AC 2012-5098: THE DESIGN, DEVELOPMENT, AND DEPLOYMENT OF AN ONLINE, PORTABLE, BLENDED COURSE FOR THE ENERGY INDUSTRY USING OPEN-SOURCE TOOLS: TECHNOLOGICAL, LOGISTIC, AND INSTRUCTIONAL DESIGN ISSUES

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The Design, Development, and Deployment of an Online, Portable, Blended Course for the Energy Industry using Open-Source Tools: Technological, Logistic, and Instructional Design Issues

Abstract

More and more often we learn of new courses or entire academic programs being brought online. While technologies have advanced in recent years, the question of how to blend computer technology with sound instructional design practices is very much alive and may be even more important when targeting content portability. This paper explores the challenges faced when using open-source applications to design, develop, and deploy the online component of an introductory course for the energy industry when the primary objectives are outreach, access, portability of content, and ease of future updates.

Introduction

The design and development of the Energy Industry Fundamentals (EIF) course was initiated by the Center for Energy Workforce Development (CEWD)[1]. CEWD is a non-profit consortium of electrical, natural gas, and nuclear utilities and their associations and was formed to help utilities work together to develop solutions to the coming workforce shortage in the utility industry. The EIF course provides a broad understanding of the electric and natural gas utility industry and the energy generation, transmission, and distribution infrastructure. The course includes business models, regulations, types of energy and their conversion to usable energy such as electric power, how generated power is transmitted and distributed to the point of use, emerging technologies, and the connection to careers in the energy industry. The existing paper-version of this course has received accreditation by the American National Standards Institute, thus leading to a Certification for students who pass a final examination over the course content.

Due to our experience in developing online curricula for the energy industry[2] [3] [4], we are collaborating with CEWD to develop an additional contextualized, scenario-based layer to the paper-based version of this course and to bring it online in a format suitable for a blended, instructor-led learning model[a]. In addition to this contextualization, one of CEWD's main objectives was to make this course available to any entity interested in teaching it.

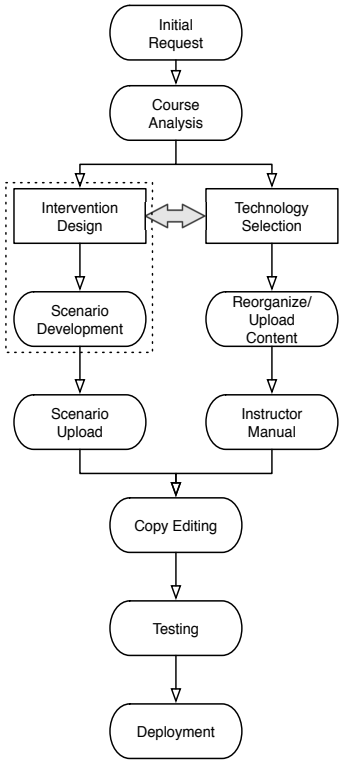

Figure 1: Overview of the design and development process

[a] This project was funded by a grant (#GJ-19902-10-60-A-29) awarded under the High Growth and Emerging Industries Recovery Act-State Energy Sector Partnership (SESP) and Training Program, as implemented by the U.S. Department of Labor's Employment and Training Administration.

The main stages of the development process are shown in Figure 1.

The first step in designing the learning experience was to analyze the existing content. Through this analysis, we began looking at content portability standards and information technologies that would support this implementation. Each of these processes is described in more detail below. Once the foundations were in place, we began an iterative design and development process, which included scenario development, porting the existing content online, copyediting, testing, and the development of an instructor manual. The various sections in this paper present the design and development process, together with the issues we encountered, the solutions we found, and the decisions made to best support the learning outcomes.

Learning Experience Design

Our efforts to define the best learning experience began with looking at the wider area of situated cognition and situated learning.[5] Further analysis narrowed down our options to Case Based Learning (CBL). The design process for the learning experience is presented in Figure 2.

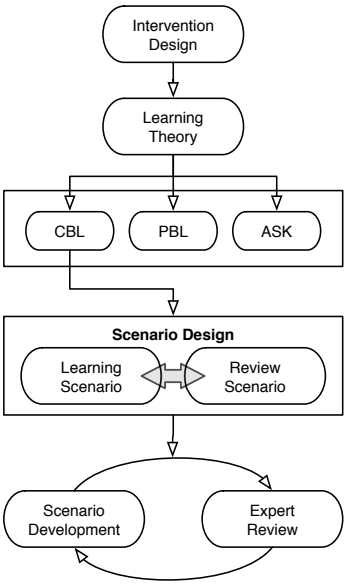

Figure 2: Learning experience design process

Learning Theory

Question: *Which method for learning experience contextualization would fit our needs?*

Objectives: *(1) provide context, (2) engage learners, and (3) improve retention and performance.*

Decision: *Case-based learning, goal-based scenarios*

Tradeoffs: *(1) complex, iterative, and lengthy design and development process, (2) possibility of cognitive overload, (3) need for subject matter experts, and (4) challenging document management.*

Research on situated cognition and situated learning shows that when people learn and reason in context, they tend to perform better in problem solving tasks and have better retention of the content.[5] In this respect, scenarios are tools instructors can use to contextualize a learner's experience to a desired domain or area. The scenarios present the learner with a story, causal in nature, which would allow the learner to predict the outcome or infer the result. According to Jonassen[6], a scenario is *hypothetical* (represents a possible situation), *selective* (represents one possible state of complex, interdependent, and dynamic events), *bounded* (limits the number of possible states, events, actions, and consequences), *connected* (causality is present to link related elements and events), and *assessable* (can be judged).

For our purposes, the case-based learning approach was chosen to provide context for learning.[7] Goal-based scenarios are used as instructional tools because the contextualization they provide promotes the best and most connected learning as the learners actively pursue a meaningful

problem solving goal that leverages contextualized knowledge. The role-playing aspect of learning using scenarios supports understanding and learning the circumstances where the new knowledge is useful (as compared to when the material is presented without the role-playing component).[8] Questions within these narratives present learners with prompts to devise arguments for others' or their own selected stances about issues and topics. As Jonassen and Kim[9] point out, argumentation can help support problem solving skills and engage learners in deeper, more meaningful forms of learning.

Learning Experience Delivery Format

Decision*: The instructor-led, blended-learning instruction format was among the initial requirements.*

The blended learning format attempts to provide the most effective and efficient instruction experience by combining delivery methods. The most common approach is to combine face-to-face instruction with online learning, both live and self-paced. This approach multiplies the ways people learn, which reportedly increases understanding and retention.[10]

When designing instruction for a blended-learning approach, two major challenges are encountered.

Management of instructional complexity. With the combination of various delivery methods, it becomes increasingly more difficult for the designer, instructor, and ultimately the learner to manage the various sources from where the content comes.

Uniform learning experience. As the different media works together, designing and delivering a uniform learning experience that combines them all becomes increasingly more difficult.

A major advantage of the blended learning format is its ability to improve effectiveness by providing the best delivery environment for each "learning object" as well as provide the learners with alternative ways of learning, thus offering them with the ability to choose the medium that works best for them. That is, it provides ways to personalize instruction and learning. Another way to view blended learning is that it allows for a variety of digital learning technologies to be integrated in a face-to-face instruction or learning experience.[11]

Design

After several iterations, we settled upon a two-step design of the learning experience by introducing two scenarios for each module or coherent unit of instruction (e.g., chapter). The first scenario, called a "learning scenario" is used alongside the text to provide context while learning the content. This scenario is introduced at the beginning of the module and continues throughout the content. It includes context setting, some theoretical background, and questions. The questions ask learners to provide an argument for a decision that has already been taken (presented to them in the scenario) and are designed to help them reason about a situation as they read the content. While working on the learning scenario, learners have the ability to consult the course content to review the material to understand the context and answer the questions.

The second scenario, termed a "review scenario" is designed to be worked out after the learners have completed the module or chapter and is intended to provide another opportunity to apply the knowledge they accumulated. It has a higher level of difficulty as in this case the leaner is asked to both make a decision from a constrained list of options presented as multiple choice questions and provide an argument to support that decision. Figure 3 shows the typical learning path designed for a course module or chapter.

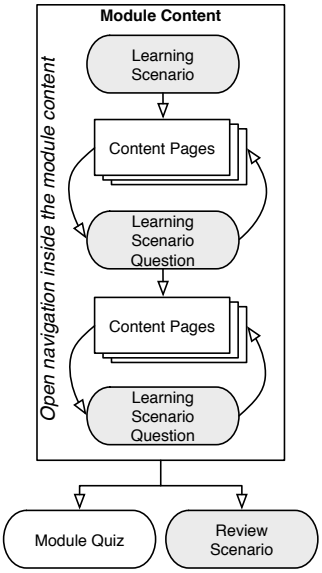

Figure 3: A typical learning path

The use of a two-step approach in designing the learning experience required differentiating how the two scenarios would be delivered. As already mentioned, the learning scenario, distributed throughout the content, requires an open content navigation model that allows learners to review the content within the module to understand the context and answer the questions. The review scenario is designed to be self-contained, outside of the main module content. The theoretical design advises the use of immediate feedback to learners' answers for both types of scenarios, as well as instructor feedback to open-ended questions. The multiple-choice answers, where appropriate, are evaluated upon submission, while the open-ended answers are sent to the instructor for evaluation, optional grading, and feedback. Additionally, for both scenario types, the initial design proposed for an expert answer to be provided to the learners upon submission of a question answer. This answer would provide the students with immediate feedback that could be utilized to evaluate their own answers. While the designed learning experience is theoretically sound, choices and technological limitations would ultimately alter this design.

Technology

With portability set as one of the main objectives driving our efforts, we began analyzing the standards that would allow us to bring the content online in such a way that it can be moved between a variety of learning management systems (LMS). As shown in Figure 4 we looked at what standards we could use to develop the content to guide our search for deployment options, learning management system applications, and content development tools.

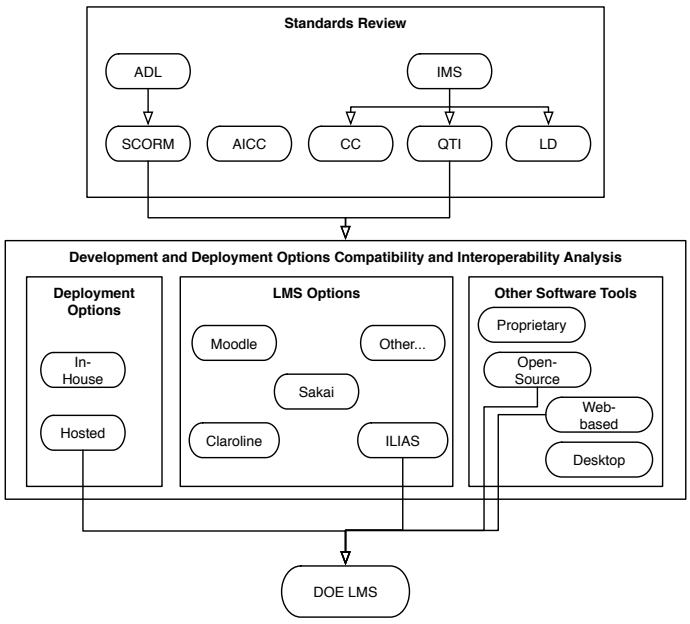

Figure 4: Overview of the standards and technology selection process

Learning Content Portability Standards

Question: *Which learning content portability standard(s) would fit our needs?*

Objectives: *(1) ability to move content between various delivery platforms, (2) preserve the learning experience, (3) permit feedback, and (4) allow instructor assessment of open-ended questions.*

Decision: *SCORM and QTI*

Tradeoffs: *(1) need to overcome standard's limitations, (2) deviations from the standard's tenants, (3) use of multiple standards to accommodate design and delivery needs, and (4) social presence is not portable between environments.*

AICC. Aviation Industry Computer-Based Training Committee (AICC) is the oldest standard in this overview. It was developed by the aviation industry in 1993, but it did not evolve much over the years. It is a precursor of the newer SCORM standard. The main issue with the AICC standard is that it does not provide a way to ensure that metadata associated with the content is portable.[12]

SCORM. The Sharable Content Object Reference Model (SCORM) was developed and is maintained by Advanced Distributed Learning Initiative (ADL). The fundamental objectives of the SCORM standard are portability, interoperability, reusability, accessibility, and durability. It is a mature standard and is arguably the most widespread standard used today for content portability. One of the major drawbacks of SCORM is that it does not allow the LMS to access the internal components of the object.[13] This means that feedback from outside the SCO (Sharable Content Object), for example, instructor feedback, is impossible to implement

IMS Common Cartridge. Common Cartridge (CC) is a more recent initiative of the IMS Global Learning Consortium, which expands the reach and interoperability of the existing standards. Notably, CC is better positioned to support a blended learning approach, provides access to a greater choice of content, has greater assessment options, and increases flexibility, sharing, and reuse. It also allows the host LMS access to the internal components of the cartridge as opposed to the other competing standards[14], which approaches some of SORM's limitations by, for example, allowing feedback to be provided to learners or making possible to include discussion threads inside the cartridge.

IMS QTI. The Question and Test Interoperability (QTI) specifications are a mature set of standards, implemented by the majority of the LMS applications. It provides specifications based on the XML language for describing questions and tests to allow interoperability between various assessment systems.[15]

AICC aside, an analysis of the capabilities of several learning management systems showed that while the IMS Common Cartridge standard could serve us better, in the interest of interchangeability, the SCORM standard is still dominant. While SCORM allows for testing items to be included in the content, its capabilities are relatively limited. Nevertheless, the IMS QTI standard is widespread, which allowed us to overcome some of SCORM's limitations by

using it to implement the tests and the review scenarios. To better understand the scope and purpose of the SCORM standard, a brief overview is presented below.

Brief Overview of the SCORM Standard

The fundamental objectives of the SCORM standard are portability, interoperability, reusability, accessibility, and durability. In SCORM terms, portability means that the content should work with no changes or adaptation in different online and offline environments. Interoperability specifies that the same content should work in the same way anywhere it is deployed. Reusability requires the ability to combine the modules in different ways. Accessibility requires cataloguing metadata to be associated with the content to make it easy for both the learners and the developers to find the appropriate content in a content repository. Finally, durability dictates that the content should only last as long as it is relevant but long enough to recover or amortize cost.

Currently, there are two major specifications of the standard. Version 1.2, released in 2001, was originally developed by the U.S. Department of Defense and designed to overcome the limitations of the AICC standard. While better than AICC, this standard still has a multitude of shortcomings and ambiguities, some of which were addressed in the newer version of the standard first developed in 2004, which evolved over the years to today's 4th edition[16 17 18].

The basic concept behind SCORM is the Content Aggregation Model (CAM), which defines the ways to identify and describe learning resources, how to aggregate them into a course and how to move them between host environments. A SCO (Sharable Content Object) is web content that should be compatible with any browser and should be able to run both in online and offline environment (e.g., on a CD) without any supplementary requirements other than a web browser. What SCORM does not specify is how to design the content (pedagogy); the look and feel (interface), what to do with the tracking data and what should be the granularity of the SCOs and other content objects.

The more significant issues with the current SCORM standard are (1) the need for extensive metadata to catalogue the SCOs; (2) the need for context metadata to describe the attributes of resources, instructions, and relationships between these instructions; (3) the fact that all this metadata is optional; (4) the fact that it does not account for any external aspects (e.g., user preferences) and (5) the documentation that is extremely technical. In addition, the content contained in a SCORM module cannot be adapted to the needs of a specific learner.

While the main advantage of using SCORM is the widespread compliance of many of today's learning management systems, partial implementation of the standard is common by both LMS and the SCORM content development software developers and vendors. Given the quality and penetration of the considered standards, SCORM was chosen as content packaging model for the content of this course, together with QTI for testing.

SCORM Impact on Learning Experience Design

Admittedly, the SCORM standard is not one of the more user-friendly content portability standards. Using it to prepare content for a blended-learning format course posed a couple of significant challenges. One issue we encountered early on was limitations imposed by the SCORM standard to access the internal components of the SCO. That is, instructor feedback for

learners' answers to open-ended questions could not be implemented, as we could not find a way to return the instructor's feedback to the SCO. While it is possible to use programming techniques to include predefined feedback, our objective for ease of updates prohibited us to do so. For this reason, the review scenario is implemented using the QTI standard, which allows the instructor to assess learners' answers and provide feedback.

Another significant issue with SCORM is related to how the content is produced. While a uniform implementation of the SCORM player (the software component which displays the content to the learners) is expected, considering possible differences between the various computing platforms where this player will be run, we limited our content to those programming elements that we knew would work on all platforms. This of course limited the types of content that we could produce. Here again, programming techniques might have helped assuage this issue, but our ability to use extensive programming was limited by our objective of making the content easy to update.

Content Development Tools

Question: *Which of the available open-source content development and packaging software tools would fit our needs?*

Objectives: *(1) ease of use, (2) maintained, with a clear development path, (3) appropriate for use by non-technical personnel, and (4) low or no cost.*

Decision: *None, deferred to the LMS decision*

As SCORM only standardizes the way the content is packaged and how it interacts with the host LMS, the content itself can be created using almost any computer-based tool available and packaged into a SCORM module as long as it meets the requirements. Since SCORM was the primary target, we looked for tools that would allow us to create the content and have the ability to package it according to the specifications of this standard.

Our research revealed that there are two categories of tools able to produce SCORM packages. One category is composed of applications that only package the content, leaving content production to other applications (such as HTML editors, Adobe Flash, etc.). The second category covers the applications that serve a dual purpose, providing both means to create the content (e.g., editors) and the ability to package and export it to a SCO.

Two objectives were considered when searching for available tools. First, we needed a tool that would help us bring the existing content online and allow us to create new content as we developed the scenarios as well as collaborate among the design and development team members. Second, considering that updates could be needed as the requirements, legislation, standards, and audiences change, we were looking for a tool that would allow us to easily change content, potentially by subject matter experts with limited computer knowledge. Given this second objective, our hope was to find an integrated tool that would provide both content creation/editing capabilities and the ability to export this content to the appropriate standard.

Based on possible deployment options, there are two categories of tools to consider: desktop applications and web-based tools. With the majority of the web-based tools still in infancy, of the

open-source desktop applications we were able to find we looked more closely at CourseLab[19], eLAIX[20], eXe[21], RELOAD[22] (recommended by ADL), and Xerte[23]. Table 1 presents an overview of our findings.

Table 1: Open-source SCORM content development and packaging applications.

Application	Pros	Cons	Conclusion
CourseLab	Accepts a wide range of content format, rich media support, familiar PowerPoint-like authoring environment, programmable content interaction, hot spots, and built-in test creation capabilities.	PowerPoint-like interface limiting the content space to a predefined size, difficult to create complex modules.	The limited space available for displaying the content was the turn-off feature as the length of our content varies significantly, making it difficult for the learners to access it.
eLAIX	Familiar word processor interface and integration, supports most of ILIAS's functionality, ability to re-import exported modules and modules generated in ILIAS, reasonably easy to learn.	Does not support SCORM modules directly, the need to install OpenOffice (or one of its clones), limited to the ILIAS LMS, which needs to be installed.	Limitations in the export format and ties with the ILIAS LMS.
eXe	Based on Mozilla Firefox code, supports development of interactive web content, support for both SCORM and IMS CC, flexible interface, templates, easy to install, easy to learn.	Supports only SCORM 1.2, slow when editing longer content pages, not actively developed anymore.	Development status and inability to export to SCORM 2004 specifications limit its usability.
RELOAD	Recommended by ADL, flexibility of export formats, platform independent (written in Java)	Does not support content creation, some difficulties installing, need for in-depth knowledge of the SCORM standard, fairly technical	RELOAD only provides the ability to package content created with other applications into a portable package format and requires in-depth technical knowledge of the packaging standards to be used. It also has a steep learning curve.
Xerte	Rich media support, extended support for programming interactions, interface design capabilities.	Need to learn a scripting language and Flash's Active Script to use interactions, steep learning curve, and limited predefined content presentation area.	The limited content space, the need to learn a scripting language as well as the steep learning curve makes this application difficult to use in our settings.

As it turned out, no individual application we looked at met the criteria we required. Since we were also looking at implementing the course using an LMS, we turned our attention to researching the available open-source LMS applications, which could provide us with the appropriate content creation and packaging tools.

The Learning Management System

Question: *Which of the existing open-source learning management systems would fit our needs?*

Objectives: *(1) compatibility with the chosen content portability standard, (2) ease of deployment and maintenance, (3) ease of ownership transfer, (4) can be used to deliver the course, (5) support multiple organizations and groups, (6) serve as example and template for other deployments, and (7) serve as repository for the course's SCORM objects.*

Decision: *Department of Energy (DOE) LMS/ILIAS*

Tradeoffs: *(1) use a learning management system that is under heavy development, with frequent updates, (2) limited administrative access to the learning management system, (3) limited to the use of social presence tools offered by the DOE platform, (4) implementation and delivery of the course has to go through a third party, (5) accept the limitations of its content development tools and (6) some knowledge of HTML and CSS still needed to develop and maintain more complex content.*

Our need for a learning management system is two-fold. On one side, the LMS will host the course and will allow instructors that do not have the appropriate means to offer this course using the framework we provide. On the other side, our implementation will provide us the ability to gain insights into how the structure and delivery of this course works as well as serve as an example and template for content organization and delivery when ported to other platforms.

Two distinct decisions had to be made: (1) choose a deployment model and (2) choose the LMS application, in this specific order. That is, the deployment model had to be decided upon first, as it would limit the range of LMS applications we would consider later.

For the deployment/hosting solution we considered three choices: (1) host using the university LMS deployment, (2) owned - host it on our own servers, and (3) hosted - host it with a third party. Option (1) did not work, as we would be using university resources to support courses delivered to third party entities. A brief pros and cons analysis of the remaining two options is shown in Table 2.

We considered option (2), hosting the course on our own servers, next. Cost considerations quickly ruled out proprietary LMS applications. Of the many open-source learning management systems available, considering our team's strength in developing and maintaining LAMP web applications, we limited our search to the LMS applications developed using PHP and MySQL. The following elements were considered: (1) technology – easy to install and maintain with little or no software requirements on the server side, (2) compliance with existing learning standards, (3) active, clear future development roadmap, (4) ability to accommodate multiple institutions and groups of learners, (5) import/export capabilities, (6) testing, (7) grading and reporting, (8) communication and social presence, (9) collaboration tools, (10) interface and usability, and (11) content development tools.

Table 2: Pros and cons analysis of LMS deployment options.

Option	Owned	Hosted
Pros	• Use of preferred LMS • Control over LMS settings and functionality • Ability to customize to needs • Low cost of increasing storage space	• No need to maintain a server • Use of preferred LMS • Control over LMS settings and functionality • Ability to customize to needs • Ease of access • Ease of expanding server and storage • Easy to transfer ownership
Cons	• Need to maintain a server • Need to maintain the application, manage users, courses, etc. • Might run into bandwidth limitations • Capacity expansion costs • Server and application upgrade and maintenance costs • Limitations that might be imposed by the university if the project grows • Need for personnel to maintain and manage the LMS and hardware/software base • Difficult to transfer ownership	• Operation costs • Expansion costs • Technology limitations • Need for personnel to maintain and manage the LMS and software base

In evaluating option (2) we also had to consider that our efforts were supported by grant funding, and as such, hosting and updating content in the future were uncertain. Therefore, we had to consider another key element if we hosted the course: transfer of ownership. In our case, transfer of ownership had two key dimensions: transfer of content and transfer of the administration of the learning management system. The most significant problem with content transfer is ease of update. The transfer of the LMS administration is more complicated, as it requires providing a way to either move the entire LMS to a different platform (server, organization, etc.) or give administrative access to the server where the application is installed. The first option poses significant technical difficulties, while the second option might face significant administrative barriers.

While gathering data on the various open-source LMS applications that meet our criteria and considering the transfer issues above, our CEWD collaborators learned that the U.S. Department of Energy was in the process of developing its own educational portal, NTER Learning[24], which included an LMS application as well as a variety of other resources. They offered us the option to host our course on their servers and invited us to review their learning management system, a customized solution based on an existing open-source LMS, ILIAS[25], one of the choices we were considering.

Upon further review, we decided to work with the U.S. Department of Energy to develop our course. The decision we made was based on the following elements. First, ILIAS is a stable learning management system with a clear development path that meets most of our criteria. Second, because the LMS is open-source and developed using technologies our team is proficient in, if needed, we would be able to install the LMS on our servers and move the content without difficulty. Third, the DOE would manage the servers, courses, and users, which would allow us to easily transfer ownership. Fourth, the LMS incorporates an extensive content

development tool, which allows us to create and edit the content in situ, making it easy to update the content in the future. Fifth, the DOE LMS implementation separates content development from content delivery. Sixth, each ILIAS deployment becomes part of a network of similar instances, which allows users to find and use resources that are not locally available. Finally, ILIAS can export the content in a multitude of formats, including SCORM and QTI, depending on content.

The LMS' content editor limitations significantly impact how the content is designed and delivered. While the editor itself provides extensive functionality to help create and format web content and includes a wide variety of multimedia, its capabilities to design interactive content are limited. Although the content itself does not require interactivity, the delivery of the learning scenarios would benefit from it in the delivery of appropriate feedback to learners' answers, especially given that the SCORM standard does not allow the LMS to access the internals of a SCO, thus prohibiting direct instructor feedback. Also, to personalize the course and content to a desired look and feel as well as to develop and maintain more complex content, some knowledge of markup languages (HTML & CSS) is still needed.

Discussion

While the SCORM standard is not particularly suitable for deploying a course in an instructor-led blended-learning format, the state of the learning content portability standards as well as their widespread implementation in existing proprietary and open-source learning management systems led to its use for this course. Nevertheless, to make it work, deviations from the tenets of the SCORM learning content portability standard were necessary.

To design and deliver this course in the required format, partial implementation of one of the main SCORM objectives, ability to recombine the content in different ways, was only partially implemented. This occurred for two reasons. One is related to the implementation of the learning scenarios, which are designed to be embedded within the module content. On one side, to work through the learning scenario, the learners need access to the theoretical content. Since when launched each learning module will run inside a player outside the LMS main workspace (per SCORM specifications) navigation to and from content would be very difficult since the learners would need to open and close the player to reach the content. On the other side, the learning scenario is designed to cover an entire module, with questions distributed throughout the content, which requires for the content to be kept together in the same module.

The other reason is related to the blended format of the course, which was needed in order to provide consistency between the printed format and the online format. Therefore, each module in the printed materials was converted into an online learning module, containing multiple SCOs. As a result of this requirement, while possible to manipulate the individual SCOs as stand-alone objects, meaningful content runs across multiple learning objects, creating relationships with content outside each SCO.

Due to the limitations of the SCORM standard as well as of the learning management system, testing and some of the content had to be implemented using a different standard. SCORM offers little capability for tracking learners' progress. The options available are tracking content navigation, as well as answers to questions. Therefore, the limitations of the SCORM standard to

allow the LMS to access its internal components as well as its limitations in two-way communication with the LMS required the tests, quizzes, and review scenarios to be implemented using the QTI standard, which provides a wider array of options for feedback and assessment.

While one might expect that today's technology would have sufficiently evolved to provide the tools for developing SCORM content, our search proved less than successful. Given our need to find a content development tool that would be relatively easy to learn and use, with a low or no price tag, the options we found were limited. Despite the fact that the SCORM standard does not enforce how the content is produced and presented to the learners (as long as it meets the criteria for portability), the tools available today seem to be directed toward developing self-paced modules, which do not require instructor intervention. The open-source tools we found that do not limit our options provided only content packaging capabilities, thus requiring knowledge of other software packages and eventually programming and markup languages for content development. In addition, the very technical nature of the SCORM standard specifications makes these software packages difficult to use. At this juncture, if ease of update by non-technical personnel is desired, our experience suggests that no existing open-source tool would work.

From the content delivery point of view, the wide range of learning management systems available today, all having similar capabilities, increases the difficulties in choosing the one that is more appropriate for more complex delivery models. The solution we chose (use of the DOE LMS environment) alleviated many issues related to administrating a learning management system and provided a web-based content development tool while posing challenges to scenario design and implementation. Of these challenges, the most important was to design the learning scenarios considering the need to limit the feedback the learners receive on their answers to the open-ended questions, thus accepting diminished returns for this type of intervention.

While this course is designed to be led by an instructor and has a face-to-face component, it is likely possible to deliver the course with a strong online component. That is, it is conceivable that potential future delivery might limit the face-to-face interaction to only those activities that require physical presence, such as demonstrations, laboratory work, etc., with the theoretical content being delivered in an online-only format. In this case, social interaction between learners will be limited and online options for this interaction to continue (discussion boards, chat, etc.) would be necessary. Unfortunately, neither SCORM nor QTI offer such options. Therefore, each separate course implementation would have to provide its own means for social interaction. Fortunately, all LMS applications have social interaction tools available for use. The remaining issue is to provide instructors with clear instructions for implementing this interaction so that the designed learning experience is maintained.

Summary

Given our objectives of outreach, access, portability of content, and ease of future updates, a complete solution could not be reached for this course. Currently, standards and standards implementation as well as the status of content development tools are not yet ready for the development of an online solution for a portable, instructor-led course delivered in a blended-learning format that would be flexible and easy to maintain.

In our experience, the development of such course requires the developers to accept a number of tradeoffs, which affect both the maintenance and management of the course as well as the learning experience. We are confident that we were able to reach a balance between the requirements of a sound instructional design and the affordances of the current technology and learning content portability standards. Table 3 briefly presents in context a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of our efforts to design, develop, and ultimately deploy the online component of an instructor-led course for the energy industry delivered in a blended-learning format using open-source software.

Table 3: Project SWOT analysis.

	Positive/Favorable	Negative/Unfavorable
Internal Factors	• Knowledge of learning theories and instructional design expertise • Course and content development experience • Expertise in using technology • Knowledge of appropriate programming and markup languages for content development	• Funding limitations • Limited number of SMEs • Availability of long-term support
External Factors	• LMS capabilities • Integration in wide network of similar LMSs • Course/user management by DOE • Stable and tested LMS platform (ILIAS) • Clear LMS development plan • Ease of ownership transfer	• SCORM standard limitations • No control over theoretical content • No control over LMS settings • Course format • Availability of content development tools • LMS under development

While, for the future, we are considering the possibility of converting this course from a blended format to a self-paced online format, our experience using the technology and following portability standards tells us that significant work would be needed, not only in how the learning experience is designed, but also on rewriting and reorganizing the content.

References

1. Energy Industry Fundamentals Curriculum Modules. http://www.cewd.org/curriculum/eif-modules.php (accessed 1/10/2012).

2. Miller, W.; Jonassen, D. H.; Schmidt, M.; Easter, M.; Ionas, I. G.; Marra, R. M.; Etter, R. L.; Meffert, B. In *Radiation Protection Technician Curriculum Development Initiative - US DOL President's Energy Sector HGJTI Grant.*, Health Physics Society 2007 Annual Meeting, Portland, OR, July 10; Portland, OR, 2007.

3. Schmidt, M.; Easter, M.; Jonassen, D. H.; Miller, W.; Ionas, I. G., Preparing the twenty-first century workforce: the case of curriculum change in radiation protection education in the United States. *Journal of Vocational Education & Training* **2008,** *60* (4), 423-439.

4. Miller, W. H.; Jonassen, D. H.; Marra, R. M.; Neumeyer, G. M.; Etter, R. L.; Easter, M.; Schmidt, M.; Henry, H.; Ionas, I. G., The Role of Instructional Technologists in the Development of a Problem-Centered Radiation Protection Technician Curriculum. In *Conference on Nuclear Training and Education CONTE 09: An International Forum on Nuclear Training and Education and Workforce Issues Facing a Renewed Nuclear Energy Option.*, Jacksonville, FL, 2009.

5. Henning, P. H., Everyday Cognition and Situated Learning. In *Handbook of Research on Educational Communications and Technologies*, Jonassen, D. H., Ed. Lawrence Erlbaum Associates: 2004; pp 143-168.

6. Jonassen, D. H., *Learning to Solve Problems. A Handbook for Designing Problem-Solving Learning Environments.* . Routledge: New York, NY, 2011.

7. Shank, R. C.; Fano, A.; Bell, B.; Jona, M., The Design of Goal Based Scenarios. *The Journal of the Learning Sciences* **1993,** *3* (4), 305-345.

8. Kolodner, J. L.; Ownesby, J. N.; Guzdial, M., Handbook of Research on Educational Communications and Technologies. 2 ed.; Jonassen, D. H., Ed. Lawrence Erlbaum Associates: 2004; pp 829-861.

9. Jonassen, D. H.; Kim, B., Arguing to learn and learning to argue: design justifications and guidelines. *Educational Technology Research and Development* **2009,** *58* (4), 439-457.

10. Dziuban, C. D.; Hartman, J.; Juge, F.; Moskak, P. D.; Sorg, S., Blended learning enters the mainstream. In *Handbook of Blended Learning Environments: Global perspectives, local designs*, Bonk, C. J.; Graham, C. R., Eds. Pfeiffer: San Francisco, CA, 2006; pp 195-206.

11. Bonk, C. J.; Graham, C. R., *Handbook of Blended Learning: Global Perspectives, Local Designs.* Pfeiffer: San Francisco, CA, 2006; p 585.

12. Ostyn, C., In the Eye of the SCORM. An introduction to SCORM 2004 for Content Developers. Ostyn Consulting: 2007. http://x-perteam.courseliner.com/medias/images-contenu/Eye_Of_The_SCORM(1).pdf.

13. Advanced Distributed Learning Initiative: SCORM. http://www.adlnet.gov/capabilities/scorm/ (accessed 12/14/2011).

14. Common Cartridge Working Group. http://www.imsglobal.org/commoncartridge.html (accessed 12/15/2011).

15. IMS Question & Test Interoperability Specification. http://www.imsglobal.org/question/ (accessed 12/15/2011).

16. *SCORM © 2004 4th Edition. Content Aggregation Model (CAM) Version 1.1*; ADL: 2009.

17. *SCORM © 2004 4th Edition Run-Time Environment (RTE) Version 1.1*; ADL: 2009.

18. *SCORM © 2004 4th Edition. Sequencing and Navigation (SN) Version 1.1*; ADL: 2009.

19. CourseLab. http://www.courselab.com/ (accessed 12/20/2011).

20. eLAIX. http://elaix.org/ (accessed 12/15/2011).

21. eXe. http://exelearning.org/wiki (accessed 12/21/2011).

22. RELOAD. http://www.reload.ac.uk/ (accessed 12/14/2011).

23. Xerte. http://www.nottingham.ac.uk/xerte/ (accessed 12/20/2011).

24. NTER National Training & Education Resource. https://www.nterlearning.org/ (accessed 1/10/2012).

25. ILIAS E-Learning. http://www.ilias.de/docu/repository.php?cmd=frameset\&set_mode=flat\&ref_id=1 (accessed 12/21/2011).