

Implications of SCORM™ and Emerging E-learning Standards On Engineering Education

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Abstract

The Advanced Distributed Learning (ADL) initiative of the U.S. Government is unifying e-learning specifications emerging from the international standards organizations into a single specification referred to as the Sharable Object Content Reference Model^{1,2,3}, or SCORM™. Today, this specification is now the de-facto standard for e-learning content developed for the Department of Defense and other federal agencies. These standards are stimulating the rapid development of learning repositories. Once deployed, these have the potential of dramatically changing the use of e-learning in engineering education and in the continuing education of practicing engineers.

This paper discusses SCORM™ and other e-learning standards and the impact they are having on developing reusable learning content. The implications of these developments on engineering education and the opportunities they afford for the future education of engineers are also discussed.

The Need for E-learning Standards

Standards Propel E-learning Innovations

E-learning, as we think of it today, dates to the early 1990's during which time software systems for managing e-courses, such as WEST, WebCT and Blackboard, were being developed and marketed. Before that time, the idea of conducting university courses on the Internet was only an afterthought. However, once HTML standards became accepted by the W3C committee⁴, user-friendly web browsers and authoring tools were rapidly brought to market. In a real sense, this started a revolution in education that continues today.

Before the adoption of a single HTML standard by the W3C in 1992, companies were reluctant to invest in the development of browsers and authoring tools that would become obsolete once a standard was adopted. A similar situation recently existed for XML, an evolving standard for the communication of information via the Internet. The W3C adopted the first XML standard in 1998. Shortly after that time, Microsoft upgraded their browser to support this standard. Netscape followed

shortly with a similar upgrade. Today, the XML standard is again launching a revolution in Internet communications.

In the 1990's, Internet standards for HTML, XML, CSS and multimedia content stimulated innovations in e-learning. In the same way, the next revolution in e-learning is on the horizon. New standards are being developed key international organizations for sharing e-learning content across different platforms and different learning management systems.

E-course Reusability & Copyrights

In the late 1990's faculty speculated whether e-courses could reduce education costs. Some speculated that although the costs associated with building high-quality e-courses was high, educational costs might be reduced by conducting large e-courses. One faculty member might be able to teach a larger class. Although cost benefits have been documented in web-assisted traditional classes, the same benefits are yet to be realized in most online courses.

Even in those cases where the topic and instructional design of a course permits teaching it with a higher student teacher ratio, the costs associated with building and maintaining course content are still very high. Some universities are responding by increasing the resources for building e-courses. Some, such as the Texas A&M System, have implemented copyright policies for governing e-courses developed by their faculty. These copyrights are seen as inherently valuable. The expectation is that this e-learning content can be reused for many years. Development costs for an e-course in a core subject, such as engineering calculus, can be amortized over several years.

However without e-learning standards, this assumption is unrealistic. Increased expectations of students for higher quality e-learning experiences, the emergence of new technology, and improvements in Internet bandwidth are happening so quickly that most university e-courses need redeveloping every 3-4 years. E-courses require significant rebuilding to take advantage of technological improvements to remain competitive in the race to produce quality e-learning experiences, even if their content is substantially unchanged.

Large collections of e-learning content can also be lost when learning management systems are changed. Texas A&M University Corpus Christi, for example, recently switched learning management systems after a researching the advantages and disadvantages of competing systems¹¹. Most learning management systems, such as Blackboard and WebCT use proprietary database formats that make it very difficult or impossible to transfer learning content from one system to another or to reuse previously developed content in other courses. Moving a course between systems can be more costly than just redeveloping that course in the new system.

Today it is very difficult or impossible to transfer learning content from one LMS to another. There is a clear need for a common data exchange format for learning content. In the current environment,

significant investments in developing e-learning content in engineering make little sense if it is developed specifically for delivery on a specific LMS.

Collaborative Development of E-courses

Similarly, differences between learning management systems make it difficult for authors to collaborate on e-course projects. This can not only increase the total cost of building e-courses, it can also lower the quality of the course. The better courses require a considerable investment in authoring and development time. Often the content expert, author, is not the person with the technical expertise to encapsulate this content into an online course. Without e-learning standards, authors collaborating on developing an e-course need to ensure that they either restrict their content development to standards-based technology, such as hypertext, or ensure that their learning management systems can share learning content.

Universities are recognizing the inherent value of high-quality online courses developed by their faculty. The Texas A&M System, for example, is looking at the collaborative development of learning content for courses being taught at nearly every campus. These are the core courses in engineering, mathematics, sciences, English, etc. The syllabus for these courses is very similar from one campus to another, and each campus has content experts that can share on a team to develop high quality learning content for these courses. Until now this content has been developed independently at each campus. Collaboration in developing learning content for these courses not only lowers development costs and shortens development time, it can also result in higher quality courses.

However, the collaborative development of courses is very difficult without a standard for sharing that content from one campus to another. The general lack of international standards for packaging e-courses adversely impacts the development of university e-courses in several ways:

1. Since content developed without standard is difficult to reuse in other courses, it contributes to increased development costs.
2. E-course copyrights for e-courses of core content are of little value since they are likely to be obsolete in a few years when learning management systems or Internet technology change.
3. Author collaboration on e-course development is difficult without e-course standards.

SCORM™

SCORM™ History

The federal government spends millions of dollars each year to develop e-learning content, including online courses, courses distributed on CD's and intranets. In the 1990's the government recognized that it was difficult to reuse this content. The Department of Defense, for example, found that the

various branches of the military had developed e-learning content on similar topics, such as management and acquisition rules. Even though those courses essentially covered the same content, it was nearly impossible to share e-content between military branches because they were developed without a common standard, and they were not designed for reuse in other courses.

The government also realized the benefits of an international standard for e-content on the training industry. A common international standard for sharing learning content would stimulate an international learning economy, similar to the economy that is developing around the Internet. If standards allow for reusing learning content developed for one course, then learning content will become a commodity.

As a result, in 1997, the Department of Defense and the White House Office of Science and Technology Policy launched the Advanced Distributed Learning (ADL) initiative. Its primary goal is to develop a learning economy by providing access to high-quality education and training material, easily tailored to individual learner needs and available whenever and wherever needed. To accomplish this goal, the ADL consolidated emerging e-learning specifications from the major international standards groups into a single specification, referred to as SCORM™.

Simply stated, SCORM™ is a set of specifications for developing, packaging and delivering high-quality education and training materials whenever and wherever they are needed. SCORM™-compliant courses leverage course development by ensuring that compliant courses are **RAID**:

- **Reusable:** easily modified and used by different development tools,
- **Accessible:** can be searched and made available as needed by both learners and content developers,
- **Interoperable:** operates across a wide variety of hardware, operating systems and web browsers, and
- **Durable:** does not require significant modifications with new versions of system software.

Although this is a government initiative, it is be wrong to think that this cannot be used in industry and academia. In fact the SCORM™ specifications are a composite of several specifications developed by international standards organizations, including the IEEE⁵, IMS⁶, AICC⁷ and ARIADNE⁸. New versions of SCORM™ are now released every 3-6 months by the ADL^{1,2,3}. Each new release incorporates recent changes and expansions of existing international specification. This process is likely to continue for years to come.

SCORM™ Components

SCORM™ can be described in many ways. The Advanced Distributed Learning Co-Laboratories refer to this as the Sharable Content Object Reference Model (SCORM™). SCORM is described

in terms of the following three components:

- Content packaging²,
- Runtime communications³, and
- Course metadata².

Content packaging refers to the packaging of all resources needed to deliver a course into a single zip file. The format for this file is described by the SCORM™ aggregate model, which is based upon the IMS Content Packaging Specification, version 1.1.2. The zip file contains not only the course files, it also contains an XML file, referred to as the *imsmanifest* file, describing the course contents and content sequencing.

The runtime communications in a SCORM-conformant course are conducted using two elements:

- Runtime commands for communicating student information to and from the LMS, and
- Student metadata for storing information on individual students.

Course metadata are data packaged with a course when it is archived in a SCORM™ repository. These data allow a course author, or student, search a learning repository containing hundreds of lessons and courses and to identify the learning content they want to use or view. For example, the course title, description, keywords, etc. are all considered course metadata.

SCORM™ Course Packaging

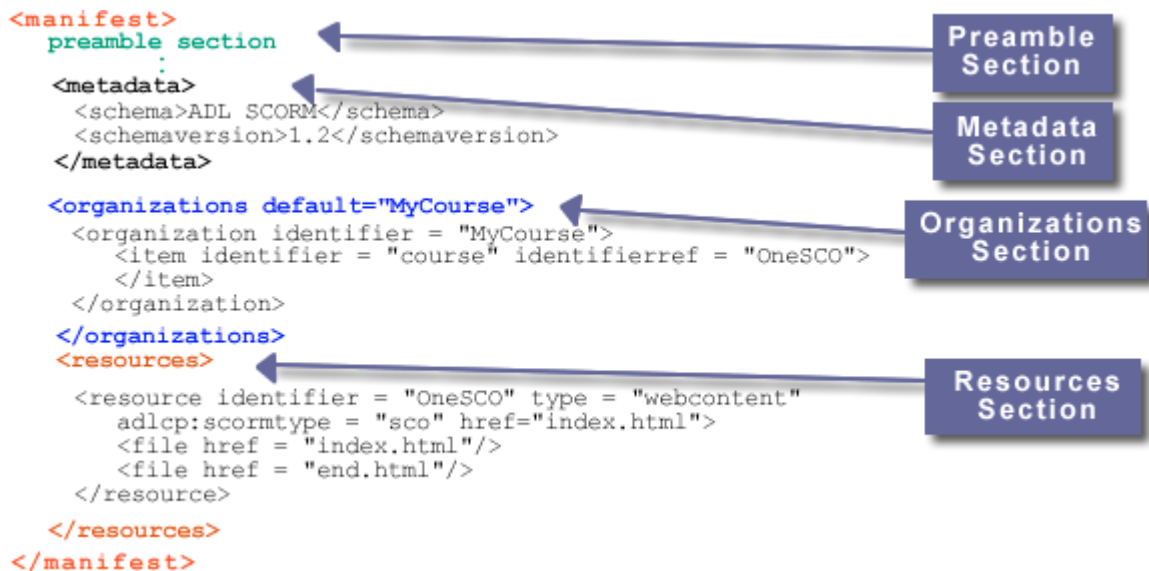
If a course is going to be shared between learning management systems or archived in learning repositories, then the organization and learning assets in the course need to be included with the course. In SCORM™, this description must be included with the course and placed in an XML file with the name *imsmanifest.xml*. The structure required for this file is detailed in the SCORM™ content aggregation specification².

A SCORM *imsmanifest* file consists of four sections:

- a preamble section containing XML pointers to the schemas required for validating this file,
- a metadata section contain global course information, such as its title,
- an organizations section describing course sequencing, and
- a resources section listing all the files used in the course.

Figure 1 is an example of a simple *imsmanifest* file for a course with a single lesson, referred to as a SCO, or Sharable Content Object in SCORM™.

Figure 1. An example imsmanifest.xml file for a simple one-lesson course.



The preamble section in this file is not listed, since its syntax is fixed for all courses. Details for the preamble section are found in the SCORM™ Content Aggregation Model specification². The metadata section can be empty. However, in this example, the metadata section indicates that the schema for this file is the SCORM™ version 1.2 schema, the specification introduced by the ADL in October, 2001.

The last two sections are generally the largest sections. The organizations section contains a list of lessons, or Sharable Content Objects, contained in this course. This example consists of a single SCO, identified as “OneSCO”. That identifier appears both in the organizations section and the resources section. The resources section identifies the assets associated with this SCO. In this case there are two web pages, identified as “index.html” and “end.html,” in this SCO.

A SCO is the smallest unit in a course that:

1. contains meaning learning content by itself, and
2. might be extracted and reused in another course.

Frequently, it makes sense to define a lesson with 1-3 major learning objectives as a SCO. However, it would not be a violation of the SCORM specification to refer to each web page as a SCO. In fact, this is the approach used by the Macromedia SCORM extension. Each web page is treated as a separate SCO. In general, however, each SCO will consist of more than a single web page.

SCORM™ Runtime Communications

Not all courses require runtime communications with the learning management system (LMS). However, many courses contain content that adapt to the learners actions in the course, including scores on assessments and reviewed content. This requires tracking of scores and progress of individual students. This is a major service provided by a LMS. Today, non-SCORM™ learning management systems use proprietary methods for obtaining and tracking runtime information. Generally, this is restricted to assessment scores and simple indications of whether certain learning content has been reviewed. For SCORM™-compliant learning management systems, on the other hand are required to provide commands for reading and writing student information to its database. Currently there are 8 commands available in SCORM™ for communicating 49 different student metadata elements.

These student metadata include:

- 15 elements for capturing the learning state of the SCO,
- 8 elements for describing and tracking learning objectives associated with an individual SCO,
- 5 elements for student language, audio and video preferences,
- 4 elements for tracking a student's progress and time limits for individual SCO's,
- 13 elements for describing and tracking a student's responses and performance on quizzes, and
- 4 elements for communicating data between SCO's and the LMS.

SCORM™ Course Metadata

SCORM™ contains a rich dictionary of metadata terms that can be used for describing course content. These data are not needed, if a course is never going to be archived in a learning repository or shared with other authors. However, the vision of the Advanced Distributed Learning Co-Labs is to create a learning economy in which authors and students will be able to search the Internet for learning resources. This type of searching and discovery requires that courses archived in a repository include not just its content, but also a readable description of that content.

The SCORM™ metadata specification is essentially the IMS Learning Resource Metadata specification, which itself is based upon the IEEE Learning Technology Standards Committee⁹ and the Alliance of Remote Instructional Authoring and Distributions Networks for Europe (ARIADNE)⁸.

A SCORM™ Course

The details associated with each of these components can be very technical. To help the SCORM™

community develop SCORM™-compliant courses, the ASEE and the ADL supported the development of an online SCORM™ course. It can be viewed at <http://www.scorm.tamucc.edu>¹⁰.

The author did the initial work on this course while completing an ASEE summer research fellow at the Joint ADL Co-Laboratory in Orlando, Florida.

Implications on Engineering Education

The emergence of e-learning specifications, such as SCORM™, presents both opportunities and challenges to online engineering education.

Current engineering e-learning content designed to run on non-conformant learning management systems, such as WebCT and Blackboard, will likely require conversion to conform to these specifications. Course assessments and quizzes for example, will not work outside a non-conformant LMS.

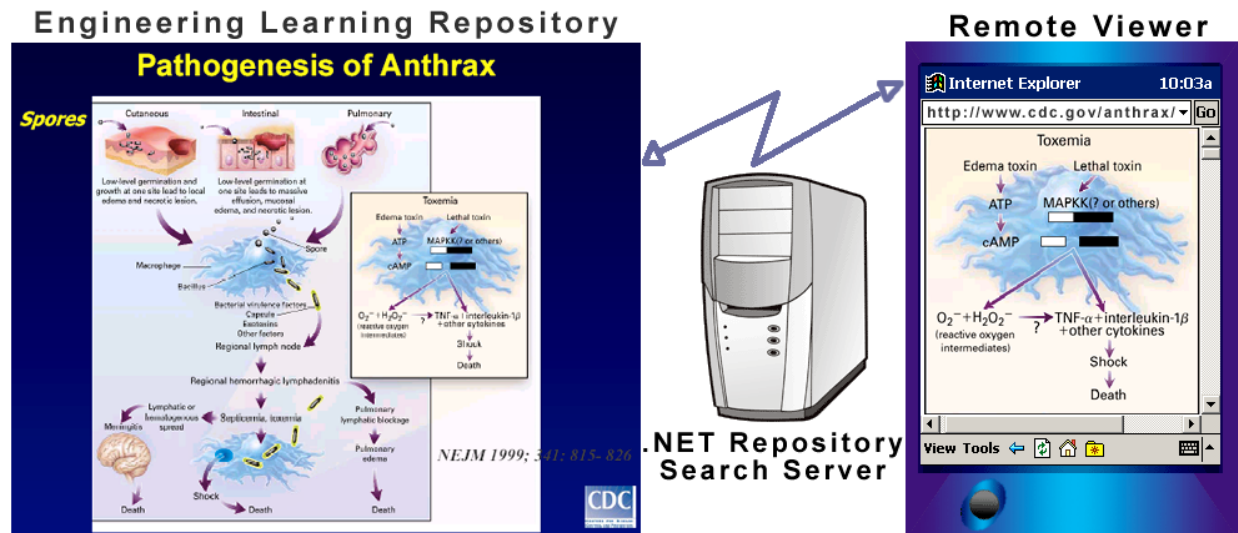
Instructional design will be more important than ever to ensure that not only does the e-course follow good design rules, it can also be incorporated into learning repositories and made reusable. Any content that is suitable for incorporation into other courses should be designed as Sharable Content Objects, SCOs.

This places certain restrictions on what an author can do within a lesson, or SCO. They cannot, for example, place links within a SCO to another SCO. Internal links between SCOs or sharing runtime data directly between SCOs makes it impossible to extract a SCO and reuse it in another course without incorporating the other SCOs. Sequencing between SCOs is controlled by the learning management system using the sequencing description contained in the imsmanifest XML file. Similarly, one SCO is not allowed to communicate data directly to another SCO. These restrictions make it very important to use good instructional design before developing course.

Incorporating quality engineering learning content into learning repositories, makes it feasible to reuse and share learning content from one course to another. Collaborative development of quality e-courses becomes easier and paves the way to providing quality engineering learning content anytime and anywhere. Learning repositories with search engines will create an opportunity for Napster-like companies offering open access to quality online learning content.

Practicing engineers will be able to search the internet for up-to-date learning content. Filters will be developed for viewing that content on a wide variety of devices including wireless devices, such as the newer Windows CE devices. Since e-content will be archived using a common specification, software can be developed to search repositories for content and then adapt that content for display on the end users device, which might be a wireless device online at an engineering site, see Figure 2.

Figure 2. Engineering Learning Repository



As of 2002, there were over 40 learning management systems that are SCORM compliant. Microsoft now offers version 3.0 of their Learning Resource iNterchange (LRN) software, which is designed to help author and display learning resources packaged using the SCORM content packaging specification. Macromedia offers an extension to their Dreamweaver product that is designed to make it easier to incorporate the SCORM runtime commands into a Dreamweaver web page.

As more tools and learning management systems incorporate these specifications into learning content, it will become easier to develop learning content that is easily ported from one system to another, that can be easily shared between authors and that can be easily disassembled and incorporated into new courses.

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