Meeting at Oklahoma State University we interviewed instructional design (ID) and KM practitioners, subject matter experts (SMEs) in industry (R. Morris, personal communication, February 19, 2008), academia (D. Biros, personal communication, February 19, 2008), and government (T. Isenberg, personal communication, February 19, 2008). The purpose of the interviews was to assess current concepts, lessons learned, and best practices for the design and development of LOs and KOs.

A detailed discussion of LOs is beyond the scope of this report (see Beck, 2007; Learning Technology Standards Committee, 2002; Wiley, 2002a for more comprehensive treatments). Our paper begins with a summary of key findings relative to digital objects. We examine learning objects and knowledge objects followed by a comparison of the concepts associated with each. These findings support our recommendations and lead to our conclusion.

LEARNING OBJECTS

Overview

Learning objects have been the subject of inquiry in the instructional design, performance support, and KM communities for almost 20 years. The vision for LOs encompasses the reuse and exchange of learning content among multiple learning, education, and training settings, instructors, courses, and institutions.

The fundamental concept behind building and using LOs is that instructional designers can build granular instructional components that can be reused numerous times in different learning contexts or applications. This characteristic of LOs appeals to both educators and technology specialists. It is attractive to educators because of an implicit promise that LOs can facilitate learning by allowing the best and brightest specialists to create learning resources that are easily accessible and can be shared, licensed, or sold to others.

Because LOs incorporate the powerful notion of object-oriented programming and libraries of pre-programmed code, their use appeals to technology specialists. This embodies the dream of reusability of objects that can be gathered and assembled as required to create entirely new learning or knowledge experiences (Advanced Distributed Learning, 2004; Epsilon Learning Systems, 2004).

LOs have been defined in a number of different ways, and there is not a universally accepted definition. Among the most frequently cited definitions are:

- Any entity, digital or non-digital, that may be used for learning, education or training (Learning Technology Standards Committee [LTSC], 2002)
- Any digital resource that can be reused to support learning (Wiley, 2000a)
- A modular digital resource, uniquely identified and metatagged, that can be used to support learning (NLII, 2008)
- A small, self-contained unit of learning ranging from 2 to 15 minutes which can be aggregated into larger collections of content and tagged with metadata allowing it to be easily discovered (Wisconsin Online Resource Center, 2000)

In spite of this apparent diversity, LO definitions generally include common language that specifies content, size or seat time, context and capabilities, and tagging and storage (Mortimer, 2002).

Due to the efforts and cooperation of numerous professional organizations and the vendor community there are widely adopted specifications and standards including SCORM that allow LOs (or in this case SCOs: sharable content objects) to be described, assembled, delivered, and tracked in a systematic and consistent way, regardless of their shape, size, or intended purpose. Among the most cited design goals are reusability, accessibility (discoverability), interoperability, and durability (Advanced Distributed Learning, 2004).

We emphasize that *reusability* implies more than one-time access. For LOs to be accessible/discoverable, some form of knowledge- or document-management is required. Therefore, a consistent indexing scheme is needed to describe the LOs. The Learning Object Metadata (LOM) standard provides a fairly robust ability to describe an object and how it can be used. There is an implicit assumption that some knowledgeable agent, such as an instructional designer or a teacher, will provide the instructional framework or context for the selected object (Epsilon Learning Systems, 2004).

Lessons Learned and Best Practices

Nash (2005) identified lessons learned (LL) and best practices (BP) for the effective use of LOs (and by extension KOs) in instructional design and performance support systems. Although Nash's primary focus was on LOs, many of these lessons learned and best practices apply equally well to KOs and to the LO-KO relationship, and therefore are discussed here.

LL #1. For an LO to be effective in an online course, it must be relevant to the course content, and must materially contribute to the achievement of outcomes.

LL #2. LOs and KOs should be accessible through more than one means of delivery, such as Podcasts and Rapid Syndication Service (RSS).

LL #3. Large LOs or KOs may be unusable if the users are distributed in remote locations where access is poor and/or slow, requiring size optimization.

LL #4. If the LO or KO is small and simple, and easily integrated into an LMS or KM system, it should be treated differently than a large, complex LO or KO.

In addition to the lessons learned, Nash identified enterprise best practices for the use of LOs and KOs.

- BP #1. Classify LOs and KOs by suggested use and employ a standard metadata schema.
- BP #2. Maintain access to the LOs and KOs in a web-based repository.
- BP #3. Use a registry with standardized metadata and classification schemas, such as the ADL Registry, to federate search of repositories.
- BP #4. Instead of trying to classify all LOs and KOs, start small and identify communities of practice (CoP) and use cases, and build support structures for each CoP.
- BP #5. Standardize as much as possible, but remain flexible to enable new types of classifications schemes and informal indices.
- BP #6. Maintain open communications, communicate frequently, and designate someone for questions, clarification, and discussion of alternative classification schemes.
- BP #7. Design LOs and KOs so that they can be reused or repurposed in multiple contexts and delivery modes.
- BP #8. Recognize and design for real user capabilities, skills, and needs.

KNOWLEDGE OBJECTS

Having discussed our findings about LOs and their associated lessons learned and best practices, we now focus on KOs as a close relative to LOs in the digital object family. As with LOs, there are differences of opinion concerning what constitutes a KO as well as about the nature and extent of the relationship between LOs and KOs. This is apparent in the work of three leaders in the field: Gene Bellenger, David Merrill, and William Horton. In this section we review their work on KOs. We discuss their common elements as well as each one's unique contribution to our understanding of LOs and KOs. We conclude our findings with a comparison of digital object concepts and provide a tabular summary.

Gene Bellenger

Gene Bellenger, a proponent of systems theory in business and organizations, distinguishes between an IO and a KO. He defines an IO as *any chunk of information or reusable digital content one can access directly on the Web to support learning.* Examples of IOs are a memo, a graph, or a video.

In comparison, a KO is *an IO that has been meaningfully contextualized. It is a highly structured interrelated set of data, information, knowledge, and wisdom concerning some organizational, management or leadership situation, which provides a viable approach for dealing with a situation* (see Figure 1). What sets KOs apart from IOs is that IOs exist in isolation while KOs include the context which gives them specific meaning Bellenger (2004a, 2004b).

KO = IO + Context

Figure 1. IO to KO conversion equation.

Based on definitions proposed by Ackoff (1989), an early KM proponent, Bellenger also differentiates among data, information, knowledge objects, and wisdom.

- *Data* represents a fact or statement of event without context.
- *Information* is relationally correlated data.
- *Knowledge objects* represent information that has been semantically contextualized with consistent relationships.
- *Wisdom* represents an understanding of fundamental principles within the knowledge.

Bellenger uses a data-to-wisdom continuum to describe the relative value and utility of digital objects measured against two dimensions: context independence and contribution to understanding (see Figure 2). As digital objects increase in context independence and contribution to understanding, they increase in value and utility and can be differentiated. Data objects have the least value and utility; they only contribute to understanding facts. As context independence and contribution to understanding increase, IOs have more value and utility than data objects. Information objects contribute to understanding relations. As context independence and contribution to understanding continue to increase, knowledge objects have the most value and utility. KOs contribute to understanding patterns. Finally, wisdom has the greatest context independence and contribution to understanding. Wisdom contributes to understanding principles. Accordingly, Bellenger's goal in creating KOs is to construct them as independent of context as possible yet still have them contribute to a higher level of understanding. This maximizes value and utility.

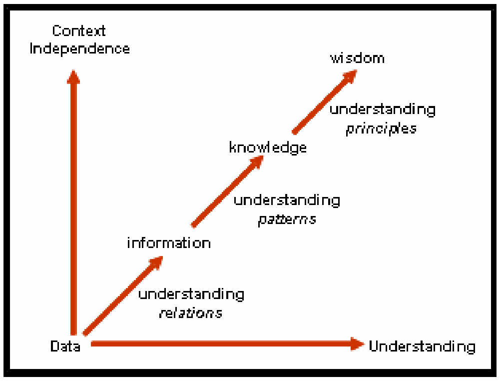

Figure 2. Bellenger's data-to-wisdom continuum.

Finally, Bellenger maintains that establishing reusability is the single, most important consideration when creating KOs. Reusability is defined in terms of two key characteristics, findability and usability.

- *Findability* is the ease with which an existing object can be easily located by someone when it is needed (also referred to as discoverability or accessibility in this paper).
- *Usability* is the extent to which users are able to understand and draw upon the object in their work situations.

David Merrill

David Merrill is a noted academic leader and pioneer of next generation instructional design. Merrill and his colleagues in the Instructional Design 2 (ID2) research Group at Utah State University conducted a seminal program of research in the 1990s and early 2000s investigating various approaches to knowledge analysis, knowledge representation, instructional strategies and instructional-design prescriptions. This research program led to the development of Merrill's Instructional Transaction Theory (ITT) (see Merrill, 1998, 2000, 2002).

In Merrill's view, a KO is *a digital object that consists of structured and organized content, such as text and media objects, without any instructional features*. Using the domain of ammunition quality assurance as an example, a KO can be visualized as a container (e.g. ammunition surveillance methods) that has compartments for different related knowledge elements (e.g., examination methods, testing methods). The individual knowledge elements within a given compartment may differ, but the nature of the knowledge element (e.g., examination methods) in a given compartment is always the same. Thus, the framework (i.e., structure and internal organization) of a KO will be the same for different topics (e.g., quality assurance versus transportation) within a larger subject domain (e.g., ammunition).

KOs can have an associated name, portrayal, and description. The name contains one or more symbols or terms that reference the knowledge. The portrayal is one or more multimedia objects (text, audio, video, graphic, animation) that will show or represent the knowledge object to the user. The description provides a place for an author to place any desired information about the knowledge object, such as metadata.

Although Merrill has continuously expanded and refined his concept of a KO there are three consistent elements. Specifically a KO provides 1) a precise way to describe the subject matter content or knowledge, 2) a mechanism for organizing a knowledge base of media resources and 3) a framework for identifying and categorizing knowledge components.

However, Merrill points out that although KOs can be used to support instruction, they cannot be considered as LOs as such because KOs lack instructional features. Therefore, to convert a KO into an LO the designer must combine the KO with four key ingredients shown in Figure 3.

LO = KO + Learning Objective
+ Instructional Strategy
+ Learning Activities
+ Assessment

Figure 3. KO to LO conversion equation.

William Horton

A third significant contributor to our understanding of KOs is William Horton, an e-learning practitioner, consultant, and author. Horton defines a KO as *a chunk of electronic content that can be accessed individually and that completely accomplishes a single goal* A KO is considered to be individually accessible if the user can navigate to and find the KO without having to go through other content. KOs can be used for education, training, quick reference, and performance support.

Horton (2001; 2006) contends that there are three parts of a KO: 1) a goal, 2) content, and 3) support materials. The goal indicates what the KO will accomplish, what concept it must teach, what skill it must convey, or what question it must answer. Content involves specifying how you will meet the goal, by identifying sub-modules to be completed or specific experiences.

Support materials include such items as an introduction, motivation techniques, exercises and assessments, a summary, and keywords. Depending on the type of support material, this definition closely resembles Merrill's definition of an LO as depicted in Figure 3.

According to Horton, there are several KO levels that exist in a hierarchical structure and a KO's content depends partly on its level in the hierarchy. For example, the content of higher-level KOs consists primarily of middle- or lower-level KOs. At the lowest level is a bottom-level KO that specifies the content necessary to accomplish the goal without referring to subordinate KOs. The bottom-level KO content consists of learning experiences (e.g., presentations, activities) necessary to accomplish the goal.

Figure 4 illustrates content that could be contained in one of Horton's low-level KOs. Horton recommends developing a specification form for each KO that contains categories for key information about the KO such as name, feedback, summary, motivation, and support (see Horton, 2001 for examples).

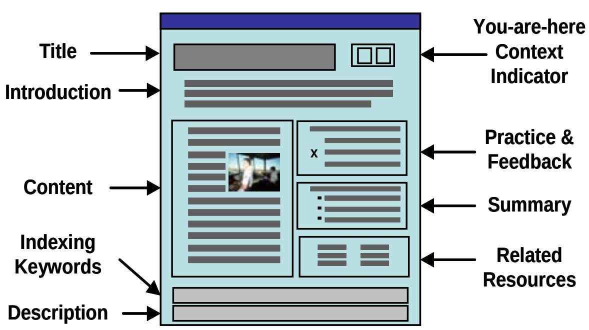

Figure 4. Content for Horton's bottom-level KO.

The effective use of KOs for instructional and performance support requires determining the tasks that workers accomplish and the knowledge they require to perform their jobs. Horton proposes using an analytical technique known as "knowledge ecology" to analyze the flow of knowledge within an organization.. It does this by identifying the performance changes necessary to accomplish a business goal.

A critical step in the knowledge ecology technique is identifying the individuals whose actions are critical for accomplishing the enterprise goal, the decisions they need to make, and/or the problems they are trying to solve. By analyzing how the work is structured and performed, Horton maintains that one can deduce what kinds of knowledge and which specific KOs are required at the goal, job, and task levels.

Finally, Horton proposes that three kinds of knowledge are required to perform tasks and jobs and to achieve organizational goals. *Strategic knowledge* is required to translate the goal into a sequence of tasks. It includes deciding what jobs must be performed to meet the goal and what tasks are required to complete each job. *Procedural knowledge* is required at the task and action level. Workers need to be able to perform the required steps. *Conceptual knowledge* is required to understand the choices and decisions workers have to make to accomplish the tasks using the necessary knowledge. Horton maintains that systematic consideration of these three types of knowledge suggest the types and number of KOs required.

COMPARISON OF DIGITAL OBJECT CONCEPTS

In the previous section of this paper we characterized LOs, IOs, and KOs, and discussed how three leaders in the ID and KM fields, Gene Bellenger, David Merrill, and William Horton conceptualize the different types of digital objects. Horton's definition of a KO more closely resembles Merrill's definition of an LO, while Merrill's definition of a KO accounts for LOs as more comprehensive digital objects that include KOs. Table 1 provides a snapshot of the significant findings. It indicates that, while there are differences between the definitions, content, and structure of KOs and their relationship to IOs and LOs, there is sufficient common ground to derive recommendations for developing KOs and facilitating the interchange of LOs and KOs. We set forth these recommendations in the following section of this paper.

RECOMMENDATIONS

Our recommendations cover four areas: terminology, processes, categorization and discoverability, and technical format.

Terminology

Our analysis of the contributions of Nash, Bellenger, Merrill, and Horton reveals the defining characteristics and practical differences among the digital objects

Table 1. Comparison of Digital Object Concepts

Contributor	Conceptualization
Bellenger	A KO is a highly structured interrelated set of data, information, knowledge, and wisdom concerning an organizational, management or leadership situation. A KO provides a viable approach for dealing with a situation. KOs are IOs plus meaningful context.
Merrill	A KO is a digital object that consists of structured and organized content, such as text and media objects, without any instructional features. A KO provides 1) a precise way to describe the subject matter content or knowledge, 2) a mechanism for organizing a knowledge base of media resources and 3) a framework for identifying and categorizing knowledge components. KOs include IOs as media objects. An LO is a KO plus instructional features.
Horton	A KO is a chunk of electronic content that can be accessed individually. A KO completely accomplishes a single goal. KOs have a goal, content, and support materials. KOs can exist in a hierarchical structure. Strategic, procedural, and conceptual knowledge are required to achieve organizational goals. KOs can be parts of LOs

discussed in this paper. IOs, KOs, and LOs share basic elements and similar family characteristics. LOs are derived from KOs, which in turn are derived from IOs. Definitions of the digital objects should reflect this common class membership.

Accordingly, we synthesized definitions from the authors' contributions. We propose defining the three digital objects so that value and utility are added as one proceeds from IOs through KOs to LOs. This is consistent with Bellenger's data-to-wisdom continuum shown in Figure 2.

- An *information object* is a granular, reusable chunk of data or reusable digital content one can access directly that contains no context or associated learning objective, activities, strategy, or assessment.
- A k*nowledge object is* a highly structured and interrelated chunk of contextualized content that contains no associated learning objective, activities, strategy, or assessment. It is an IO that has been at least partly contextualized.
- A *learning object* is a collection of IOs and KOs with meaningful context, and with associated learning strategy, activities, and assessment that support a learning objective.

We recommend that the learning and KM communities consider adopting these definitions of IOs, LOs, and KOs along with the equations shown in Figure 5.

Processes

KOs can be used to create LOs and LOs can be decomposed to become KOs. Learning and KM practitioners should begin to consider the potential use of KOs as LOs, and LOs as KOs very early in the design process to ensure that each contains the appropriate components and is structured properly during the development phase.

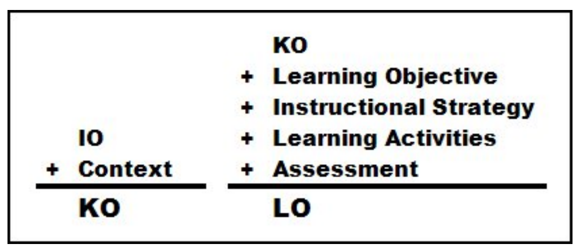

Figure 5. IO, KO, and LO inter-relationships.

Ensuring the appropriate structuring of KOs and LOs will involve changes to the enterprise content development processes of most enterprises. It may also require the re-training of content developers and KM personnel in techniques for creating KOs and/or LOs with relatively low levels of context, with the understanding that users will add higher levels of context to reflect their unique learning or job performance situation. Practitioners must shift the focus of design and development efforts from "course development" to the development of highly granular objects that could serve as KOs when appropriate, but that at a minimum can also be combined with the appropriate ingredients to create meaningful LOs.

Providing the appropriate context is critical for maximizing the value of both KOs and LOs. Hill and Hannafin (2001) noted that, rather than a digital object's meaning being contextually fixed from its inception and defined within a single context, the relevance as well as meaning of the object is continually redefined by the changing context of its use. Thus, developers, instructional designers and knowledge managers can introduce a given object across a wide range of different contexts. Users will assign its meaning by the particular situation.

For example, when developing LOs for a course in HAZMAT Transportation the ID should ensure that the content, independent of instructional strategy is granular enough that portions are suitable for multiple audiences (e.g. certified shippers, vehicle operators, quality assurance inspectors, and warfighters) and purposes (on-the-job performance support as well as courseware).

In this example, KOs act as job aids describing how to complete HAZMAT shipping papers. When combined with learning activities the KOs demonstrate how to complete each section of the shipping papers. Adding an assessment of the learner's ability to complete the shipping papers creates an LO that could be used by all of the audiences previously described.

Likewise, when capturing knowledge from recently deployed or retiring ammunition personnel and transforming it into KOs, KM practitioners must ensure that the content and structure of the resulting items meets the structural requirements for KOs defined in this paper.

As proposed by Horton, practitioners should identify and develop exemplary representations of *strategic*, *procedural*, and *conceptual* learning. The representations from the school house and operational environments can be developed and delivered as KOs and LOs using the process defined above and the categorization and discoverability recommendations described below.

Categorization and Discoverability

KM personnel need to properly identify and categorize KOs so that they and content developers can locate and reuse the KOs. A critical step in properly categorizing enterprise content for reuse is the development of a comprehensive and usable object-oriented taxonomy or activity-oriented taskonomy, or a taxonomy of tasks, (Cichelli and Shimp, 2007; Dougherty and Keller, 1985) with sufficient breadth and depth to address both instructional content development and the development of KOs.

KOs must be easily discoverable to maximize their usability and reusability in performance support and learning applications. We recommend the following activities to facilitate the discoverability, usability, reusability, and conversion of KOs and LOs:

- Development of standard metadata schema based on the IEEE LOM and a standard metadata vocabulary.
- Registration of LOs and KOs in the ADL Registry.
- Storage of LOs and KOs in a central, web-based repository.

Technical Format

Epsilon Learning Systems (2005) suggests that, while metadata could (and should) be maintained in a separate (relational) database, it is advantageous to include it directly in the structure of the KOs. To accomplish this, learning and KM practitioners need to author KOs and LOs using a standard XML content schema such as DITA (Darwin Information Typing Architecture) or S1000D. This will allow more control over output formats including html, PDF, Flash, and plain text as well as integration of metadata. Structured KOs should be developed and managed in an object-oriented repository to enable dynamic assembly at the time of need to meet the content developer's or learner's precise requirements.

CONCLUSION

In the past LOs and KOs, as essential building blocks for SCORM-compliant training and performance support, have often been developed for different purposes and applications, with little regard for their interrelationship. This practice affects their structure, content, and reusability. Unfortunately, this state of affairs has resulted in the training, performance support, and KM communities often failing to use LOs and KOs effectively and efficiently.

Based on our findings we judge it is reasonable to state that LOs and KOs may not be directly interchangeable without some degree of modification. These differences need to be recognized to enable the effective and efficient use of digital objects in the future.

However, this is not to say that the effort required to convert one form of digital object to the other minimizes their ultimate value and utility. Initially, in the spirit of develop once, use many times, some of the effort required to convert LOs to KOs and KOs to LOs will be manual. That said, by employing the recommendations provided in this paper, practitioners will be able to not only design and develop KOs and LOs more quickly and efficiently, but also will be able to convert KOs to LOs and LOs to KOs virtually automatically. If properly implemented, this strategy can result in a significant savings in time and resources.

Since KOs and LOs are functionally and structurally interrelated, KOs can be used to create LOs and LOs can be decomposed to become KOs. Likewise, practitioners will be able to leverage the development of individual KOs and LOs to expedite the development of related KOs and LOs using DITA or S1000D as the XML structuring schema.

How we choose to characterize and conceptualize objects or entities, be they digital or otherwise, has a great effect on how we think about their value and utility in our everyday and professional thoughts and actions. Given the similarities and differences between the types of digital objects reviewed in this paper, we propose that the science of learning and performance support will be best advanced if we consider LOs and KOs as birds of a feather, and not as different species altogether.

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