SCO Trek The Next Generation: A New Trend To Enhance Reuse

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ABSTRACT

Since the first draft version of the Sharable Content Object Reference Model (SCORM) was developed in 1999, many organizations have tried to implement it by using many different methods. Although we've seen SCORM progress over the past four years, there is still some ambiguity on what constitutes a Sharable Content Object (SCO). We do know that a SCO is a collection of one or more assets that make up a course of learning. However, SCORM does not actually define the size of a SCO. It can be a single HTML page or a series of HTML pages. It can be as simple as a job aid, as short as five minutes in length, or as long as needed. Additionally, it can have different levels of reusability and sharability depending on individual and program needs. Based on our research partnership with the Joint ADL Co-lab and our experience of designing SCORM compliant Web-based training for various sponsors, we believe the Advanced Distributed Learning (ADL) community should consider adopting a variety of standard SCO categories. The purpose of this paper is to describe these SCO categories, and to propose that the ADL community study them further and consider adopting them for consistency across the training community. This paper will discuss the proposed SCO categories, explain why they are important, and provide examples of how they could be used in a Web-based training course on Cryogenic Engineering that was sponsored by NASA and the Florida Space Research Institute. Proposed SCO categories include: Course, Course Strategy, Section, Lesson, Learning Objects, Content Objects, Job Aids, Transitions, Test Items, and Raw Media.

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The University of Central Florida's Institute for Simulation and Training (IST), in conjunction with the Florida Space Research Institute (FSRI) and National Aeronautics and Space Administration (NASA), is developing a web-based training prototype entitled Introduction to Cryogenics. The development of this prototype stems from NASA's desire to create an Advanced Learning Environment (ALE) that will capture the knowledge of NASA's aging workforce. As appropriately stated by Cavanagh and Metcalf (2002):

> Currently NASA is facing a potential crisis. At the Kennedy Space Center and Cape Canaveral Air Force Station alone nearly 60% of the workforce will reach retirement age within the next few years. Capturing the knowledge of the experienced workforce, as well as preparing and supporting the next generation of aerospace workers, is critical to ensure the success of future military and commercial space operations (p. 2).

Funded by the State of Florida and developed by FSRI, the ALE contains many important aspects of web-based training, all of which are designed to incorporate the evolving Sharable Content Object Reference Model (SCORM) standards. The SCORM is a collection of specifications adapted from many sources to provide a plethora of e-capabilities that enable interoperability, accessibility and reusability of web-based learning content. This reference model aims to coordinate emerging-technologies and commercial and/or public implementations (http://www.adlnet.org).

At NASA, working with cryogenic fluids is a precise and dangerous task. Cryogenic fluids such as liquid oxygen and liquid hydrogen are used to fuel the space shuttle. Just transporting these fluids and off-loading them from the tanker trucks to the 800,000 gallon holding tank can be quite an undertaking. Any minor mishap during a tanker off-load shuttle fueling can turn into a catastrophe due to the volatility of these fluids. The challenge of creating a web-based training course on cryogenics is that it needs to be created with the sense of danger and urgency that hands-on training provides, while still being just as effective.

Additionally, NASA spends a large sum of money over a lengthy period of time training engineers and physicists on the intricacies of Cryogenic Engineering for the Space Shuttle Launch Program. Besides capturing the knowledge of the aging workforce, the purpose of the Introduction to Cryogenics prototype is to design a Web-based application that will run in the ALE, and effectively train more cryogenic engineering students over a shorter period of time with less funding than current training provides.

By creating reusable chunks of content, many aspects of the Introduction to Cryogenics prototype, such as cryogenics engineering basics, may be used for space applications and applications in other fields. In the past, our design team has worked with the SCORM model, along with the design and development of Sharable Content Objects (SCOs).

Although the SCORM has progressed significantly over the past four years, there is still some ambiguity over what constitutes a SCO. Currently, a SCO is defined as an independent chunk of instructional content that can stand alone to teach a skill or concept or can be combined with other SCOs to create a larger course of instruction. Following SCORM specifications, a SCO represents the lowest level of granularity of content that can be tracked by a Learning Management System (LMS) using the SCORM Run-Time environment. In order for SCOs to be discoverable and ultimately reused, accompanying metadata provides the important descriptive information about an object. (Tanner, Hamel, Blickensderfer, and Caudill, 2002)

Many partners we have worked with in the ADL community have provided feedback and expressed interest in creating a more useful and robust method of reusing SCOs to design instruction. Based on this feedback and our previous experiences, the Introduction to Cryogenics prototype provided our design team with a unique opportunity to further study how SCOs could be applied to Web-based training applications for NASA's Advanced Learning Environment (ALE). Our design team would like to propose in this paper ten different categories of SCOs that we believe organizations in the Advanced Distributed Learning (ADL) training community

should consider adopting. These SCO categories include: Course, Course Strategy, Section, Lesson, Learning Objects, Content Objects, Job Aids, Transitions, Test Items, and Raw Media.

CREATING SHARABLE CONTENT OBJECT (SCO) CATEGORIES

While designing previous Web-based training applications, our design team used three different categories of SCOs, each of which had accompanying metadata. These three SCO categories included: Course SCOs, Learning Object SCOs, and raw media SCOs. Currently, SCORM does not actually define the size of a SCO. It can be a single HTML page or a series of HTML pages. It can be as simple as a job aid, as short as five minutes in length, or as long as needed. Additionally, it can have different levels of reusability and sharability depending on individual and program needs. This ambiguity about SCOs led our design team to propose the ten different categories of SCOs and how to apply them to Web-based training, specifically to our Introduction to Cryogenics prototype. Designing these SCO categories with accompanying metadata would help address the training community's need for different levels of content reuse. In some cases, an entire course may be shared or reused, while in other cases, a lesson, a learning object, test items, or even interactive job aids/training tools may be shared or reused. The level of reusability/sharability depends on the audience, the content, and the environment. The purpose of this paper is to describe each type of proposed SCO category and how it could be useful in a web-based training application, specifically NASA's Introduction to Cryogenics prototype.

Course SCOs

Course SCOs are considered to be at the largest possible level of granularity. Course SCOs are rarely shared or reused because most organizations have training needs unique to that organization or company. The only time an entire course might be reused or shared is if the audience, content, and the environment are the same or nearly the same.

Additionally, an entire course of instruction has a practical application from a sharability standpoint when it comes to research purposes. For example, our design team created the Introduction to Cryogenics course specifically for newcomers in the cryogenics field. The entire course consists of three main sections, an Introduction, cryogenics basics, and liquid oxygen (LO2) tanker off-load. The cryogenics basics section is highly reusable while the specific application of cryogenic engineering (a Liquid Oxygen (LO2) tanker off-load), is specific only to NASA's Space Shuttle Launch Complex. However, with NASA permission, the entire course could be used for research by the University of Central Florida's engineering department. Students could take the course to study cryogenics basics and a specific application of cryogenics. They can receive first-hand experience about the dangers of cryogenics by seeing how it is applied in a real world situation, even if they don't end up working for NASA's cryogenics team. Taking the entire course may help students to decide whether they really want to work in such a dangerous environment, where precision could mean the difference between life and death. NASA can even collect data on what intermediate or advanced level engineering students know about cryogenics before they graduate. They may then assist the University of Central Florida Engineering program in designing curriculum specifically for NASA or the aerospace industry. In this case the audience (engineering students) and environment (university) are not the same as the audience and environment taking the Introduction to Cryogenics course for NASA. Yet the same course can be used.

Course Strategy SCOs

A course strategy SCO is a course outline listing all the lessons, topics, and subtopics that have been pulled together to create a course of instruction. This can be useful to course designers searching for reusable content because it can provide them with a list of lessons and topics they can use to compare and contrast with their own strategy.

Introduction to Cryogenics

Section 1: Introduction
- 1.1: Overview

Section 2: Cryogenics Concepts
- 2.1: What is Cryogenics
- 2.2: Thermodynamic States

Section3: LO2 Tanker Off-Load Operations
- 3.1: Tanker Operation Preparations
  - 3.1.1: Support Preparations
  - 3.1.2: Safety Preparations
  - 3.1.3: LOX Storage Preparations
- 3.2: Tanker Off-load Procedures
  - 3.2.1: Pre-fill Operation
  - 3.2.2: Fill Operation
  - 3.2.3: Post-fill Operation

Figure 1: Introduction to Cryogenics Course Strategy

More than likely, the course strategy will not have all the information they want in the sequence they want it. However, these designers can use an existing course strategy to pull together or list their own ideas. Designers may have to make minor or major changes to their course strategy, but the benefit of having an existing strategy can be useful from a time constraint and idea creation perspective. Course designers from a wide range of environments with different audiences or students may find a Course Strategy SCO useful.

Section SCOs

A section SCO is more detailed than a Course SCO, although it is still relatively large in granularity. The possibility is higher that an entire section of a course could be reused or shared more easily than an entire course. However, there are still many problems that may arise by trying to reuse an entire section of a course for other than purposes of research. For example, refer to Figure 1, the Introduction to Cryogenics course strategy. Compare the sections on Cryogenic Concepts to LO2 Tanker Off-Load Operations. More than likely, the section on Cryogenics Concepts could be reused or shared among several audiences and environments, as long as there are not detailed references to Tanker Off-load operations. However, the section on Tanker Off-load operations is very specific to NASA's Space Shuttle Launch Complex. Although certain aspects of a tanker off load could be used for other applications, the majority of the content is too specific to the NASA audience and environment to be applied elsewhere. Yet, in many cases where there are similar audiences and environments, having the ability to search and pull in entire sections of a course can be more efficient than trying to pull together very tiny chunks of content to create a course of instruction.

Lesson SCOs

Generally, lesson SCOs are more sharable than Section SCOs. Lessons come in all different sizes, ranging from a few screens to many screens. But what constitutes a lesson SCO?

Lesson SCOs are chunks of content containing several Reusable Learning Objects (RLOs). RLOs are small chunks of reusable content that can stand alone to teach a skill or concept. Lessons however, may or may not be reusable and sharable depending on an organization's needs. Take for example the University of Central Florida's Engineering Department and its use of the Introduction to Cryogenics course. Novice level learners may not have any use for a lesson on Thermodynamic States, nor will they have a use for a lesson on Tanker off-load operations because it is too advanced. An intermediate level learner might have a use for the lesson on Thermodynamic States, but the lesson on Tanker Off-load operations is still too advanced, or not even in their specific field of interest. However, an engineering student that wants to specialize in cryogenic engineering, specifically for NASA, may have a need for both lessons. Once again, it depends on the needs of the individual or organization, the environment, and the type of content involved.

Many may ask what the point is of reusing an entire lesson if you can just pull together three or four learning objects to make that same lesson. The answer would be convenience. If a course designer can find an entire lesson containing the content he or she needs, then it would make no sense to search for several different learning objects, and try to create transitions so the learning objects flow together to form a lesson. A lesson SCO will be used more often than a Section SCO, but not as often as a Learning Object SCO.

Learning Object SCOs

Most instructional designers consider the Learning Object level to be the standard SCO in a course of instruction. Many course designers will not have a need for an entire existing lesson. Many will, however, only want small or granular chunks of content that can easily be reused for many different training situations. Learning Objects usually consist of several small topics strung together, each not more than few screens worth of information. In most cases, the small topics that are strung together to form that Learning Object may make the Learning Object completely reusable. However, a topic can easily be deleted, or added to the Learning Object to fit individual's or organization's needs. Rather than design an entire chunk of instruction from scratch, it is more convenient to use a Learning Object that already exists and only have to make minor adjustments (adding or deleting content) to fit your audience's needs.

The figure below shows how different categories of SCOs are used in the Introduction to Cryogenics Course. If you look at one of the Learning Object SCOs entitled "Ideal vs. Real Gases," note that theoretically it could just as easily be constituted as an entire Lesson Object with its own set of unique Learning Objects in an Engineering course at University of Central Florida: a prime example of a different level of granularity for an entirely different organization.

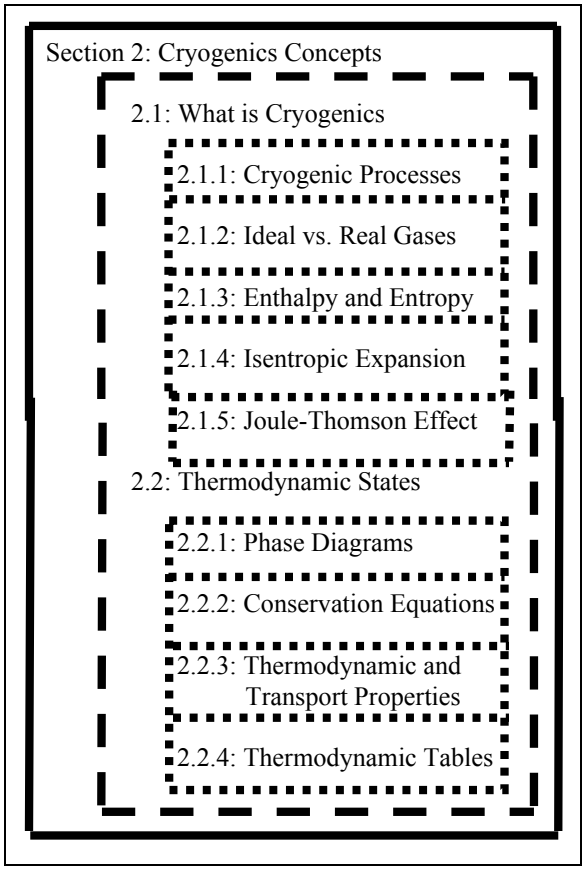

Figure 2: Breakdown of Section, Lesson, and Learning Object SCOs in the Introduction to Cryogenics course:
Solid line – Section SCO:
Dashed line – Lesson SCO:
Dotted line – Learning Object SCO:

Content Object SCOs

Content objects are very small chunks of information that can be reused. They can include, but are not limited to definitions, examples, acronyms, or sample questions. For example, in the Florida Space Research Institute's Introduction to Cryogenics course (2002) the definition of thermodynamic state is: *the condition of the system described by the values of its properties, such as temperature, pressure, and density*. This definition may be shared or reused in many different courses of instruction. Rather than search for terms and definitions within an entire Learning Object or lesson, designers could search for that term in a database of small objects that might only include definitions. Ideally, users would specifically type in that they are searching for a 'definition style content object' called thermodynamic state. If they want an example of a thermodynamic state, they could search for an 'example style content object' called solid, liquid, or gas. Content Objects can be very useful when a course of instruction is heavily enriched with definitions and examples. The course designer is saved the extra time it takes to create and research definitions, examples, acronyms, and sample questions.

Job Aids SCOs

Job aids are highly important aspects of training and can be interactive or static. Most of the time job aids are used as reminders to help users complete a task. For example, they can be as simple as a quick handheld fact sheet, reminding people which types of household chemicals are lethal or non lethal, mixable or not mixable. They may also be designed for online or Web-based training use. In some cases they can be reused or shared, and in other cases not.

In the Introduction to Cryogenics course, the same job aid is used in each of the tanker off-load lessons. The purpose of the job aid is to help learners identify important objects in the tanker off-load hazardous operations area. Knowing where these different objects are located can mean the difference between life and death in an emergency situation. This type of a job aid could be reused for University of Central Florida engineering students. Although these students do not work in the hazardous operations area at Space Shuttle Launch Complex 39, the hazardous operations job aid could be useful in teaching students the different safety equipment that is used when working with cryogenic fluids. As with Content Objects, searching for specific job aids and key words associated with those job aids can help course designers develop instruction more efficiently over a shorter period of time.

Transition SCOs

Transitions SCOs are basically transition pages that link a set of SCOs together to form a course. They are rarely reusable and are difficult to apply in different contexts. Instead of having several Learning Objects strung together with no transitions between them, transitions help to create a smooth-flowing course for the learner. Transitions help to keep a course flowing smoothly by providing objectives and linking a topic to previous topics in a course of instruction (Tanner, et al 2002). Although the complete content of a transition SCO is not reusable or stand-alone, parts of the content such as subtopic titles, graphic files, or any other raw media files that were part of the SCO, could be placed in a repository for reuse.

In some aspects, a transition SCO is very similar to a course strategy, except it can be used as a specific section, lesson or learning object strategy. Transition SCOs are mainly used as a reference for course designers to see what a specific chunk of content

consists of. While creating metadata, it would be important to include an element stating which topic the transition is coming from, to which topic the transition is moving. More than likely, instructional designers or developers will have to design their own transitions between lessons or Learning Objects, although graphics associated with the transitions may be shared or reused.

Test Item SCOs

Many course designers would prefer to incorporate existing and valid test items into their course, rather than designing test items from scratch. Having the ability to search in a repository for specific test items on thermodynamic states or phase diagrams can be extremely useful for people designing their own course of instruction on cryogenic engineering. Although a complete test on thermodynamics may not be reusable, several questions from that test may be. Once again, it depends on the content, audience, and environment. For example, if a high school teacher is designing an online test for his or her students, he or she would not reuse advanced level questions stored in a repository. That teacher would prefer to choose test items from a category that are classified as novice, intermediate, or advanced to make the search process easier. Additionally, it would be important to note whether the test items were tested for validity and reliability, and the source through which they were tested. The worst thing a course designer could do would be to take test items that are not valid, and use them for his or her own purposes.

Raw Media SCOs

Raw media SCOs include but are not limited to all graphics, audio, and video included throughout a course of instruction. Many Web-based courses of instruction can contain as many as 500 pieces of raw media. Without a proper metadata generator, filling out raw media metadata would be a tedious, time-consuming, and daunting task. However, if this is accomplished correctly, graphics, audio, and video files could easily be reused for other Web-based courses and presentations.

Now that so many people use the World Wide Web, copyright issues have become more prevalent. By creating a repository of Raw Media SCOs, course designers can pull existing raw media deemed as "free." This may help the designer in two ways. First, the course designer does not have to create his or her own raw media, thereby freeing up development time. However, it is possible that the developers will have to create some raw media if they cannot find what they are searching for. Secondly, course designers or even people using pictures for PowerPoint presentations, don't have to worry about whether the picture or video they are using will result in copyright infringement litigation. Most raw media is field specific. However, if you create a large enough repository of raw media, it will begin to satisfy many of the needs of the training community.

ADDITIONAL ISSUES WITH DESIGNING AND IMPLEMENTING SCO CATEGORIES

Creating Metadata Files

One of the most important aspects of creating the ten SCO categories would be creating metadata for each of the reusable items. Creating metadata has proven to be an arduous and time-consuming task. The ability to create effective metadata generators, along with the continued progression of SCORM, will aid course designers and developers in creating more detailed metadata for use across the training community. Figures 3 and 4 show a comparison of how two metadata templates might look using two of the ten SCO categories.

Title: Introduction to Cryogenics
Catalog: --
Entry: --
SCO Category : content object
Style/Type: Definition
Description: Definition of Thermodynamic State pertaining to an Introduction to Cryogenics course
Keywords: Definition, Thermodynamic State, cryogenics
Version: 1.0
Status: Draft
Metadata Scheme: SCORM 1.3
Format: text/html
Location:
http://www.fsri.org/ale/cryogenics_definitions.htm
Cost: no
Copyright: Yes
Contact: Florida Space Research Institute
Purpose: Educational Objective
Description: Intermediate or advanced course
Keywords: intermediate, experienced, advanced

Figure 3. Example of a theoretical Learning Object SCO metadata template

Title: Introduction to Cryogenics
Catalog: --
Entry: --
SCO Category: Test Items
Style/Type: Multiple Choice
Description: Test item on how transport properties are used in cryogenics
Keywords: test item, cryogenics, transport properties
Version: 1.0
Status: Draft
Metadata Scheme: SCORM 1.3
Format: text/html
Location:
http://www.fsri.org/ale/cryogenics_testitems.htm
Cost: no
Copyright: Yes
Contact: Florida Space Research Institute
Purpose: Educational Objective
Description: Intermediate or advanced course
Keywords: intermediate, experienced, advanced

Figure 4. Example of a theoretical Test Items SCO metadata template

Each element of the metadata templates would be considered mandatory. Additionally, the majority of elements would be the same across the templates, with only a few minor changes based on the type of SCO. For example, the Content Object SCO incorporates three additional mandatory elements called 'SCO Category,' 'Style/Type,' and 'Contact.' 'SCO Category' describes which of the ten SCO categories you are storing your content as, discussed in this paper. 'Style/Type' describes the type of Content Object used, in this case a 'definition style Content Object.' Lastly, 'Contact' provides information on whom to contact to receive copyright permissions. The Test Items SCO incorporates three additional mandatory elements as well: 'SCO Category,' 'Style/Type,' and 'Contact.' Both 'SCO Category' and 'Contact' have the same purposes described earlier, while 'Style/Type' describes the actual type of test item used, such as multiple choice, true/false, drag and drop, etc. Other than the elements described above, note that the majority of the elements are the same. Theoretically, all the mandatory elements for a course of instruction can be programmed to automatically fill, based on what was provided in the original Course SCO. The only thing the instructional designer or programmer has to do is add any additional keywords, descriptions, etc.

Advantages of Creating SCO Categories

One of the greatest advantages of creating SCO categories is that they could decrease development time and costs once an effective repository is created along with a good metadata generator. This repository would be able to store all the different types of SCOs for use across the training community. Many course designers have complained that there needs to be more descriptive metadata to create an effective repository. The different categories would help provide more descriptive metadata and allow more content to be available to different audiences in a variety of environments. Although large scale repositories that allow for many different SCO categories do not exist, there is future potential based on the way technology and the SCORM initiative continue to progress. The ability to use existing content for free, or for a small fee can save organizations the expense of creating on-line training from scratch. Although some content adjustments would be required, it would still benefit organizations from a cost-time perspective. Additionally, Instructional Designers, Developers, and Program Managers could save time and money by focusing their concentration on instructional design and development, rather than the time it takes to research content and consult Subject Matter Experts (SMEs).

Disadvantages of Creating SCO Categories

Although there are many advantages to creating SCO categories, there are some obstacles that must be overcome before they can be used effectively. One of the greatest disadvantages is the fact that it will take more work to categorize content into the ten SCO categories. Creating SCOs along with metadata is a difficult task to begin with. Asking course designers to further categorize their content could be more time consuming. Additionally, an efficient metadata generator must be created to assist course designers with the arduous task of writing the hundreds of metadata files needed for an effective repository.

Another disadvantage of Creating SCO categories deals with the use of repositories in general. Tanner, Hamel, Blickensderfer, and Caudill 2002 stated that one of the greatest disadvantages of using a repository for SCOs is that the content in the repository would require constant review and updating (p. 8). Updating repositories is inefficient from a cost-time perspective. Currently, content must be designed for a broad spectrum of users. What good is a repository if it is inflexible or not designed for many different audiences or environments?

Lastly, there needs to be agreement on creating a standard vocabulary for SCO categories along with its metadata elements. Without a standard vocabulary that

is recognized by instructional designers, programmers, and web developers, descriptions of SCO will be meaningless.

Progression of SCOs and Metadata

Developing SCO categories has enormous potential as long as SCORM and metadata generators continue to progress. Having a repository that is flexible and useful for different audiences and environments will be highly beneficial to the training community. A flexible user-friendly repository will help organizations save government, industry, and taxpayer money. Based on our design team experiences, we believe these efforts are possible with the progression of SCORM, efficient and user-friendly metadata generators, and agreement on the vocabulary for SCO categories and metadata elements across the training community.

AUTHORS NOTE

The views expressed herein are those of the authors and do not reflect the official positions of the organizations with which they are affiliated.

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