

行政院國家科學委員會專題研究計畫 期中進度報告

Hard SCORM(2/3)

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執行期間：94年05月01日至95年07月31日

執行單位：淡江大學資訊工程學系

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九十五年度成果摘要報告

支援自律學習之超互動式行動學習平台－Hard SCORM(2/3)

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中文摘要

在本整合型計畫中，子計畫一乃根據共享內容物件參考模組(Sharable Content Object Reference Model, SCORM)進行相關課程資源之編輯，其中包含了遠距教學中教材內容及使用者的學習紀錄追蹤等項目。在 SCORM 中有關學習順序的定義方面，教材編輯者可以為學習者編排適當的學習順序來學學習課程，不過在學習順序中定義了多項控制項，例如在眾多控制項中最基礎的設定 Control Mode 定義了 Flow、Choice、ChoiceExit、ForwardOnly，等四種學習行為，當教材編輯者混合設定時就會發生有些課程根本無法學習或發生學習中斷，在 Rollup Control 中會發生閱讀完課程後學習狀態仍然為不滿足的狀態，因此本篇論文基於發生以上的狀況，提出針對教材編輯者在 Control Mode 以及 Rollup Control 中偵測錯誤的方法，並以圖示的方式來提醒教材編輯者有問題的設定。

關鍵字：SCORM、網路服務、遠距教學、行動學習裝置、輔助資訊、LOM、學習順序

Abstract

Advanced Distributed Learning (ADL) Initiative proposes SCORM (Shareable Content Object Reference Model) that aims to provide the specifications necessary to enable content developers with the ability to produce content that is sharable, accessible, reusable, and most importantly interoperable. In SCORM 2004 also defines the sequencing information that describes how SCORM-conformant content may be delivered to the learner through a set of learner or system-initiated navigation events. It provides course designers the ability to prescribe the intend learning sequencing strategy, but however, it lacks the completed definitions and lacking the testing mechanism for those authored sequencing information which might results in designing the unreasonable or careless settings of SCORM sequencing.

In this paper, we proposed a detecting mechanism to detect the improper settings of Sequencing Control Mode and Rollup Control elements applied to the SCORM-compliant learning activities. An assistant truth table derived from the definitions of Sequencing Control Mode elements will be introduced to check the undesired learning sequence. Some experiments were made to illustrate the verification with the latest ADL runtime environment as well. Finally, in the system implementation section, a set of effective warning messages were demonstrated according to our proposed detecting algorithm

Key words: SCORM, Web Service, Distance Learning, Mobile Learning Devices, Metadata, LOM, Learning Sequencing

1. Introduction

Parts of SCORM Sequencing and Navigation [1] are originally derived from the IMS [2] Simple Sequence Specification (SSS) which was first introduced and developed in the SCORM 1.3 specification. The IMS SSS allows components in a courseware to be specified in a relative order, in which conditions and selections are precisely defined. The SCORM Sequencing extends from IMS SSS defines the required behaviors and functionalities for SCORM-conformant LMSs to be implemented to process sequencing information at run time. More specially, it describes the branching and flow of learning activities in terms of an Activity Tree, based on the result of a learner's interactions with launched content objects and an authored sequencing strategy.

SCORM sequencing and navigation specification defines quite intricate modes and behaviors. Sequencing Control Mode is one of these defined modes which allows the content developers to affect how navigation requests are applied to a cluster and how the cluster's activities are considered while processing sequencing requests. According to our proposed architecture and algorithm, authors can trigger the sequencing detecting function to verify the authored values of Sequencing Control Mode elements during editing the learning content and sequencing strategy. As a result, the robust sequencing information can be interoperably transferred between systems and reduce the cost of revising improper sequencing strategies.

2. Related Works

With the rapid development of e-learning technology and the popularity of SCORM, more and more tools are developed to facilitate the practical usage for e-learning applications. Some related SCORM sequencing tools such as providing an user-friendly interface to assist teachers/instructors efficiently construct SCORM compliant courses with learning sequencing information [4] and a visualized online Simple Sequencing authoring tool to help instructors edit existing SCORM-compliant content packages[5]. The study tries to decrease the complexity of the sequencing definition by applying the features of Petri net can be found at [6]. Academic ADL Co-Lab also develops a Sequencing Visualizer Tool[7] that using graphical representation of the imsmanifest XML file and programmers are able to step through content to ensure all rules are working as desired. The rest content of this section will introduce the cluster definition and elements defined in Sequencing Control Mode.

2.1 Cluster definition

As shown in Figure 2.1, an activity tree can be separated into several smaller cluster units which considered as a basic building block of learning activity. SCORM sequencing is especially applied to clusters. The parent activity of the cluster will contain the learning sequencing information. The child activities in the cluster will have associated learning content and objects. The cluster is defined for learning sequencing strategy.

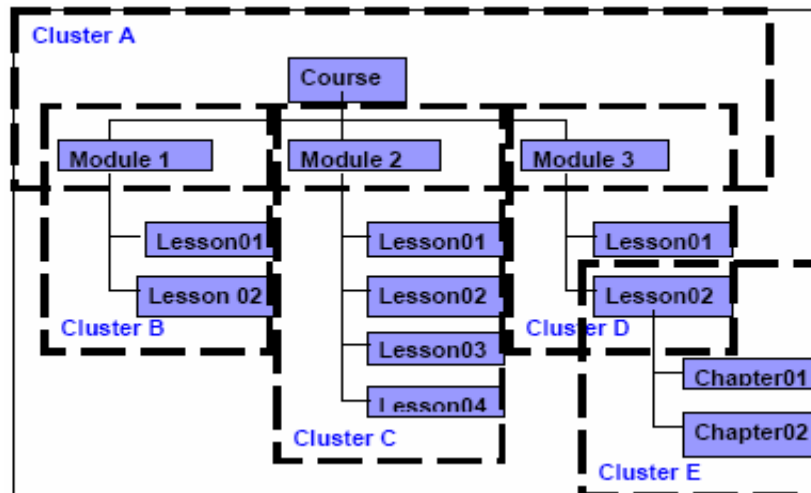


Figure 2.1: Cluster Example

2.2 Sequencing Control Modes

The control modes can be used in the following ways:

- During processing of a navigation request to determine whether or not the request will translate into a valid sequencing request.
- During various sequencing request for sub-processes to affect the activities for delivery.
- During various sequencing behaviors to affect how tracking status information is managed.

There are six elements defined in Sequencing Control Modes includes Sequencing Control Choice, Sequencing Control Choice Exit, Sequencing Control Flow, Sequencing Control Forward Only, Use Current Attempt Objective Information and Use Current Attempt Progress Information. The last two elements are used for Tracking Model which will not be discussed in this paper. The following short descriptions of the other elements in Sequencing Control Model would directly affect the learner's learning sequencing.

2.2.1 Sequencing Control Choice

The Sequencing Control Choice element indicates that the learner is free to choose any activity in a cluster in any order without restriction. If a parent activity has Sequencing Control Choice element with default value; true, then its child activities are all valid targets for a Choice navigation request. The Sequencing Control Choice control mode has no affect when defined on a leaf activity.

2.2.2 Sequencing Control Choice Exit

Sequencing Control Choice Exit indicates whether a Choice navigation request can target activities that are not descendants of the affected activity, and causes the affected activity to terminate. ChoiceExit only can be applied to an active activity. The default value for Sequencing Control Choice Exit, if not explicitly defined for the activity, is True.

2.2.3 Sequencing Control Flow

In Sequencing Control Flow, the system directed sequencing through the child activities of a cluster is supported. The default value for Sequencing Control Flow, if not explicitly defined for an activity, is False.

2.2.4 Sequencing Control Forward Only

The Sequencing Control Forward Only indicates that system directed sequencing through the child activities of the cluster is constrained to disallow previous navigation request and to disallow Choice requests that would move in a backward direction.

3. Sequencing Errors Detecting Concept

The improper sequencing information would lead a learner to attend unanticipated learning activities, or causes unexpected situations such as learner's attempt is stuck in a certain activity or some relevant activities are not able to be identified for delivery always.

According to the experiences of designing sequencing information, the following unexpected situations probably may occur during run-time.

- Learning attempt is stuck in a certain activity
- Learning attempt is fallen into a vicious learning circle.
- Deserved activities are not identified for delivery

Of course, these unexpected situations could have reciprocal effect to each other.

3.1 Reduce the problem and build the truth table

We reduce the detecting problem to the simplest situation, a single cluster, which has a parent activity with a single child activity or a parent activity with multi-child activities.

As mentioned before, there are four Sequencing Control Model elements directly affect the learning sequencing navigation requests. Therefore for the simplest case, there are totally 28 combinations to construct the truth table. According to the different characteristics of Sequencing Control Choice, Sequencing Control Flow and Sequencing Control Forward have no effect when they are defined on a leaf activity and Sequencing Control Choice Exit can be only applied to active activities. Therefore all possible authored cases can be simplified to sixteen cases as shown in table 3.1. The result of each case in table 3.1 is derived from the experiments tested in the latest version of ADL runtime environment and analyzing the reciprocal effect between the sequencing navigation behaviors defined in Sequencing Spec.

Table 3.1

Case	Parent Activity			Child Activity	Result
	Flow	Forward Only	Choice	Choice Exit	
1	<i>False</i>	<i>False</i>	<i>False</i>	<i>False</i>	<i>Block</i>
2	<i>False</i>	<i>False</i>	<i>False</i>	<i>True</i>	<i>Block</i>
3	<i>False</i>	<i>False</i>	<i>True</i>	<i>False</i>	<i>Block</i>
4	<i>False</i>	<i>False</i>	<i>True</i>	<i>True</i>	<i>Ok</i>
5	<i>False</i>	<i>True</i>	<i>False</i>	<i>False</i>	<i>Block</i>
6	<i>False</i>	<i>True</i>	<i>False</i>	<i>True</i>	<i>Block</i>
7	<i>False</i>	<i>True</i>	<i>True</i>	<i>False</i>	<i>Block</i>
8	<i>False</i>	<i>True</i>	<i>True</i>	<i>True</i>	<i>OK</i>
9	<i>True</i>	<i>False</i>	<i>False</i>	<i>False</i>	<i>OK</i>
10	<i>True</i>	<i>False</i>	<i>False</i>	<i>True</i>	<i>OK</i>
11	<i>True</i>	<i>False</i>	<i>True</i>	<i>False</i>	<i>OK</i>
12	<i>True</i>	<i>False</i>	<i>True</i>	<i>True</i>	<i>OK</i>
13	<i>True</i>	<i>True</i>	<i>True</i>	<i>False</i>	<i>OK</i>
14	<i>True</i>	<i>True</i>	<i>True</i>	<i>True</i>	<i>OK</i>
15	<i>True</i>	<i>True</i>	<i>False</i>	<i>False</i>	<i>OK</i>
16	<i>True</i>	<i>True</i>	<i>False</i>	<i>True</i>	<i>OK</i>

We take two single cluster examples to explain the blocking cases in table 3.1. In figure

3.1, the sequencing setting of this single cluster corresponds to blocking cases includes case 5, case 6 and case7. In this cluster the Parent Activity has Flow defined as false. LMS will not provide any mechanism for the learner to indicate their desire to “Continue” to the next activity or to go back to a “Previous” activity. But the child activities are all valid targets for learners to choose due to the Sequencing Control Choice defined as true. If a learner chooses Lesson2, the learner’s attempt will always be stuck in this activity. The reason is that when a learner’s attempt is on Lesson2, the parent activity of Lesson2 has Sequencing Control Choice defined as true so every sibling of Lesson2 is a valid target for a Choice navigation request. But allow one of Lesson1 or Lesson3 or Lesson4 to be identified for delivery would result in Lesson2 terminating, violating the intention of Choice Exit control. At the moment, the learner can neither trigger Flow nor Choice navigation requests, so there is no activity could be identified for delivery. The figure 3.2 shows the real content package which has the same sequencing information with Block Example 1 is running in ADL runtime environment. After a student clicks the Lesson2, the content aggregation tree and all navigation requests button are disappeared except suspend and quit request buttons for this learning process.

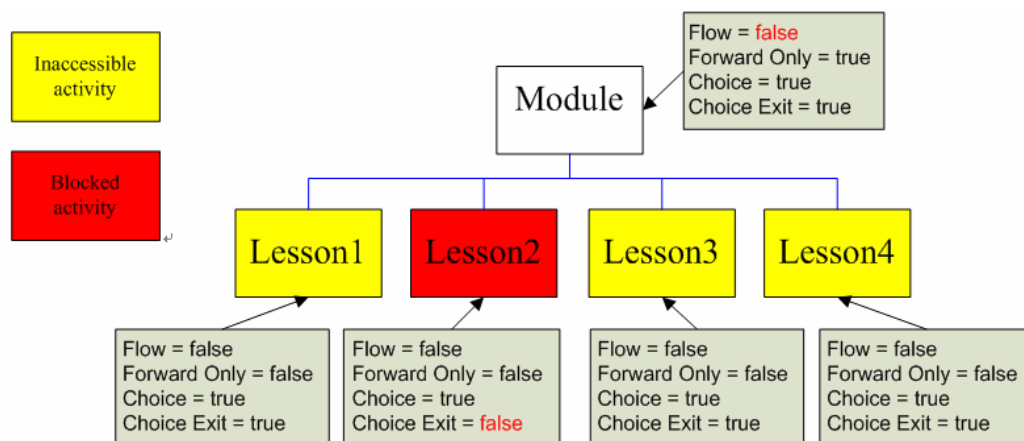


Figure 3.1 Blocking Example 1

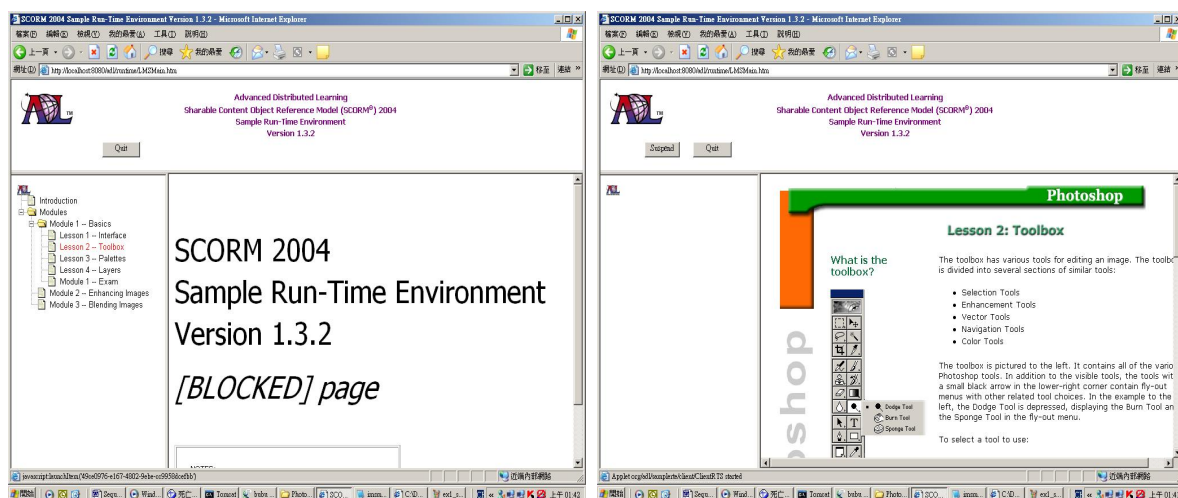


Figure 3.2 Blocking Example 1 tested on ADL runtime environment

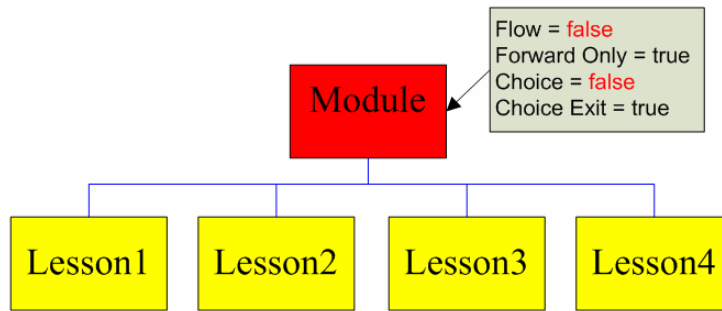


Figure 3.3 Blocking Example 2

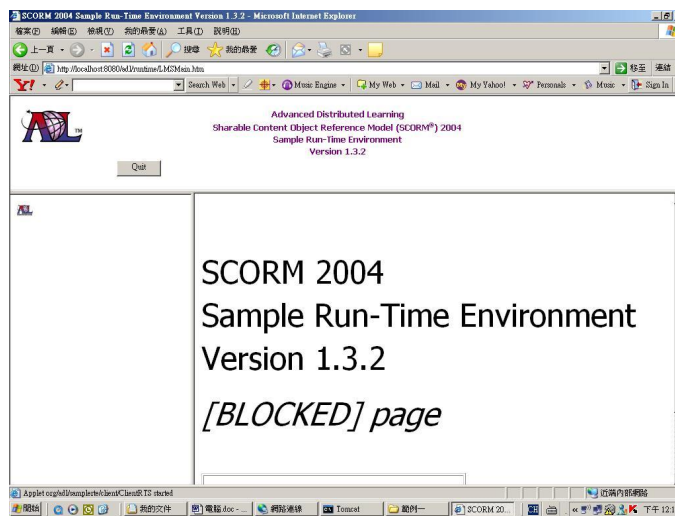


Figure 3.4 Blocking Example tested on ADL runtime environment

The second example is shown in figure 3.3, a Parent Activity has Flow and Choice defined as false. LMS will disable the Continue and Previous navigation requests. All child activities will not be valid targets for learner to free choose either due to the parent activity has Sequencing Control Choice defined as false. As the result, a learner could be stuck in front of the Module node and Lesson1 to Lesson4 all become inaccessible nodes in this Activity Tree. This situation corresponds to blocking case includes case 1, case2 and case3 in Table 3.1. The practical content have to be tested on latest ADL runtime environment, the result is shown in figure 3.4.

3.2 Detecting Algorithm

In previous section, we introduce an assistant truth table constructed by Sequencing Control Elements definitions and behaviors. The following detecting algorithm extends the detecting mechanism to a general course consists of more than one single cluster. Furthermore the algorithm is based on recursion such that no matter the input course aggregation tree is a partial tree or a complete aggregation tree can be worked well.

```

Given:
SCT: Sequencing Control Truth Table
CAT: Course Aggregation Tree
CC: Course Cluster {
    Cluster Number;
    Sequencing Information
}
Steps:
j = 0;
SCA(CAT, CT, j){
    If(CAT can not be separated into any cluster anymore){
        Return;
    }
    Else{
        Separate a cluster unit CU from CAT according to Depth First Search.
        j = j + 1;
        Add CU to CT;
        CU.Cluster Number = j;
        SCA(CAT, CT, j);
    }
}
For(i = CT.length; i >= 0; i--){
    Compare the CT[i].Sequencing Information with SCT;
    List the compared result and CT[i].Cluster Number.
}

```

An input content aggregation tree is going to be separated into several defined clusters according to the Depth First Search. The sequencing information defined in the individual cluster will also be saved. When the tracking status of an activity changes, the tracking status of its ancestors may be affected. Consequently, we use the bottom-up method to detect the collected cluster unit from the cluster tree. One of the children of a cluster is possible be a parent activity of another cluster. The basic idea is as long as we ensure the accuracy the cluster's all children clusters and then the cluster's accuracy can be ensured as well. Extend the recursive method from a single cluster can ensure the accuracy of a whole cluster tree.

3.3 Detecting Working Flow

Our proposed detecting function can detect not only a partial uncompleted courseware but also a completed packaged courseware has defined sequencing information. Sensibly, the

detecting function should be triggered whenever authors need it at editing learning content phase.

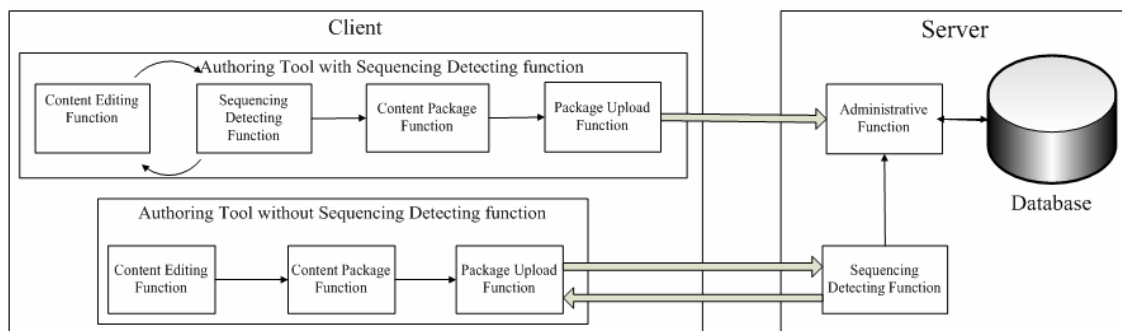


Figure 3.5 Working Flow of Sequencing Test

Present general authoring tools do not provide the sequencing error detecting function of authored sequencing information. In figure 3.5, at client side, an authoring tool with sequencing error detecting function can ensure the accuracy of the authored sequencing information before packaging and uploading the course content. On the other hand, for general authoring tools without sequencing error detecting function, LMS should provide the same detecting service. While uploading a SCORM compliant course package, the LMS is going to evaluate the uploading manifest file with detecting schema real time and then responding the warning messages on web page. This service should be an option rather than a restriction.

4. Implementation and Experiment

In this section, we will use two different examples to demonstrate the detecting interface on application and web page respectively. In figure 4.1, Hard SCORM Authoring Tool[8] provides a click button to trigger the detecting mechanism for current authoring sequencing strategy anytime. Users can trace and understand the statuses of current authored sequencing information by visualizing results while course editing phase. It does not matter the editing course process is finished or not. The activity in red indicates that students might be stuck here and consequently its child activities or sibling activities will probably become inaccessible nodes expressed by yellow background color. At the same time, the program will list the authored sequencing information of red color activity and warning messages to describe the critical situation.

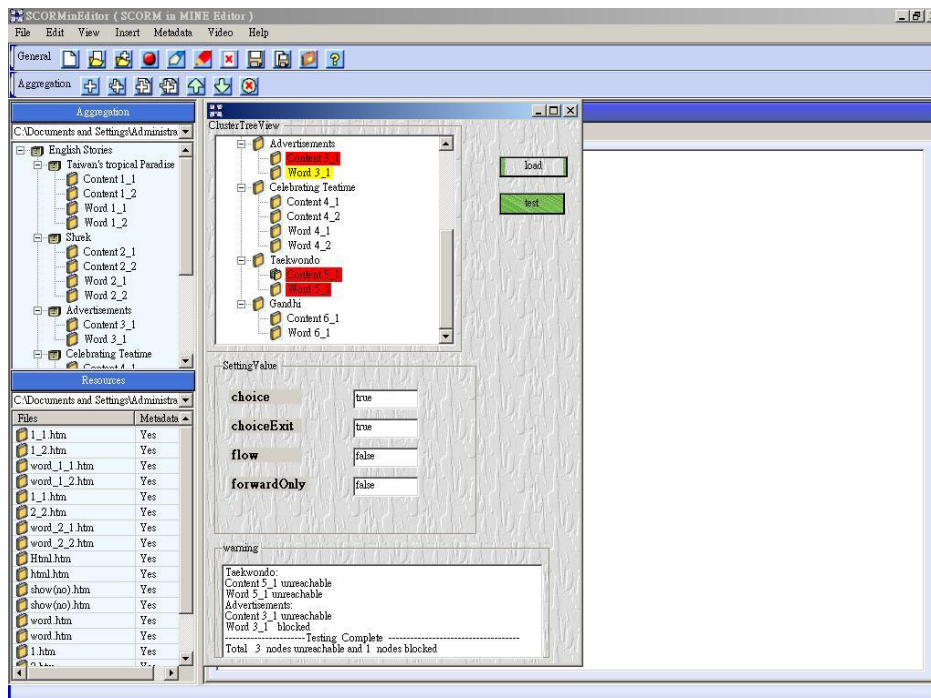


Figure 4.1 Detecting results on MINE SCROM authoring tool

We take another example course designed by a Junior High School teacher. Just like general teachers who dose not very familiar with the all sequencing definition but like to add the applicable sequencing strategy to her teaching materials. She used general authoring tool without sequencing error detecting function to edit learning content and define sequencing information. Although accuracy of her authored sequencing information can not be ensured at authoring client, the detecting function can be executed at our LMS as well. The course package uploaded to our developing LMS which provides sequencing error-detecting option that is similar to ADL runtime server has testing mechanism to ensure the uploading package containing complete SCORM Conformance. The detecting results are shown in Figure 4.2. In this case, Server found six inaccessible nodes and a blocking node, related detail information is shown at the bottom of this figure. LMS just indicates the possible improper sequencing information but does not constrain user to upload the course package.

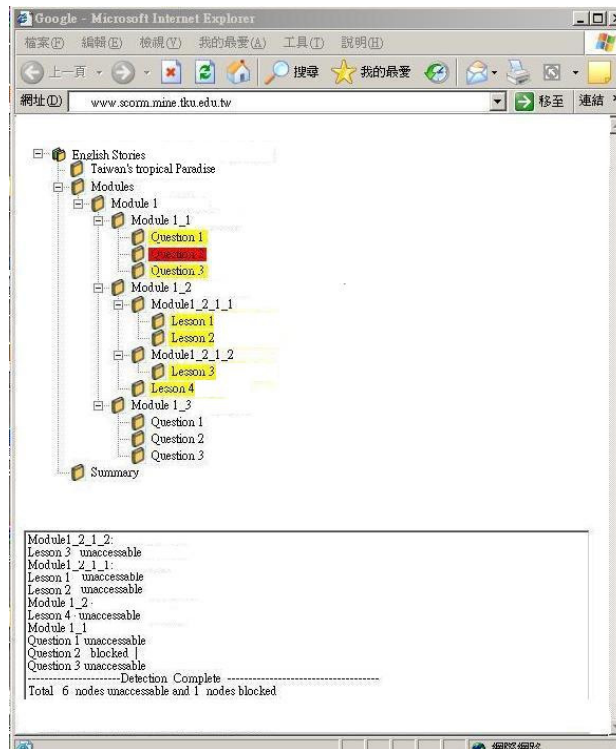


Figure 4.2 Detecting results on web page

5. Conclusion and Future Work

The proposed detecting mechanism for SCORM Sequencing can be used to help content developers or teachers to design a more robust sequencing strategy applied to learning activity. An authoring tool with the sequencing error detecting mechanism can ensure the accuracy of current defined sequencing strategy at editing learning materials phase. Our MINE SCORM LMS also provides a detecting option for other authored SCORM-compliant course package designed by general authoring tools without sequencing error detecting mechanism. Our main contributions are not only reducing the cost of revising uploaded courses with careless or improper sequencing information but also help general users have the inclination to try the complicated sequencing definition. For the moment, our testing task focused on the generally used Sequencing Control Mode. Extending the sequencing errors detecting mechanism to other models and rules included in Sequencing Control Definition Model is our main future work.

6. References

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行政院國家科學委員會 數位學習國家型科技計畫

九十五年度研究成果資料表

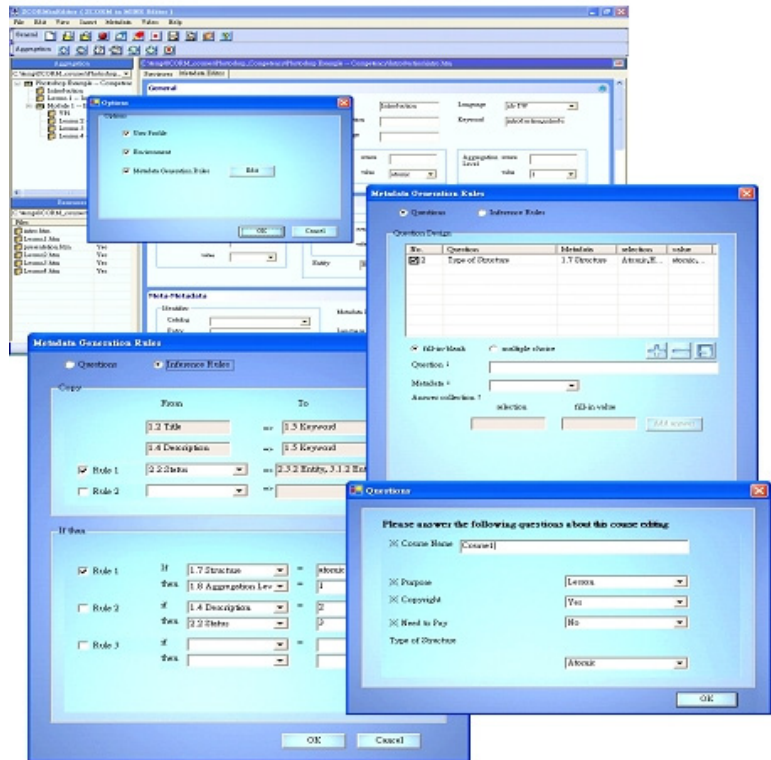
日期：95年5月20日

國科會補助計畫	<p>計畫名稱： 支援自律學習之超互動式行動學習平台—Hard SCORM(2/3) 計畫主持人：施國琛、游國忠 研究人員：謝勝文、鄒孟廷、張建蒼、張漢賓、陳信儒、張玄菩 計畫編號：NSC 94-2524-S-032-002-</p>
研究摘要	<p>中文： 在本整合型計畫中，子計畫一乃根據共享內容物件參考模組(Sharable Content Object Reference Model, SCORM)進行相關課程資源之編輯，其中包含了遠距教學中教材內容及使用者的學習紀錄追蹤等項目。一般而言，目前坊間 SCORM 相容性的學習管理系統大多以透過網頁瀏覽器或透過 Java 程式建構而成，而在本計畫中，我們將 SCORM 教材的應用層面透過網路服務的概念推廣至行動學習裝置與紙本書籍當中。我們發展了一套符合 SCORM 標準的課程編輯系統，藉由這套系統的使用，教材設計者可輕鬆的編輯出符合 SCORM 規範的教學資源供學習者取用。而這些學習資源可透過高科技之行動裝置以及紙本書籍傳遞給學習者進行相關學習活動。學習者可透過傳統紙本教科書進行所有的學習活動，而這些學習行為也將滿足 SCORM 所定義出的學習模式。在本年度的計畫中，我們將著重於教材內容設計，其中包含符合 SCORM 規範之輔助資訊設計以及相關的學習順序設計等方面進行實作。如此一來，教材之間之共享性以及學生學習之瀏覽順序將有所規範。而這些符合 SCORM 規範的學習資源可透過不同學習裝置的擁有不同的呈現方式，而教材設計者只需設計一次，便可達到這樣的目的。</p> <p>英文： Our proposed project is based on Sharable Content Object Reference Model (SCORM), which includes a representation of distance learning contents and a learning behavior definition. SCORM was widely used to assist the e-learning industry in standardizing the best approaches to creating, storing, transferring and deploying learning content. Generally SCORM-compliant systems were based on multimedia and Web technologies on PCs. We further aim to build a pervasive learning environment, which allows users to read SCORM-compliant textbooks with multimodal learning devices. Respecting the learning contents for supporting pervasive learning environment, we developed an authoring tool for instructors to construct the SCORM-compliant</p>

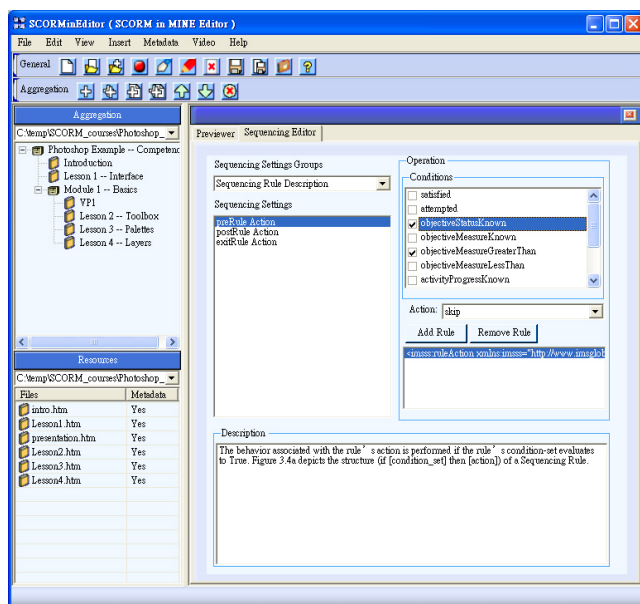
	<p>learning contents. Some specific tags were defined to specify the corresponding information or interactions that can not be performed in the hardcopy books. The authored course contents should be kept availability while applying to the multimodal learning devices, such as PDA or on a hard copy book. Even the various types of display devices may have different layouts; the content will be the same.</p>
<p>研究特色</p>	<ol style="list-style-type: none"> 1. 透過網路服務架構，提供教學資源之搜尋、下載與共用等機制，供教材設計者能更輕鬆便利的製作相關教學內容，並於不同的學習裝置中呈現。 2. 學習者可透過多種輔助學習裝置，於符合 SCORM 標準之多元式學習環境進行學習與評量活動。 3. 提供傳統紙本書籍閱讀方式，並結合多樣的電子輔助裝置之學習環境，以增進學習者之學習成效，並分析相關學習行為與成效。 4. 透過 SCORM 規格定義出的相關規範，如根據教材中之學習順序規格，學習者能更有效率進行教學資源的瀏覽，以達成適性化及自律學習之目標。 5. 提供教材設計者有關課程之輔助資訊製作精靈，以減低其在設計符合 SCORM 課程時所需花費之額外時間成本。
<p>研究成果可應用範圍</p>	<p>教材設計者可透過子計畫一的課程編輯系統快速的製作出符合 SCORM 的教材內容，由於 SCORM 是全球性的數位教材規範，因此，這些符合 SCORM 的教材內容，皆可於符合 SCORM 的學習平台進行傳遞。為了節省花費在找尋教材的時間，輔助資訊的建立與提供就變的十分重要。為了搭配遠距教學上與教育上的功能，SCORM 所定義出的輔助資訊規定了許多的欄位與內容。一方面好處是提供足夠且豐富的資訊讓使用者使用，另一方面，也增加了教材的共享性與再利用性；然而相對之下，過多的欄位也會造成使用者每次的編寫教材上的不便利。有鑑於此，我們提出的一套整合式的課程編輯系統，稱為 Hard SCORM Authoring Tool。在我們提出的系統架構中，教學者在設計教材所需花費的精力可以減輕，所設計出的教材也能跨越不同的系統平台不需一再地重新製作，在學生的學習紀錄資料也能夠傳輸給不同的學習管理系統，加上學生個人學習紀錄的資料模型，學生可以不用一再地重複學習已經學習過的教學內容，而達到更加的學習效率，而對教學組織而言，也可節省訓練人員上的學習成本。</p>
<p>研究成果預期效益／商機</p>	<ol style="list-style-type: none"> 1. 依據 SCORM 規範，定義相關課程標準輔助資訊，以期達成教材共用與資訊分享之目標。 2. 建立紙本書籍與電子輔助資訊之關連性，並結合紙本書籍之閱讀舒適性及多媒體學習資源之豐富性，進而引發學生學習興趣，並以提昇整體學習成效為系統主要目標。

3. 結合紙本書籍與互動式數位媒體，以期增進傳統紙本書籍之資訊豐富性。對於傳統出版業者因應數位化潮流，將有所助益。
4. 藉由實作符合 SCORM 規範之教材內容，並了解其細部規範，可與國內外相關機構研發之 SCORM 標準之學習平台共用，將有助於台灣在國際上有關遠距教學之學術地位提升。

研究成果圖片

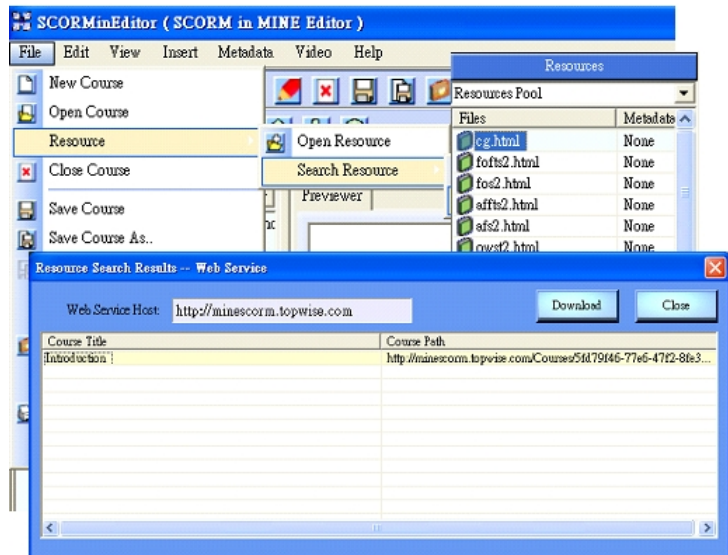


課程輔助資訊編輯精靈之使用者操作介面

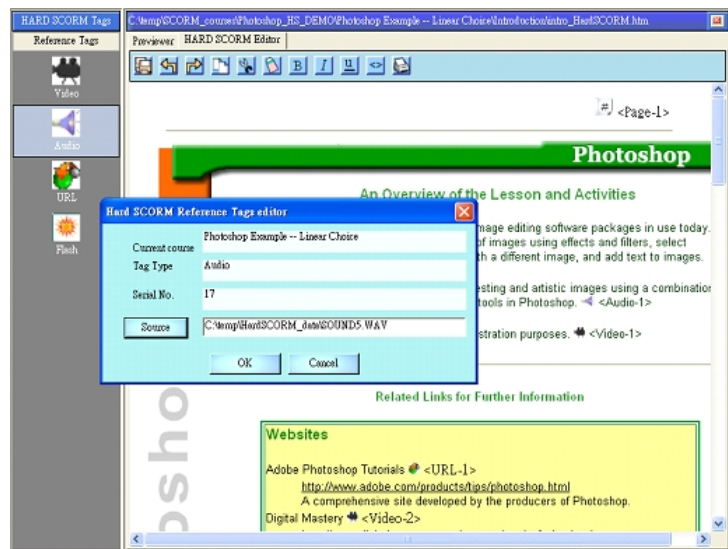


符合 SCORM 學習順序規範之編輯介面

研究成果圖片



Hard SCORM 課程搜尋與教學資源載入之使用者操作介面



Hard SCORM 紙本書課程編輯系統