Chapter IV

A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

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ABSTRACT

The sharable content object reference model (SCORM) includes a representation of distance learning contents and a behavior definition of how users should interact with the contents. Generally, SCORM-compliant systems were based on multimedia and Web technologies on PCs. We further build a pervasive learning environment, which allows users to read SCORM-compliant textbooks with multimodal learning devices. Respecting the learning contents for supporting such learning environment, an efficient authoring tool was developed for serving this goal. Some specific tags were defined to specify the corresponding information or interactions that cannot be performed in the hardcopy books. These tags can be printed in SCORM-compliant textbooks and recognized by Hyper Pen to facilitate the affinity between the physical textbooks and digital world. Therefore, users can read the SCORM-compliant hardcopy textbooks in a traditional manner. The authored course contents will be the same while applying to the multimodal learning devices with different layouts.

INTRODUCTION

From time immemorial, the pedagogy evolved in line with its contemporary technologies and requirements. The innovation of the evolitional education is not only on the instructional methods, but also on the learning contents. With the widespread deployment of information technologies and network services, the trend of education nowadays is toward diverseness and convenience.
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

An obvious example is distance learning. However, distance learning does not on its complete substitution for traditional education. Instead, the two paradigms should work together to realize a better future educational style.

Most conventional learning models focus on the physical world only, and thus the interesting multimedia learning content cannot be used in the learning process. On the contrary, recent learning technology focuses on digital input/output. It will cost large amount of effort to transform all physical contents into digital contents. A natural way to fully utilize contents resources is to use both physical and digital contents, simultaneously. The advantages of physical contents include easy thinking, comfortable reading, rich content in library and familiar learning experience. On the other hand, the advantages of digital contents include fast searching, easy sharing, supporting interesting multimedia, and high interactivity. Thus, if advantages of both sides can be put together, the learning performance will be improved. Fortunately, there are pen-like OCR devices available to allow users to scan through textbooks. In our project, we call these types of pen devices the Hyper Pens. The name of Hyper Pen comes from the fact that a hyper jump is performed from one is using the device in the physical world for reading, to a virtual world in an electronic device which pronounces a vocabulary, or even shows motion pictures on a computer.

The key factor of the successful distance learning popularization is based on the well-developed e-learning standards. In addition, from the aspect of constructing learning materials, the shareability and the reusability of the various learning contents are the main issues for saving the cost of building the e-learning materials. As a result, we aim to provide an authoring tool for instructors to construct courseware based on SCORM (http://www.adlnet.org) specification for supporting pervasive learning environment with multimodal learning devices. Thus, we call this new definition of Hyper Pen-based learning mechanism as the Hard SCORM (Wang, Chang, Sie, Chan, Tzou, & Shih, 2005). Two important issues arose in building up such SCORM-compliant instructions. They are the conformance with the SCORM specification, and the content layouts for applicable learning devices. We proposed an effective courseware authoring tool, named the Hard SCORM Authoring Tool, for solving these issues. By using the Hard SCORM Authoring Tool, instructors are allowed to aggregate the various learning objects and to pack them into deliverable courseware. The courseware can be easily accessed by different devices including Hyper Pen, which recognizes a set of Hard SCORM tags.

In the following sections, we would like to present a brief survey on the related researches, starting from a detailed introduction of SCORM. The relevant third party authoring tools and some interesting Human-Computer Interaction researches for the affinity between physical and digital worlds are discussed. The architecture of our proposed Hard SCORM project and a formal definition of the Hard SCORM tags are also addressed. The implementation of our proposed Hard SCORM Authoring tool and some experimental results of our proposed ideas are illustrated as well. Finally, we give a brief conclusion and the future works as shown in the last section.

RELATED WORKS

As previously mentioned, the shareability and the reusability facilitate the constructing of various learning contents. A well-defined e-learning standard, named “SCORM,” was designed to serve this goal. In addition, there exist many applications for generating the learning content in the distance learning environment, and here we outline the features of other SCORM-compliant authoring tools. Furthermore, some interesting researches on the interactions between the physical world and the digital world in computer and
cyberspace are addressed to bridge the gap for the affiliation.

**SCORM Specification**

With the improvement of e-learning, there exist some acknowledged standards for the asynchronous education. In order to reduce the time and money costs of a good course presentation, ADL ([http://www.adlnet.org](http://www.adlnet.org)) proposed the shareable content object reference model (SCORM) specification in 1997 and tried to solve the problem. SCORM has been in wide use within the distance learning community for several years now. The original purpose of the SCORM was to enable interoperability between learning content and learning management systems (LMS). Over the years, ADL has updated the specification three times, from SCORM 1.0 to 2004, in attempts to better meet this goal.

The SCORM 2004 specification has technical issues presented in three parts: the content aggregation model (CAM) for the format of courseware, the run-time environment (RTE) for the protocol of courseware running, and the sequencing and navigation model (SN) for the learning status tracking, sequencing rules, and the application program interfaces. The former two parts are responsible for learning objects to support adaptive instruction. And the last part servers the dynamic presentation of learning content based on learner needs.

As we mentioned above, the purpose of the shareability and the reusability is a great help to save the cost of building the e-learning materials. The content aggregation model (CAM) in SCORM specification is designed for these issues. CAM mainly contains the content model, the metadata, and the content packaging. The content model represents the different levels of content components for learning experiences, such as assets for representing the most basic forms of learning resource, SCOs (shareable content objects) for communicating with the backend LMS, and content organization for indicating the intended use of learning contents. Metadata in SCORM represents a form of labeling for each learning resource, and provides an easy way for learning contents identifying, categorizing, and searching. Furthermore, by using the appropriate metadata, the purposes of sharing and reuse can be facilitated. Metadata definitions in SCORM 2004 specification are categorized into nine parts with more than 70 items. Content packaging provides a standard way to exchange learning content between different systems or tools, such as the learning content management system and the content authoring tool. A content package contains an XML-based document, named “imsmanifest.xml,” for describing the learning content structure and all the referenced physical files, such as the media files, text files, assessment objects, or other pieces of data in electronic form. A content package binds the two above mentioned components in the format of a compressed archive file, named Package Interchange File (PIF), for the content exchanging and delivering in general purposes.

Respecting the interoperability, the SCORM RTE can be used to establish a standard protocol for the learning content to communicate with back-end LMSs. While a learning activity starts, a launch process defines the relationship between LMSs and SCORM-compliant learning content, and then all the content relies on a SCORM conformant LMS can be delivered and displayed to the learners. During the learning phase, a set of predefined functionalities (a.k.a. the APIs) enable communication between an LMS and the SCOs it launches. Eventually, the information about the learning activities will be tracked and passed to the backend LMS by using the data model.

A systematic control mechanism, named the sequencing and navigation (SN) model, between the learner and the LMS, is defined to provide a standard way to specify the navigation of course content browsing and the behavior of the individual learner. The SN allows components in a courseware to be specified in a relative order,
in which conditions and selections are precisely defined. The sequencing definition model contains a set of elements that can be used to describe and affect various sequencing behaviors. Some of the SN setting can be applied to the sequences of the course content delivery, and some of them can be considered as the conditions for the learning performance after the assessment. Instructors can specify the applicable SN setting by using the SCORM-compliant authoring tools. And the process of sequencing controls can be applied to each learner with the learning activity tree, which is a conceptual structure of learning activities managed by the LMS for each learner. The outcomes of the sequencing process may update the learning activity status of each individual learner.

**Third Party SCORM-Compliant Authoring Tools**

From the perspective of learners, the most attractive things in the e-learning environment are the various types of learning content. Hence, courseware authoring tools can be considered as the foundations for building up an attractive e-learning environment. Usually, the categories of SCORM-compliant authoring tools can be generalized as three parts: the SCORM content development, the meta-data generation and editing, and the content packaging. Here, we briefly introduce some applications for creating the SCORM-compliant courseware from the three directions.

The RELOAD Editor ([http://www.reload.co.uk/](http://www.reload.co.uk/)) is a content package and metadata editor, which serves the purposes of the creation, sharing, and reuse of the SCORM-compliant learning objects. RELOAD tries to make an easy way to construct the SCORM-compliant learning content by avoiding working directly with XML, such as the metadata and the mentioned imsmanifest.xml for content packaging. RELOAD also allows instructors to take their own electronic content, for instance, the Web pages, images, flash animations, Java applets, and so forth, and to package and describe it ready for storage in content repositories.

Another interesting work of SCORM-compliant authoring tool is Manifest Maker Version 2.0, which is proposed by E-learning Consulting ([http://www.e-learningconsulting.com](http://www.e-learningconsulting.com)). The Manifest Maker can be applied to easily create a manifest for a content aggregation which is compatible with the SCORM 1.2 specification. There are several additional toolkits integrated with the Manifest Maker, such as the HTML Course Development Toolkit for creating the e-learning courses in HTML file format, and the Flash Course Development Toolkit for generating the SCORM-based learning content with Flash animations. An extra toolkit, named Test Builder, is also included within the Manifest Maker for the assessment. The Test Builder provides the functionalities of creating tests and quizzes in multiple question types. A question pool is developed for the repository of the assessment content.

With respect to the various learning content, the HunterStone ([http://www.hunterstone.com/](http://www.hunterstone.com/)) developed the THESIS which provides SCORM 1.2 compliant e-learning authoring tools for Microsoft Office. The advantages of the THESIS enable a user to author e-learning resources and objects straight from the familiar Microsoft Office applications such as Word, PowerPoint, Excel, Visio, and Producer from different sources.

As previously mentioned, Metadata serves as the auxiliary information for describing and searching of the learning content, and accordingly, the reusability and the shareability will be easily achieved. The Metadata Generator Lite ([http://www.jcasolutions.com/](http://www.jcasolutions.com/)) from the JCA Solutions provides a SCORM 1.2 conformant tool for serving this purpose. It utilizes the concept of templates to support the metadata generating by one-touch operation. Because the SCORM uses plenty metadata for describing the learning content, it reveals the fact that the metadata
in SCORM specification should be easily made without consuming time. The metadata Generator Lite supports the importing learning content by searching and exchanging as well.

The Course Creation Toolkit from the Graphic Education Corporation (http://info2.graphiced.com/newsite/home/index.asp) provides a WYSIWYG (What You See Is What You Get) user interface to construct the SCORM compliant learning content. The operations for the toolkit use the one-button insertion of Multimedia in the learning content. The creation of the questions for testing and assessment is also comprised in this toolkit.

There exist many serviceable applications for generating the SCORM compatible learning contents with diverse features. However, most of the systems are currently compatible with SCORM 1.2 specification. In this paper, we will introduce our proposed Hard SCORM Authoring Tool to facilitate the generation of SCORM 2004 compatible learning content, which can be brought to the learners via multimodal learning devices.

**Human-Computer Interaction Issues**

Even though Web technologies and Internet are popular, as a practical situation among several virtual universities, textbooks are still widely used. Paper remains a fundamental resource for many human activities. The fact is people still prefer reading books instead of facing screens. Paper is very convenient, familiar, flexible, user modifiable, portable, inexpensive, and offers excellent readability properties, but it is static and does not offer the dynamic content and hyperlinking. Human-computer interaction then becomes an essential discussion issue from this perspective. Practically, advanced hardware and communication technologies need to be used in conjunction with the affinities between real-world and computers, known as the proper noun “Augmented Reality.” Some of those augmented systems are equipped with extra facilities for serving the goal of the gap bridging. The researches in the HCI scope are quite miscellaneous and imaginative, and the researchers tried to ease the ways to connect the two isolated worlds.

The Listen Reader system (Back, Cohen, Gold, Harrison, & Minneman, 2001) used RFID embedded in a real book, with images and text. An electronic field sensor is then used to connect to a back-end device, for presenting sound tracks. The RFID is now widely used in many occasions, such as tickets for the subway, keys for the gate, and many objectives for pattern recognition. RFID in Listen Reader contains a thin flexible transponder tag with a unique ID that can be embedded in the paper of each page for recognition of the page identification, and a special tag reader is affixed to the binding of the back of the book. The system was demonstrated in a museum for bringing out the information that cannot be displayed in the paper-based collections. Another work is ENHANCEDDESK proposed by Koike, Sato, and Kobayashi (2001). It provides the smooth integration of paper and digital information on a desk and direct manipulation of the digital information with the hands and fingers of users. By using an infrared camera instead of a regular CCD camera, the regions of a user’s arms are found in an input image, fingertips are searched for in those regions with a certain range of temperature. However, these systems require specific instruments for connecting the digital world and physical worlds. As a result, it may not be portable to cope with the need of mobile learning, and may be too costly to benefit general learners while learning in their daily life.

Paper++ (Luff, Heath, Norrie, Signer, & Herdman, 2004) is another notable research which utilizes a nonobtrusive pattern on the page to interlink papers and digital resources. The system includes an authoring tool which allows users to create “active” pages. The relation between the physical and the digital can be defined by using conductive inks as the tags and a co-axial pen for
the object recognition. Nevertheless, Paper++ will be bound with a specific printer for generating the conductive and nonobtrusive ink patterns on the hard copies. Accordingly, the portability and flexibility of paper will be detracted.

Other interesting work in Ariel (Mackay, Pagani, Faber, Inwood, Launiainen, Brenta, & Pouzol, 1995) detects the x-y positions on paper-based documents by recognizing the red-colored pointers. A similar work, the InteractiveDESK (Arai, Machii, Kuzuniki, & Shojima, 1995), identifies the objects on its desktop by reading special color coded tags attached to the objects. The NaviCam (Denari, 1996) is another approach for viewing the augmentations of those objects through the camera image by using the color coded strips to recognize objects. However, the coarse resolution of the printing will diminish the performance of those tagging systems.

Another system to allow support digitally augmented paper via an authoring tool was presented in Norrie and Signer (2003). The system is able to provide a hypermedia access between hard copy papers and multimedia devices. In addition, a multilayered linking technology is developed with digitally augmented paper (Signer & Norrie, 2003). These systems all point out an important message: hard copy textbook is required in learning, even though multimedia presentations may provide a higher degree of interaction for learning. Some of the above surveyed ideas are worthy to us in developing the Hard SCORM project. Contrarily, some of the issues, such as the cost, mobility, and convenience, should be take into considerations as well while developing such a pervasive learning environment.

**ARCHITECTURE AND SYSTEM DESIGN OF HARD SCORM AUTHORING TOOL**

Considering different sorts of learners, including those who prefer to read from a book, we aim to facilitate the SCORM-compliant courseware to be delivered to a pervasive e/m-learning environment, which can be accessed via different presentation devices. Thus, the gap between digital cyberspace and our physical world can be eliminated. In this section, we would like to talk about the architecture of the Hard SCORM project and the authoring process of the Hard SCORM Authoring Tool. Furthermore, the coursework can be easily accessed by different devices including Hyper Pen, which recognizes a set of Hard SCORM tags. We’ll discuss the definition of these tags and the interrelations between the tags and the corresponding digital information.

**Constructing a Pervasive Learning Environment**

In our proposed idea, three main components are needed for constructing SCORM-compliant multimedia courses on hard copy books in the pervasive learning environment, and they are Hard SCORM Authoring Tool for the related course content generating, a learning management system based on the Web Service architecture for managing the content delivering and the specified services needed in the environment, and finally, an auxiliary learning tool for sending the information that Hyper Pens recognized to the backend server side. The outline of the system architecture can be illustrated as following:

- **Hard SCORM authoring tool:** The Hard SCORM Authoring Tool deals with the editing of SCORM-compliant course contents. Not only the learning contents for the general learning behavior on PCs, but also the learning content for the hard copy books can be created by using the Hard SCORM Authoring Tool. Instructors can easily build up the course by some simple operations, even though they are not familiar with the specific computer skills. Furthermore, the detailed information that is compatible
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

with SCORM specification, such as the metadata information and the sequencing rules setting, will be also available after using the authoring tool. The detailed illustration of the tool will be presented in the next section.

- **A SCORM/Hard SCORM learning management system:** The SCORM-based LMS (Shih, Chang, & Lin, 2003) is able to provide various services for the pervasive learning devices, such as the Hyper Pen, PC or PDA (Shih, Lin, Chang & Huang, 2004). This run-time environment normally delivers course contents to students in different formats. The environment also records the navigation behavior of learners. Some additional sophisticated mechanism for controlling the learning behavior should be integrated within the specified LMS, for instance, the undesired learning behavior while learning through the SCORM-compliant hard copy books. In addition, the embedded specified Hard SCORM tags will be recognized by Hyper Pen, and the result should be transferred to the LMS. A set of corresponding actions can be performed or brought out to learners, such as the multimedia files referencing or the learning records maintaining.

- **An auxiliary learning tool:** This auxiliary tool is responsible for the Hyper Pen to communicate with the supplementary learning devices. While learning on the hard copy books, the learner should open the auxiliary tool for the Hyper Pen to send the recognized result of Hard SCORM tags to the backend LMS. The corresponding actions or information will be returned to the learner through the learning device where the learning tool runs. Wireless communication for the pen-like OCR devices will be used in the near future to enhance the flexibility.

The first two components are SCORM compliant, and the third tool serves as the front-end medium between the first two components, with additional functions, such as the detection and automatic revision of identified tags.

### The Hard SCORM Tags

From the perspective of learning content, there exist many multimedia references while learning in the digital world. However, the same references might not be displayed functionally within the hard copy books (that’s the reason why we call them “Hard Copies”). For this reason, those media which cannot be presented in the hard copy books should be transformed into another way to be displayed. The related digital information will be shown by the multimodal learning devices, such as the PCs or the PDAs, in a seamless manner of the traditional learning behavior. Thus, learning activities may be extended to both physical and digital worlds. On the other hand, the SCORM standard is extended to a hard copy form. As a result, the learning behavior and records on the paper-based books could be standardized and compliant to the SCORM specification.

In order to allow Hyper Pen and the back-end LMS to communicate with each other, a special communication mechanism is necessary. We need to define a set of Hard SCORM tags, which can be embedded between the lines in the Hard SCORM textbooks, and be recognized by Hyper Pen. During a session of reading, these tags are scanned and recognized by the Hyper Pen. The definition of Hard SCORM tags considers effective interaction and fits with the navigation and sequencing specification of SCORM. Currently, the recognition of Hard SCORM Tags is in text forms, because OCR-based technology is well-developed. By using the Hard SCORM Authoring Tool, these tags are printed on hard copy books automatically. Hard SCORM Tags are divided into four categories for different purposes:
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

- **Navigation tags**: User navigations are controlled by using navigation tags. These tags are generated automatically by the authoring tool according to the definition of sequence specification given by the author.
  - **p – Page Tag** is associated with a SCO page number, p, which indicates current navigation focus. Activation of the tag changes the status of an activity tree.
  - **Next Page Tag** allows a navigation to move forward to the next SCO page and change the status of an activity tree (i.e., flow control).
  - **Previous Page Tag** is similar to the Next Page Tag.
  - **p – Page Index Tag** allow users to jump to a particular page (i.e., choice control).

- **Reference tags**: Multimedia resources can be displayed on electronic devices as references, which is triggered by reference tags.
  - **id – Video Reference Tag** shows a video.
  - **id – Audio Reference Tag** presents an audio clip.
  - **id – URL Reference Tag** launches a Web site.
  - **id – Flash Reference Tag** brings out a Flash animation.

- **Answer tags**: Answers in a test can be recorded by a SCORM LMS.
  - **Start Quiz Tag** starts a quiz session. All answers will be recorded.
  - **End Quiz Tag** ends a quiz session. Evaluation of the quiz is given.
  - **id – Question Tag** allows the user to identify a question to give the answer.
  - **1 | 2 | 3 | 4 | 5 – Multiple-Choice Tag** allows a learner to give an answer.
  - **Yes | No | Y | N | True | False | T | F – True-False Tag** is similar to the Multiple-Choice Tag.
  - **Fill-in-Blank Tag** allows a learner to give an answer to LMS. A popup window on PC or PDA is used.

- **Auxiliary tags**: These tags turn on/off or control Hard SCORM.
  - **Start Tag** turns on Hard SCORM.
  - **End Tag** turns off Hard SCORM.
  - **Pause Tag** suspends Hard SCORM.
  - **Continue Tag** resumes Hard SCORM.
  - **Learner Status Tag** provides status parameters to learners as an output.

Some of the above mentioned Hard SCORM tags can be allocated by instructors, and some of them could be generated automatically from the existing information, such as the sequencing rules setting and the context of the learning content itself. As we know, there are many media that could not be displayed on the hard copies, and accordingly the reference tags should be extensible, even though there are currently four types of multimedia supported in the authoring process.

From the inner view of the Hard SCORM tags, the interrelation to the digital information can be recorded in specific data structures according to the mentioned categories. For the navigation tags, they can be bound with the unique identifier with the corresponding learning contents, and furthermore, the sequencing setting should be included regarding the navigation behavior in the pervasive learning environment. For the reference tags, the unique identifier should be provided as well. This is because the learner can turn to any page on a textbook without letting the underlying sequence engine gain the navigation control. Thus, the learner may reference to the forbidden information while accessing to unanticipated reference tags in the hard copy books. Some essential information is required in reference tags, such as the file type, the relative reference path, and the order number.
A URL reference tag may contain the hyperlink information to the desired Web site in addition. For the answer tags, the identifier of the quiz should be taken respectively. The answer and items for each quiz is also addressed. Furthermore, the overall results of the assessment will be sent back to the backend LMS server for the evaluation. Finally, the auxiliary tags contain the identifier of the specific content aggregation and the identification information of learners. As a result, the learning records can be precisely maintained while learning through Hyper Pens.

**The Authoring Process of Hard SCORM Authoring Tool**

The Hard SCORM Authoring Tool is responsible for constructing multimedia courseware, which can be delivered to the multimodal learning devices, based on the SCORM 2004. Two issues should be taken care of here. Firstly, because all the authored learning materials should be conformant with SCORM 2004 specification, the conformance then becomes an important principle while developing SCORM-compliant authoring tools. Secondly, the Hard SCORM tags should be embedded between the lines in the Hard SCORM textbooks for the affinity between books and digital information, and the transformation of original learning contents into paper-based learning contents then will become an essential subject in our development.

While considering the authoring process for constructing the practical learning materials, a series of tasks can be sketched as following:

1. Prepare the required assets that will be brought to the learners via different kinds of learning devices.
2. Create a content aggregation that will contain all the learning contents.
3. Load the required assets into the resources pool and place them in the aggregation with the drag-and-drop operations.
4. Arrange all the learning contents into the content aggregation. Modules and clusters are optional to be considered as the categories in the aggregation.
5. Attach the metadata information based on SCORM specification to the components in the content aggregation. The metadata can be filled automatically or manually.
6. Decide the corresponding learning sequencing and navigation rule depending on the instructor’s disposition for supervising the learners’ behavior in the SCORM-compliant RTE.
7. Using Hard SCORM editor to transform the learning materials into paper-based contents respectively, and build up the interrelations between embedded Hard SCORM tags and the corresponding digital information.
8. Print out the Hard SCORM textbooks, and save the content aggregation. Finally, export it to the backend LMS in a PIF file.

This authoring process for instructors is very simple and straightforward. The main benefit of this authoring process is its generality, because it fits well with the needs of generating SCORM-compliant learning contents. Besides, it also avoids the direct manipulating with the heavy XML descriptions for a nonexpert instructor in computer science to produce such kind of learning contents.

**Implementation on Hard SCORM Authoring Tool**

Why is courseware authoring tool essential to the e-learning community? The most attractive things in the e-learning environment are the various types of learning contents. Hence, the authoring tool can be considered as the foundation for building up an attractive e-learning environment and the whole learning processes. To construct the learning contents for multimodal learning devices in our proposed pervasive learning environment,
we develop a user-friendly authoring system, named “Hard SCORM Authoring Tool” based on SCORM 2004 specification. Additionally, as we introduced many outstanding authoring tools for building the SCORM-compliant learning objects in the second section, we devised some specialized functionalities to facilitate and enhance the constructing of the courseware in our proposed Hard SCORM Authoring Tool.

Our Hard SCORM Authoring Tool contains all the necessary functionalities for constructing the learning contents, such as the metadata description, the sequencing setting, the content aggregation, and the content packaging. For the consideration about the generation of hard copy books, the Hard SCORM tags should be automatically or manually placed and recognized by the Hyper Pen in the hard copies for making the physical world in books to affiliate with the digital world in the computer.

The Hard SCORM Authoring Tool is a content aggregation and packaging tool. The interface is divided into five areas. As illustrated in Figure 1, these areas are:

1. Menu and tool bars
2. Content aggregation window
3. Resource pool window
4. Hard SCORM tag bar (optional)
5. Content design/preview window

A menu and tool bars include a set of rich editing functions, which are similar to ordinary Windows applications. The content aggregation window visualizes SCOs and assets, which can be inserted, deleted, moved, renamed, and rearranged by ordinary drag and drop operations as the operations provided by Windows Operating System. The Hard SCORM Authoring Tool can create a new course or load an existing course with the content package, known as the imsmanifest.xml, or in the compressed archive file format. The multiple content aggregations can be loaded as well to the authoring tool for advanced editing.

Figure 1. The GUI of the hard SCORM authoring tool
This will allow the insertion of the current course aggregation into another one.

The Resource Pool Window shows the learning resources in the current course content aggregation. Furthermore, it displays the available assets which can be stored in different directories or searched from the local and remote sites by some criteria according to the metadata definition for the use of inserting to the current content aggregation. The Hard SCORM Tag Bar currently contains four types of reference tags, which can be added to a Hard SCORM textbook. These reference tags, when triggered by a Hyper Pen device, can present multimedia resources such as flash animation, audio, video, and even the Web pages for referencing on a computer or other learning devices. The Content Design/Preview Window provides a visualized preview window for the content previewing. The metadata editor and sequencing editor are available within this area as well. It also allows the final design of assets. The Hard SCORM Authoring Tool can be used with ordinary Web presentation design tools which generate standard HTML files as assets.

In addition to course content, some interesting and imaginative toolkits are integrated with the Hard SCORM authoring tool. We aim to provide an easy way for instructors to build up the diverse SCORM-compliant learning content which can be applied to the pervasive learning environment. Also, under this scheme, an interface for the instructor to pick up the questions and exams in the question database is also available in the authoring tool for supporting the assessment. An exam is composed from a set of questions, which is designed based on another distance learning standard. At the time this proposal is written, SCORM does not incorporate the IMS Question & Test Interoperability (QT&I) specification.

A tree structure for representing the content aggregation is utilized instead of directly manipulating the xml-based imsmanifest.xml. The tree structure has its remarkable advantages for instructors to perform some essential operations with the content aggregation. All the operations of the tree structure can be done as easily as the ones in Windows operating system platform. Furthermore, a well-designed context menu for the responding course node will facilitate the various setting of each different node. The assets in the resource pool can be easily integrated into the current content aggregation by drag-and-drop operations as well. Those assets could be loaded from the local file systems. In addition, a search mechanism is also available for finding the precise learning content from the local system or the remote server.

With respect to shareability, the advantage of using metadata allows users to search for a learning object in a precise manner according to accurate descriptions or predefined vocabularies of SCORM metadata. According to SCORM 2004, the number of entries of metadata is more than 70 for each learning object. An efficient metadata editor is integrated with our authoring tool for the completion of SCORM-compliant learning contents. The metadata editor is associated with different levels of content details of an individual learning resource. The use of metadata can be shown in a query process module, which helps instructors search for suitable and reusable learning resources.

By analyzing the CAM specification of SCORM 2004, the metadata can be separated into two parts: the optional and the mandatory metadata. The former represents the auxiliary information for the searching and reusing, and the latter indicates the required information for describing the learning content. We further consider the data fields of all the mandatory metadata with the internal relationship for their attributes, and we found some of them could be derived from the preexisting information, such as the system environment, the user profiles, and so forth. Hence, we developed a toolkit named the Metadata Wizard for easing the generation of all the metadata for different levels in our Hard SCORM Authoring Tool, as shown in Figure 2.
To avoid the omission of metadata setting for each learning resource, the completeness checking of the required metadata is necessary in the saving phase. This will ensure that all the learning resources within the current content aggregation will be exchangeable and shareable. We also allow the instructor to make some inference rules and questions to extract the information for describing the metadata in the Metadata Wizard. As a result, instructors can easily create all the necessary metadata without additional costs in time and efforts.

The learning sequencing is a supplement to the SCORM specification in the latest version. It can be applied to control and specify the navigation behavior of a learner while learning. Those sequencing and navigation information can be stored in the CAM by specifying a sequencing node in xml format, as shown in Figure 3. However, this kind of sequencing node is hard for instructors to design due to the complexity of XML syntax. As a result, we aim to provide an effortless toolkit for instructors to specify applicable sequencing setting for serving this purpose. We call it the Sequencing Editor. In the Sequencing Editor, we hide the complexity of the XML syntax in specifying the sequencing rules; instead, we transform

Figure 2. The Metadata Wizard in hard SCORM authoring tool

Figure 3. An XML-based sequencing node representation

```xml
<imsss: sequencing>
  <imsss: controlMode choice="true" choice="false" flow="true"/>
  <imsss: sequencingRules>
    - <imsss: preConditionRule>
      - <imsss: ruleConditions>
        <imsss: ruleCondition condition="completed"/>
      </imsss: ruleConditions>
      <imsss: ruleAction action="disabled"/>
    </imsss: preConditionRule>
    <imsss: exitConditionRule>
      <imsss: ruleConditions>
        <imsss: ruleCondition condition="completed"/>
      </imsss: ruleConditions>
      <imsss: ruleAction action="exit"/>
    </imsss: exitConditionRule>
  </imsss: sequencingRules>
</imsss: sequencing>
```
them into a list of items. Instructors can simply set the various sequencing rules by the drop-down menu and fill the information for the data value. Currently, the schema of the items is stored in the database for the conceivable extension in SCORM specification. Figure 4 shows the user interface of the Sequencing Editor.

A mechanism for content developers to check the accuracy of the specified sequencing information can be found in Chang, Wang, Wang, Jan, and Shih (2006). It’s possible that a learning content that might not be reached all the time even if it has already been in the content aggregation, or when the learners start to browse the learning content but they cannot browse another learning content anymore due to the improper sequencing setting. The improper situations might be caused by the unreasonable learning sequencing strategies or the careless filling of the information of sequencing. Figure 5 represents two examples of the improper sequencing setting in the Hard SCORM Authoring Tool. The course node marked in yellow represents the unreachable course node, and the one in red indicates the node which might cause blocking.

The Hard SCORM Course Editor, as shown in Figure 6, is responsible for creating the SCORM-compliant hard copy books for the pervasive learning. The Hard SCORM Tag Bar currently contains four types of reference tags, which can be added to a Hard SCORM textbook with affiliated digital learning resources. Hard SCORM tags, when triggered by a Hyper Pen device, can present digital multimedia resources for reference or perform the corresponding interactions while learning with the hard copy books. The system will automatically assign an identification number, known as the SCO number, to the selected course node, and this information is useful in the sequencing controlling of the Hard SCORM text-

Figure 4. The sequencing editor in hard SCORM authoring tool
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

Figure 5. Sequencing testing mode in the hard SCORM authoring tool

![Figure 5](image)

Figure 6. Hard SCORM course editor user interface

![Figure 6](image)

book. Each SCO number will be bound with the unique ID of the specified course node within the content aggregation. As a result, after the learner scanned the SCO number in the Hard SCORM text book with a Hyper Pen, the recognized result will be sent back to the backend LMS and the learning record of the learner will be updated to the current state.

The relations between the digital files and the physical tags in the hard copy books are recorded during the design phase, and then all the information will be integrated into the current content package for uploading to the LMS. Due to the advantages of Web Service architecture, we can easily build up the relations between the Hard SCORM digital file resource and the recognized...
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

Figure 7. The Printing Wizard for creating the SCORM-compliant textbooks

Regarding the SCORM-compliant hard copy book printing issues, we provide a printing wizard, as shown in Figure 7, to print out all the Hard SCORM courses within the current course aggregation.

Basically, the most important reason for creating metadata according to the SCORM specification is to allow users to precisely search for learning objects for reuse. The Hard SCORM Authoring Tool provides a search interface (see Figure 8), which allows the user to search for reusable learning objects in the local machine or on the remote server side. The search criteria have the same definition as the metadata. Learning objects allocated by the search engine can be loaded into the resource pool and applied to a new content aggregation. A local resource buffer is used to hold the local search results. For the search on the server side, users can download the result as a new course within their computers by clicking the “Download” button or double-clicking the item in the result list. Then the shareability will be accomplished.

With respect to the federation, the Hard SCORM Authoring Tool also allows system administrator to set up multiple servers, which contain different learning objects that can be discovered for reuse. Figure 9 illustrates such an interface for Web services configuration. The allocation of Web services can be selected while requiring the Web services, such as searching for reusable learning objects remotely and uploading the PIF to different LMS servers.

There are some advanced toolkits integrated with our Hard SCORM Authoring tool, such as the Video Presentation Course Toolkits and the Video SCORM Authoring Tool. Those advanced toolkits can be applied to enhance the variety of the course contents. The outcome of those toolkits can be considered as the learning resources within the resources pool for the use in the content aggregation. We briefly discuss these toolkits.

The Video Presentation Course Toolkits contains three functions for the video presentations creating. The Video Presentation Recording allows the user to bring up a MS PowerPoint file and
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

use a CCD camera to record a lecture. The video will be synchronized to the change of PowerPoint slides. The Video Presentation Editor allows users to combine several video presentations, trim a video presentation, or reorganize presentation sequences. All the video records and the PowerPoint slides in the video presentation course will be rearranged automatically. The Video Presentation Post Processing Toolkit is responsible for embedding some relevant information to an existed video clip at specific time scale. The outcome of the tool is in html file format and can be considered as a

Figure 8. Metadata searching engine in the hard SCORM authoring tool

Figure 9. Allocation and selection of remote server
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

Figure 10. The video presentation toolkits and the layout of the video presentation course

Figure 11. The video SCORM authoring tool
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

single SCO and multiple assets in the SCORM specification. The layout and the user interface of the toolkit can be shown in Figure 10.

The Video SCORM (Wang, Chang, Chen, & Shih, 2006) is a project for building the SCORM-compliant course on TV. In another words, this project aims to provide a TV-based learning environment for supporting SCORM. The course content should be in the video file format and can be browsed not only on the Web-based LMS, but also on the set-top-box of a digital TV. The authoring tool for Video SCORM can be shown as Figure 11, and instructors can make various scenes and actors to indicate the information or knowledge that is going to be passed to the learners. After a Video SCORM course generated, the outcomes are able to be loaded into the resource pool in Hard SCORM Authoring tool as a Video SCORM Project. Then the Video SCORM course can be added into the current content aggregation by using simple drag-and-drop operations. The Video SCORM course node in the content aggregation can be redesigned by invoking the Video SCORM Authoring Tool.

EXPERIMENTS RESULTS

Content Layout for Applicable Learning Devices

The Hard SCORM Authoring tool runs on a PC for instructors to build the SCORM compliant courses which will be delivered to multimodal learning devices for supporting the pervasive learning environment. Thus, course contents should be kept available while applying to the PDA or on a hard copy book. Even the various types of display devices may have different layouts; the content will still be the same. The courseware also maintains a consistent access and an interaction strategy. Thus, students using different interfaces will use the same sequencing and navigation control module of the SCORM/Hard SCORM LMS. Furthermore, the layout of the Hard SCORM books will be considered as a key factor to the success in the paper-based learning environment which can be connected to the digital world.

Generally, the organization of a Hard SCORM textbook printing is similar to a traditional textbook. We believe that it is easier for the readers to follow if traditional reading behavior is considered. Thus, in the development of the Hard SCORM project, we carefully consider the behavior of ordinary readers while they are reading. Their detailed learning behaviors are considered in the design of tag printing, as well as in how Hyper Pen should be used. Following a typical textbook, with a limited modification, a Hard SCORM textbook includes several portions:

- **The HardSCORM Control Panel**: contains special tags for navigation control.
- **Table of Contents**: of a Hard SCORM-compliant textbook allows a choice mode of sequencing and navigation specification. The hierarchy can be extended to an arbitrary level. The sequence engine should be able to recognize the page index tags on the table of contents, and guide the user to flip to a specific page.
- **Chapters and Sections**: (include tests) represent the aggregation. Each chapter, section, and test may contain Navigation Tags, Reference Tags, and Answer Tags in the corresponding SCOs.
- **Index**: contains a list of term and page index tag pairs. Invocation of a page index tag allows the user to navigate to a specific page which contains such term. The sequence engine should be able to guide the user to flip to a specific SCO page.

The Hard SCORM Control Panel will be printed as a separated page for each Hard SCORM-compliant textbook. Invocation of tags in the control panel will change the navigation status of
A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

Figure 12. Example of a hard SCORM student ID and control panel

![Figure 12](image)

Figure 13. Example of a hard SCORM textbook

![Figure 13](image)

Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1</td>
<td>1.1</td>
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A SCORM Compliant Courseware Authoring Tool for Supporting Pervasive Learning

Figure 14. Various layouts of the SCORM-compliant courseware on different learning devices

an individual learner. In addition, a Hard SCORM Student ID is printed for each student to use while logging in to the system with different lectures, respectively. An LMS supports the administrative functions and an underlying database will keep the student records, which is used to produce the IDs. Figure 12 shows an example of ID and Hard SCORM Control Panel. A Hard SCORM textbook will have a table of contents, chapter and sections, tests, and index. An example of Hard SCORM textbook is shown in Figure 13.

The authored learning contents can be delivered to the multimodal learning devices as well for supporting different types of learning styles. Figure 14 shows the authored learning contents on PCs and mobile devices.

Experiment Results and Evaluations

In summer 2005, the Hard SCORM project was used by a domestic high school (see Figure 15). Two English teachers used our Hard SCORM Authoring Tool and designed six units of course materials based on contents supported by the Ivy League Analytical English, Taiwan. Some auxiliary information such as the bilingual terminology glossaries, the synonyms, the antonym, the pronunciation, and even the online dictionary, can be bound with the embedded reference tags in the Hard SCORM textbook. Most of the auxiliary learning resources are formed in Micromedia Flash file format, and the rest of them are formed in video, audio, and even hyperlinks to the remote sites.

The learners use tablet PCs or PDAs, which were equipped with Hyper Pens for the innovative learning. From the perspective of learners, according to their learning experience, most students are interested in using high-tech devices such as PDAs and Smart Phones for learning. Furthermore, the Hard SCORM textbooks, which contain the six learning units and the associated digital references, are quite attractive to the students due to the variety and extension that conventional textbooks lacked. As a result, by utilizing the Hard SCORM textbooks, the learning performance is improved, especially in English vocabulary and pronunciation. From the viewpoint of instructors, the Hard SCORM Authoring Tool facilitates the learning contents generation. For an instructors who are nonexperts in computer, they are able to design an attractive courseware simply by using the Hard SCORM Authoring Tool. The instructors need not take account of the SCORM
specification, and the interoperability among those multimodal learning devices.

With respect to the performance of our proposed Hard SCORM Authoring Tool, we ask two professors in computer engineering to evaluate the software performance. The result of the evaluation shows the functionalities are sufficient and convenient for constructing SCORM-compliant learning contents for supporting multimodal learning devices, and the auxiliary toolkits are beneficial in creating the attractive learning materials for the various learning activities.

We also have a questionnaire designed by a professor in education school on the evaluation of authoring tool for the instructors and course contents for the students, respectively. We summarize user experiences and feedbacks from these two aspects. A few important comments can be summarized, as in Table 1.

Table 1. The evaluations of hard SCORM authoring tool and the learning materials

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<th>Advantages</th>
<th>Drawbacks</th>
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| Evaluation of the Hard SCORM Authoring Tool (from the instructors) | • The operations for generating course contents are simple and accommodating.  
• The Hard SCORM tags are easily assigned.  
• The auxiliary toolkits are beneficial for generating multimedia courses.  
• A user manual is helpful to understand the instructions. | • The sequencing rule setting is complex, according to the SCORM specification.  
• The Hard SCORM Tags will be broken while running into the margin of the document. |
| Evaluation of the course contents in multimodal learning devices (from the learners) | • The hyper links from a textbook to multimedia presentations are useful.  
• The use of Hyper Pen for learning fits ordinary reading behavior.  
• The Hard SCORM textbooks are attractive and interactive. | • The Hard SCORM Tags may mix with text instructions and handwritten notes in hardcopy books. |
CONCLUSION AND FUTURE WORKS

Courseware authoring tools can be considered the fundamental systems for constructing attractive learning materials in an e-learning environment. Furthermore, the well-developed e-learning standards facilitate the whole learning processes, and simplify the interoperability regarding the diverse learning contents. The Hard SCORM Authoring Tool allows instructors to develop courseware based on the SCORM 2004 specification, such as the learning content aggregation, the metadata generating, the sequencing rules setting, and the navigation behaviors specifying. Some auxiliary toolkits were integrated with the tool for enriching the variety of multimedia presentations to fit the pedagogic needs. Out of the ordinary third party tools, the learning contents generated via the Hard SCORM Authoring tool can be delivered to learners via multimodal learning devices. It is also the first time that Hyper Pen device is used in a SCORM-based learning environment.

The proposed pervasive learning environment supports students to use multimodal learning devices to read the same course materials, and the individual learning records can be maintained in a central server consistently. Furthermore, the outcomes of the Hard SCORM Authoring tool can be in the hard copy form for serving the advantage of ordinarily comfortable and long-time reading for learners in a traditional learning manner. The Hard SCORM Authoring Tool is available at our site for a free try. A video demonstration section is also included, and interested readers are welcome to visit http://www.mine.tku.edu.tw/SCORM/.

In the near future, we are looking at two directions in our future research. Firstly, the current Hard SCORM tags are static. That is, even the navigation topology can vary from student to student, and the activation of a tag results in a unique outcome. However, it is possible to use an encoding technique to embed multiple branching of tag activation. In general, the encoding technique could be used with an intelligent tutoring system, which is based on the revision of sequence and navigation specification, as well as an assessment on student test performance. Thus, with the same hard copy textbook, supplementary references on PC or PDA are used as remedial lectures for those who need help. The second approach is to enhance the recognition of the Hard SCORM tags. Currently, the Hard SCORM tags contain a part of text-based information for representing the unique feature of specific digital information, and it’s hard to be precisely recognized due to the tag appearance in small size. The automatic generation of unique Hard SCORM tag appearance in image-based should be considered with the relation to the specific digital information. We aim to use content-based image retrieval technologies, which allow graphical tags to be recognized by using a built-in camera on PDA or cellular phone. Therefore, a student is able to use a PDA or cellular phone to read a Hard SCORM textbook and display the attractive digital information with the same learning devices.

REFERENCES


In *Proceedings of the Fourth International Conference on Web Information Systems Engineering* (pp. 209-218).


