

INTEGRATING SPC TABLE FORMATIVE ASSESSMENT WITH SCORM

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Received 22 June 2007

Accepted 31 October 2007

SCORM (Sharable Content Object Reference Model) is one of the international e-learning specifications, which provides sharable content, compatible run-time environment and learning profile. SCORM supports accessibility, adaptability, affordability, durability, interoperability and reusability. People can share their own learning content with each other and learn things on the Internet. SCORM learning content can run on the SCORM learning management system. However SCORM do not have a complete evaluation mechanism. The SP chart represents students and problems. It is a tool to analyze the relationship between students and their answers to test problems. In this paper, we integrate the SP chart into SCORM as a formative assessment and add course as the third dimension to strengthen SCORM assessment. The developed tool can be used for SCORM assessment in three perspectives: student-problem, course-problem, and student-problem. So any test problem set and the student performance can be thoroughly examined. The tool was applied to a class and the empirical results are presented in this paper.

Keywords: SCORM, SP chart, SPC table, e-learning, formative assessment.

1. Introduction

E-learning provides people a convenient and efficient way for learning things. The teaching materials are transferred via satellites and the Internet. With the fast development of wireless technology, people access distance learning courses at any time, any place. However e-learning did not provide good methods for assessing learners. In traditional education, the teacher can modify his/her lecturing style or content flexibly to maximize the teaching quality with students' response face to face. However, it is hard for teachers to modify the learning content or style immediately in the distance learning environment. For example, instructors recorded their teaching materials before classes

begin in asynchronous learning. Learning material has to be perfectly organized in e-learning. Then it will be published on the Internet. For the instructor, they have to predict his/her students' learning ability thoroughly before the class begins. In the distance learning environment, the instructor can accurately analyze the student learning records in the past, which provides information to the teachers to modify the learning contents or learning sequencing much more appropriately.

Specifications and standards help the academia and the industry to develop products in a standard method which also makes the products be produced rapidly and more reliable. Specifications defined united rules about how to create a certain product. With the specification revolution, the product can be developed more perfectly. Some committees proposed infrastructures or specifications of standards for asynchronous distance learning, such as IEEE Learning Technology System Architecture (IEEE LTSA) [4], the Sharable Content Object Reference Model (SCORM), and the IMS [5] Simple Sequence Specification. It is significant to have a standardized representation of contents which promote the development of e-learning in industry, academic and government. It is a trend to standardize the format of the learning contents.

Nowadays there are many learning management systems (LMSs) which provide learning content, member login, discussion board and content viewer. Each LMS has its own learning content format, so that it is hard for different LMSs to exchange their contents to each other. SCORM (Sharable Content Object Reference Model) [1] is an international specification for e-learning. It provides sharable content, compatible run-time environment, and learning profile. SCORM learning content called Sharable Content Object (SCO) can be imported into any LMS that is SCORM compatible. With SCORM assistance, the SCOs from any LMS can be imported into other SCORM-compliant LMSs without additional transformation. The advantages of SCORM are the following: Accessibility: the ability to locate and access instructional components from one remote location and deliver them in many other locations. Adaptability: the ability to tailor instruction to individual and organizational needs. Affordability: the ability to increase efficiency and productivity by reducing the time and cost involved in delivering instruction. Durability: the ability to withstand technology evolution and changes without costly redesign, reconfiguration. Interoperability: the ability to take instructional components developed in one location with one set of tools or platform and used them in another location with a different set of tools and platform. Reusability: the flexibility to incorporate instructional components in multiple applications and contexts.

SCORM focused on defining reusable learning objects, developing new content models, developing learner assessment models, and creating new models for sequencing content. The three main components are the Content Aggregation Model (CAM), the Run-Time Environment (RTE) and the Sequencing and Navigation (SN). Advanced Distributed Learning Initial (ADL) is developing the common cartridge for more stable learning content format in the near future.

E-learning specifications make it convenient to produce the e-learning application and digital content. However a lot of e-learning specifications have their learning content formats which are not compliant with other e-learning specifications. The IMS Global

Learning Consortium announced IMS Cartridge specification which combines Content Packaging, Question/Test Interoperability, and Metadata. It can be a new specification for digital educational contents and e-Learning systems. IMS Question/Test interoperability (QTI) specification describes test, test result data, item banks and some authoring tools specifications. Even though IMS QTI supported a lot of assessment functionaries, it is too hard to be applied into e-learning.

CAM defines the responsibilities and requirements for building content aggregations (e.g., course, lessons, modules, etc.). CAM contains information on creating content packages, applying metadata to the components in the content package and applying sequencing and navigation details in the context of a content package. There are two elementary objects in SCORM – asset and SCO. An asset can be a JPEG file, an MPEG file, or an HTML file. A Sharable Content Object (SCO) is a basic learning unit with communication Application Program Interfaces (APIs) in SCORM. SCO can be imported to any SCORM LMS (i.e., Run-Time Environment) and communicate with the LMS. SCORM Run-Time Environment plays a role to communicate with its underlying Learning Management System (LMS) that is both machine-independent and operation-system-independent.

Sequencing and navigation defines the learning sequencing behavior and the learner navigation. In other words, the learning behaviors from different learners will lead to different learning paths. Interactivity and tracking of learning status of individual users were addressed in the SCORM 1.3 sequencing definition model. The content of a SCORM course is described in a tree-like structure. The structure defines clusters which are specialized forms of learning activities. SCORM sequencing rules are especially applied to clusters. The parent activity of the cluster will contain the learning sequencing information. The child activity in the cluster will have its associated learning contents and objects. A cluster is defined as a learning sequencing strategy. Instructor declares the relative order in which elements of contents (SCOs) are to be presented to the learner and the conditions under which a piece of content is selected and delivered or skipped during presentation. The learning behaviors from different learners will lead to different learning paths. And, individual learner records can be stored as different activity trees. With the technical help, it is much easier to realize the learners' activities and learning record.

The related work section describes some related SCORM systems and the SP chart systems. After related work section, the main methodology is presented. It delineates how to combine the SPC table and the SCORM learning system. The experiment section recorded the results of our empirical study. Finally, a brief conclusion is drawn.

2. Related Work

There are some learning systems compatible with SCORM. A well organized and adaptive learning course provides appropriate and convenient learning. A good assessment not only supplies suggestions for instructors to edit their learning material but

also supports learners to comprehend the knowledge they misunderstood. Therefore, finding out the relationship between the learner, the course, and the exam is important. Some research focused on these issues and they are listed in the following.

The SP table is a two dimensional table. The row represents the student number and the column is the problem number of an exam. It shows the relation between the students and the problems. How can it be used? When No. X student answers No. Y problem correctly, the corresponding cell (row: No. X; column: No. Y) is marked as '1.' On the other hand, if the student failed the problem, the corresponding cell is marked as '0.' Consequently, the value of each SP table cell is either '0' or '1.' After all the student exam results are recorded, students and problems are sorted the number of 1's from high to low. The sorted upper-left triangle in the SP table should be filled with 1's because it is believed that students who have good grade should answer simple questions correctly. (Students with higher scores appear in the upper part of the sorted table. And problems correctly answered by more students appear in the left part of the sorted table.) It is abnormal when 0's show up in the upper-left triangle of the sorted SP table and 1's appear in the lower-right triangle of the table. Kazuo Yamanoi [6] used Microsoft Excel to implement the SP table. The tool is useful and user-friendly. It can draw the S-curve and the C-curve easily. However the results are analyzed by human, not by computer.

Dai et al. [2] discovered some significant things: (1) the class-based analysis unit of the S-P chart; (2) the diagnosis of students' learning outcome in regards to S-P chart; (3) the diagnosis of test item quality according to S-P chart; (4) the forecast of students' placement; (5) facilitation to the analysis and testing the test quality of the related subjects test bank; (6) an blend tool to construct the web-based test. Chen et al. [3] incorporated the response time, the difficulty index, and the discriminatory index of each test item into an S-P model during the analysis. Moreover, Chen et al. [10] implemented an online assessment feedback mechanism into SCORM 2004 content package.

To improve further the SP table, Shih et al. [11] developed the Student-Problem-Course (SPC) table to analyze the relations among student, problem, and course in three dimensions. Integrating the SP table and course, the SPC table provides three domains, course-problem, student-problem and course-student. The SP domain is the same as the SP table method. The SP table records the relationship between learners and questions in an exam. In the CP domain, instructors are able to know the relationship between the course and the question of an exam. The SC domain presents the relationship between the learner and the course.

Chang et al. [12] proposed an assessment metadata model which integrates assessment and SCORM for e-Learning operations. With support from assessment metadata, the authors can incorporate measured aspects of the following list into the metadata description at the question cognition level, the item difficulty index, the item discrimination index, the questionnaire style, and the question style. The assessment analysis model provides analytical suggestions for individual questions, summary of test results, and cognition analysis. Lin et al. [7] applied influence diagram method to analyze the learning progress. The authors combined SCORM specifications with design of the

course diagram. The courseware can be generated automatically with the distance learning specifications. The instructor can receive prompt feedback from students.

3. Integrated SPC and SCORM

This section is the main methodology which involved the system architecture, the SP chart, the SPC table, and how the SPC table can be integrated with the SCORM learning management system. The system architecture (see Figure 1) includes administration service, learner profile service, content management service, delivery service and assessment service. Administration service is responsible for user registration. Learner profile service is responsible for learner profile record, learning progress, learning style, typical learning time, and learner assessment result. Content management service is divided into learning contents and exams. They have the same functions including content packaging, simple sequencing code generation, metadata generation, and content aggregation modification. Delivery service is responsible for learning contents and exam contents delivery to the users. Assessment service is in charge of SPC analysis including SP (student-problem), CP (course-problem), and SC (student-course) domains. With the assessment result, the system can do the following activities: reconstruct the aggregation tree, generate new sequencing code, find corresponding metadata learning content, and deliver the appropriate learning content to the learner. In the following, the analysis methodologies for the three domains are presented.

The CP Table

Rows are course units and columns are problems in the CP table (see Figure 2). With the CP table, instructors are able to know the relationship between each course unit and each problem of the exam. The value domain of the CP table is {Y, N}. If a cell of the CP table is marked as 'Y,' it means that the corresponding problem of that cell is from the corresponding course unit.

The SP table

The SP table (see Figure 3) recorded the relationship between students and problems in an exam which is held by using our system. There are two possibilities correct and wrong. When a student answered a question correct then marked as "1" in SP table, else marked as "0" representing wrong in SP table. After SP table has been constructed, we sort the SP table vertically according to students' grade and horizontally according to number of correctly answered of each problem. An example of a sorted SP With sorted SP table, we could get two learning curves, which are S curve and P curve, according to students' grade and number of students. S curve and P curve reflect the relationship of students and problems of an exam. P curve is drawn by the problem sum of each student. S curve is drawn by the student sum of each problem. Theoretically, the left upper triangle area is filled with "1", and the right down triangle area is filled with "0".

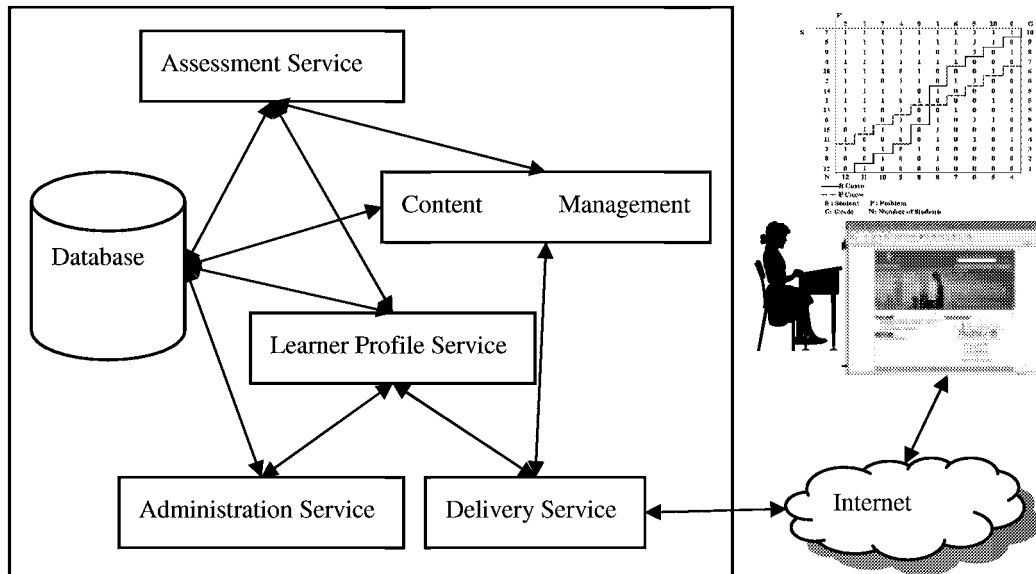


Figure 1. System Architecture.

	1	2	3	4	5	6	7	8	9	10	Sum
2-1	Y	Y									2
2-2				Y							1
2-3			Y								1
2-4											0
2-5					Y						1
2-6									Y		1
2-7				Y		Y					2
3-1							Y		Y		2
3-2							Y				1
3-3											0
4-1							Y				1
4-2							Y		Y		2
4-3								Y			1
4-4											0
4-5							Y				1
	1	1	1	1	1	1	1	5	1	3	

Figure 2. Course-Problem Table.

The SC Table

The SC table (See Figure 6) shows the relationship between the student and the course. Columns of the SC table are course units and rows of the SC table are students. The value domain of SC table is $\{1, 0\}$ where '1' indicates a student learned and passed a course unit, and '0' indicates a student failed the course unit. If a student wants to pass a course unit, he/she has to satisfy the conditions defined in SCORM. SCORM applies IMS SS Specification which employs a rule-based sequencing model. A set of zero or more

Sequencing Rules (see Figure 7) can be applied to an activity and the rules are evaluated at specified times during various sequencing behaviors. Each Sequencing Rule consists of a set of conditions and a corresponding action. The behavior associated with the rule's action is performed if the rule's condition-set is evaluated to be true. Satisfaction means the learner fulfills the corresponding condition set. For example, most common conditions are *attempted*, *satisfied*, *completed*, and *objective measure greater than*.

In order to provide personalized learning in a SCORM based environment, the SPC table can analyze the learning results and modify the learning contents. Our method also gives the instructor hints to modify the inappropriate questions and course contents. Each learner who failed the course will receive individual learning contents in the system. Therefore, learner's learning speed depends upon the learner's ability and the evaluation results. For the instructors, the system provides a question evaluating mechanism. The following is the introduction to the evaluation features. What is the SPC table analysis? There are three aspects: Student-Problem, Student-Course, and Course-Problem.

Student-Problem

For illustration purpose, an example is given first. In Figure 3, problem quality is not so good. For example, Problem 7 is too hard or the problem has no correct answer because no one answered it correctly in the exam. When this happens, the system can suggest the instructor to modify the problem. After the problem is modified, the system will adjust the content aggregation tree. The horizontal axis is the student number. The last column is the number of students who answered the problem correctly. For example, 34 students answered Problem 4 correctly. The correct percentage is 0.76 for No.4 problem. On the other hand, No 9 student answered 7 questions correctly. The correct percentage is 0.7 for No.9 student. The original SP chart provided CP (Caution index for items) and CS (Caution index for students). Equations (1) and (2) describe how to calculate CP and CS. We assumed that there are N students and n problems.

$$CP_j = 1 - \frac{\sum_{i=1}^N (y_{ij})(y_i) - (y_j)(\mu)}{\sum_{i=1}^{y_j} y_i - (y_j)(\mu)} = \frac{\sum_{i=1}^{y_j} (1 - y_{ij})(y_i) - \sum_{i=y_j+1}^N (y_{ij})(y_i)}{\sum_{i=1}^{y_j} y_i - (y_j)(\mu)} \quad (1)$$

$$CS_i = 1 - \frac{\sum_{j=1}^n (y_{ij})(y_j) - (y_i)(\mu')}{\sum_{j=1}^{y_i} y_j - (y_i)(\mu')} = \frac{\sum_{j=1}^{y_i} (1 - y_{ij})(y_j) - \sum_{j=y_i+1}^n (y_{ij})(y_j)}{\sum_{j=1}^{y_i} y_j - (y_i)(\mu')} \quad (2)$$

	4	3	1	10	9	5	8	2	6	7	Dead	perc	student
9	0	1	1	1	1	1	1	0	1	0	7	0.7	0.67
2	1	1	1	1	0	1	0	1	1	0	7	0.7	0.32
15	1	1	1	1	1	0	0	1	1	0	7	0.7	0.47
7	1	1	1	1	0	1	1	0	0	0	6	0.6	0.24
43	1	1	0	1	1	1	1	0	0	0	6	0.6	0.28
3	1	1	1	0	1	1	0	1	0	0	6	0.6	0.33
8	0	1	1	1	1	1	0	0	0	0	5	0.5	0.19
11	0	1	1	1	1	1	0	0	0	1	5	0.5	0.64
17	1	1	1	0	0	1	1	1	0	0	5	0.5	0.31
19	1	0	1	1	0	1	1	0	0	0	5	0.5	0.40
21	1	1	1	1	0	1	0	0	0	0	5	0.5	0.05
30	1	1	1	0	1	1	0	0	0	0	5	0.5	0.05
40	1	1	1	1	0	1	0	0	0	0	5	0.5	0.05
41	1	1	1	1	1	0	0	0	0	0	5	0.5	0.00
42	1	1	1	0	0	1	1	0	0	0	5	0.5	0.31
1	1	0	1	1	0	1	0	1	0	0	5	0.5	0.49
24	1	0	0	1	0	1	1	0	1	0	5	0.5	0.85
35	1	1	0	1	0	1	0	1	0	0	5	0.5	0.45
44	1	1	0	1	1	0	0	0	1	0	5	0.5	0.45
37	0	1	1	1	1	0	0	0	0	0	4	0.4	0.27
45	0	1	1	0	1	1	0	0	0	0	4	0.4	0.32
5	1	0	1	0	1	0	1	0	0	0	4	0.4	0.40
12	1	1	0	0	1	0	1	0	0	0	4	0.4	0.35
13	1	1	0	0	1	1	0	0	0	0	4	0.4	0.11
16	1	1	1	0	1	0	0	0	0	0	4	0.4	0.00
23	1	0	0	1	0	1	0	0	0	0	4	0.4	0.16
27	1	0	1	1	1	0	0	0	0	0	4	0.4	0.11
29	1	0	1	1	0	0	0	0	0	0	4	0.4	0.00
34	1	0	0	1	1	0	1	0	0	0	4	0.4	0.46
39	1	1	0	0	0	1	1	0	0	0	4	0.4	0.40
4	1	0	0	1	1	0	0	1	0	0	4	0.4	0.56
10	1	0	0	1	1	0	0	1	0	0	4	0.4	0.56
28	1	0	1	0	0	1	0	0	1	0	4	0.4	0.62
6	0	1	0	0	1	0	1	0	0	0	3	0.3	0.72
31	0	1	1	1	0	0	0	0	0	0	3	0.3	0.31
26	0	1	0	0	0	1	0	1	0	0	3	0.3	0.91
22	1	1	0	0	1	0	0	0	0	0	3	0.3	0.06
25	1	0	0	0	1	1	0	0	0	0	3	0.3	0.25
18	1	0	0	1	0	0	0	1	0	0	3	0.3	0.66
14	1	0	0	0	1	0	0	0	0	0	2	0.2	0.16
20	1	0	1	0	0	0	0	0	0	0	2	0.2	0.08
33	1	0	0	0	1	0	0	0	0	0	2	0.2	0.16
32	0	0	1	0	0	0	0	0	0	0	1	0.1	0.32
36	0	1	0	0	0	0	0	0	0	0	1	0.1	0.39
38	0	0	0	0	0	0	1	0	0	0	1	0.1	1.37
num	34	28	26	24	24	22	13	9	7	0	187		
perc	0.76	0.62	0.58	0.53	0.53	0.49	0.29	0.20	0.16	0.00			
ave	0.60	0.42	0.46	0.29	0.82	0.33	0.75	0.60	0.27	0.00			

Figure 3. Student-Problem Table

- represented the P curve and -- represented the S curve

We applied equation (1) to get the item analysis (See Figure 4). Sato [8,9] proposed the following criteria. (1) When $0 < CP < 0.5$, this kind of question is acceptable. (2) When $0.50 \leq CP < 0.75$, we need to pay attention the question. It is suggested to reedit the question. (3) When $CP \geq 0.75$, the question needs to be revised.

y_i means the sum which No. i student get.

$$\mu = \frac{1}{N} \left(\sum_{i=1}^N y_i \right) \text{ means the average score of all the students}$$

y_j means the sum which answer no. j question correct

$$\mu' = \frac{1}{n} \left(\sum_{j=1}^n y_j \right) \text{ means the average score of all the students}$$

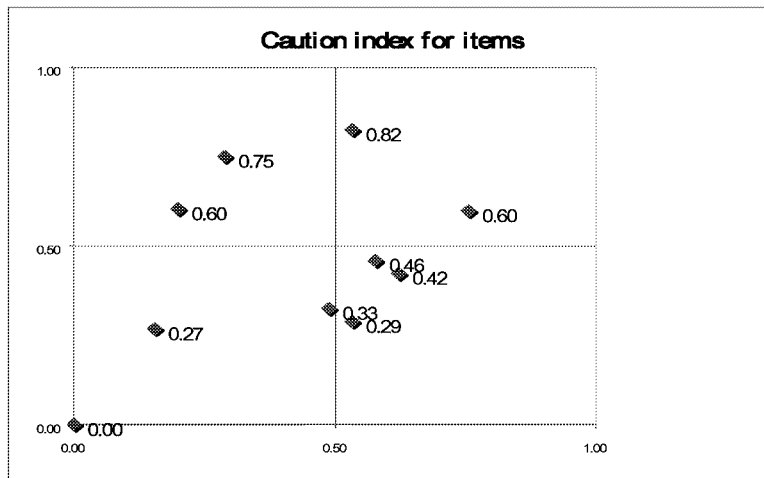


Figure 4. Caution Index for items.

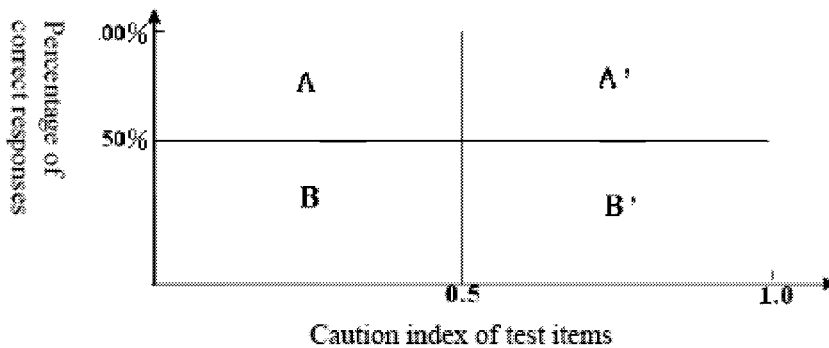


Figure 5. Analysis of Caution Index for test items (Sato [8, 9]).

In Figure 5, there are four areas. Area A indicates that the test item is suitable for both the low performance student group and different types of student groups. Area B shows that the item is used to discriminate the high performance student group. The test items in Area A' contains possible abnormal components or it might include some inadequate choices. It is suggested that the test item should be modified. Area B' indicates that the semantics of the test items are ambiguous.

No	2-3	4-1	2-6	3-3	4-3	4-4	2-2	2-4	2-7	4-5	2-1	2-5	3-1	3-2	4-2	Sum
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
4	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
5	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
6	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
8	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
10	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
11	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
12	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
14	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
17	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
20	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
21	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
25	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
26	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
27	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
34	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
35	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
36	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
37	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
39	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
41	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
42	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
44	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	10
18	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	9
19	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	9
29	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	9
43	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	8
33	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	7
2	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	6
3	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
9	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
13	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
15	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
16	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
22	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	6
23	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
32	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
38	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
40	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
45	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	6
24	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
31	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Sum	43	43	40	40	40	40	31	31	31	31	2	2	2	2	2	380

Figure 6. Student-Course Table.

Student-Course

The horizontal axis is courses and the vertical axis is students in Figure 6. Most students failed course units [2-1], [2-5], [3-1] and [3-2]. The system will inform the instructor to adjust the course units with contents of active learning and high interactivity. Then the

Simple Sequencing rule is modified. The learners will have remedial sequencing course. The system can generate new SCORM compatible contents with appropriate learning sequencing automatically.

Course-Problem

Some course units might have no problems in the exam (Figure 2). This might bias the student learning behavior. Students would be able to obtain high scores even if they do not learn well about these course units. The system will remind this situation to the instructor who then can decide if he/she want to revise the exam or not.

If (not)			Then	Precondition Actions		Postcondition Actions			
				Skip		Exit Parent			
	Attempted			Objective Measure Known		Disabled		Exit All	
	Objective Status Known			Objective Measure Greater Than		Hidden From Choice		Retry	
	Satisfied			Objective Measure Less Than		Stop Forward Traversal		Retry All	
	Activity Progress Known			Always		Exit Action		Continue	
	Completed		Attempt Limit Exceeded		Exit		Previous		

Figure 7. (if [condition_set] then [action]) of a Sequencing Rule referenced from [1].

We use SCORM metadata to solve the adaptive learning content support. The metadata properties are listed in the following.

[interactivityType/educational]: It is divided into active, expositive, and mixed. Active learning means that learners can complete the course with some learning actions. For expositive learning, learners learned the course by themselves. Mixed learning is composed of active and expositive learning.

[learningResourceType/educational]: It has exercise, simulation, questionnaire, diagram, figure, graph, index, slide, table, narrative text, exam, experiment, problem statement, self assessment, and lecture. The system can choose or change the personal content from the higher interactive learning content, such as figure, graph, experiment, exercise and simulation to support learning.

[interactivityLevel /educational]: It has very low, low, medium, high and very high. Therefore we can provide high interactivity level learning content for the learner.

[typicalLearningTime /educational]: It records the typical learning time. The longer the learning time, the less the learning efficiency. The system will choose the learning content with the typical learning time less than the previous one.

4. Experiment

Forty-five students in the Information Management Department of Chung-Hua University in Taiwan, who took the C programming course, are involved in the experiment. Figure 12 shows the course `imsmanifest.xml` which Figure 13 is the content aggregation tree. The `imsmanifest.xml` file is used to describe the structure of SCORM course. LMSs realize and share SCORM course with the `imsmanifest.xml` file. For users, they can see the content aggregation in LMSs and authoring tools. Content aggregation tree is a tree-like structure for describing course structure.

We applied the SPC table in the C programming course. The system analyzes the results. In this section, there are some course code names which are indicated in Table 1. In Figure 2, the horizontal index means problem no. and the vertical index means courses. For example, we set 'Y' in Course unit 2-1 and no.1 question cell to mark the relation which represented the Problem 1 is related to Course 2-1. In Figure 2, Courses 2-4, 3-3, and 4-4 have no relation with any of the problems. The system will send suggestions to the instructor since some courses are not included in the exam. On the other hand, no.8 and no.10 questions contain learning materials in more than one course units. Other problems just focus on one course unit. In Figure 3, No.7 learner only passes no.1 question but failed no.2 question. He or She will need to re-learn the related course again following the relation in Figure 2. In Figure 3, the result showed 13 learners passed no.8 question and 24 learners passed no.10 question. The system can do advanced analysis. For instance, No.3 learner failed both no.9 and no.10 questions. No.3 learner needs to learn 2-6, 3-1, 3-2, 4-1, 4-2 and 4-5 course units again.

This experiment uses SPC table for analyzing result which is useful for learners and instructors. Learners can get the remedial course sequence when he/she log in the LMS. Instructors will receive the reedit questions' hint form the LMS. We also find the relation where some learners are in the same learning group. They will discuss and teach each other in real world and get higher grade in the exam.

Table 1. Course content table.

	Chapter 2		Chapter 3		Chapter 4
2-1	Using Variables	3-1	<code>printf()</code>	4-1	Operator of Relation and Logic
2-2	Declaration of Variables	3-2	<code>scanf()</code>	4-2	For Loop
2-3	Basic Data Type (int, char, float, string)	3-3	Character Input / Output Functions	4-3	While Loop
2-4	Constant			4-4	Do-While Loop
2-5	Arithmetic Operation			4-5	If Loop
2-6	Transformation of Data Type				
2-7	Special Operation in C				

In order to provide an adaptive SCORM learning management system from the SPC table support, our system can provide useful and adaptive learning information for learners. There are some examples. Figure 8 shows the original course content aggregation tree. The course has three modules. Each module has some lessons and exams. In Figure 9, the learner failed in some lessons. The courses marked in red mean the failed course. The system will generate a new content aggregation tree to strengthen learning. The system will also provide personalized tutoring. In Figure 10, the system applied Simple Sequence to modify the content aggregation tree with invisible property. For example, the learner can see the course but they can not navigate the course in the e-learning system. Such a system is SCORM compatible and provides intelligent tutoring. With SPC Table analysis, the system will inform the instructor which problems and courses need modify (See Figure 11). The lessons and problems marked in green means the contents and problems need to be revised. We applied this experiment to the C programming course content aggregation tree shown in Figure 12.

SPC table as a formative assessment, it supports learners know where they learned and how well they are. We can collect many SPC analysis result for a long term, such as a semester. The system will show the learner performance. Some learners might have stable learning behavior. Some learners might have great advanced in some SPC tables. If the learner is unstable for more than two SPC analyses, the system may send suggestions to instructors and learners.

<p>Figure 8. The original course content aggregation tree.</p>	<p>Figure 9. The marked lessons are the lessons which learners failed.</p>

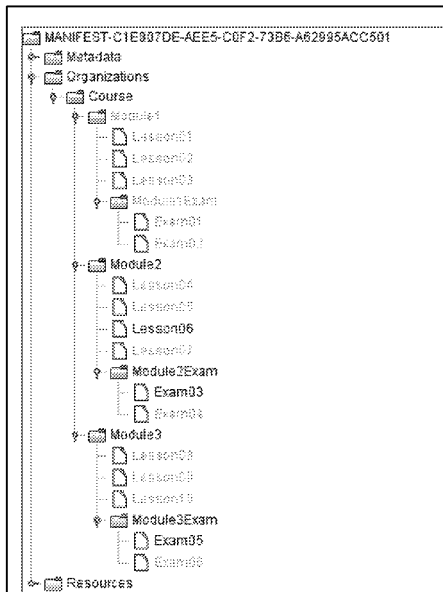


Figure 10. The modified content aggregation tree.

```

- <organizations default="course">
  <organization identifier="course">
    <title>C Language Programming Language</title>
    <item identifier="Chapter 2" identifierref="RESOURCE1">
      <title>C language data processing concept</title>
      <item identifier="2-1" identifierref="RESOURCE1">
        <title>Using Variables</title>
      </item>
      <item identifier="2-2" identifierref="RESOURCE2">
        <title>Declaration of Variables</title>
      </item>
      <item identifier="2-3" identifierref="RESOURCE3">
        <title>Basic Data Type (int, char, float, string)</title>
      </item>
      <item identifier="2-4" identifierref="RESOURCE4">
        <title>Constant</title>
      </item>
      <item identifier="2-5" identifierref="RESOURCE5">
        <title>Arithmetic Operation</title>
      </item>
      <item identifier="2-6" identifierref="RESOURCE6">
        <title>Transformation of Data Type</title>
      </item>
      <item identifier="2-7" identifierref="RESOURCE7">
        <title>Special Operation in C</title>
      </item>
      <item identifier="Chapter 3" identifierref="RESOURCE8">
      <item identifier="Chapter 4" identifierref="RESOURCE11">
    </organization>
  </organizations>
* <resources>
</manifest>

```

Figure 12. Course imsmanifest.xml which is the content aggregation tree file in SCORM specification.

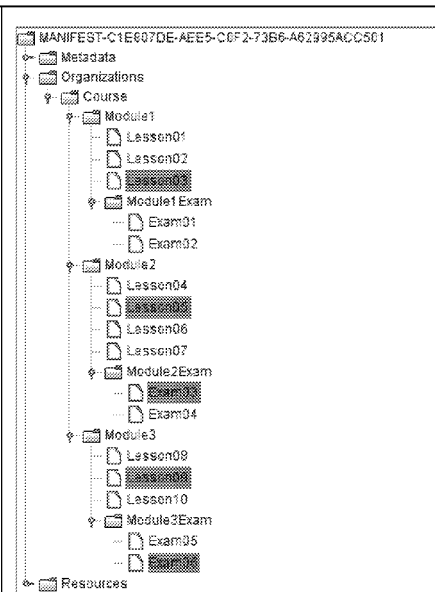


Figure 11. With analysis result, the marked lessons are informed to the instructor.

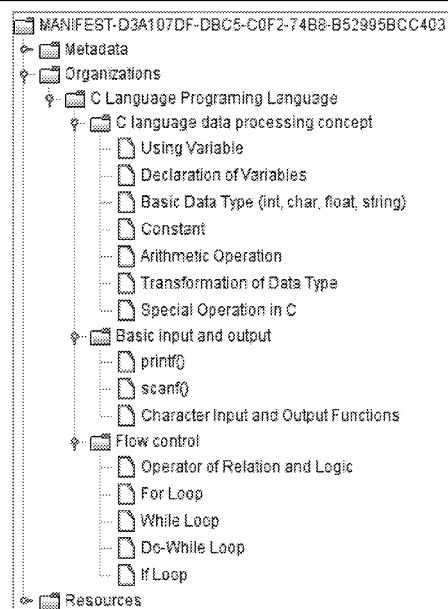


Figure 13. C programming course content aggregation

5. Conclusions

E-learning specification is important since it helps the distance learning contents evolves to better meet the users' needs. E-learning utilized the web page, multimedia, CD-ROM, audio, video, animation and communication technology to attract the learner. The SCORM specification designs an integrated components and environment to assist the content developers, tool designers, and web environment producers to develop compatible e-learning features. SCORM content aggregation supports learning content design with metadata, content packaging, and content aggregation. Simple sequencing supplied learning sequencing order in e-learning environment which can record and analyze the learning behavior. With the SCORM specification, learning content can reach accessibility, adaptability, affordability, durability, interoperability and reusability.

To further enhance the SCORM specification, the developed SPC table combines students, problems and courses. The Student-Problem table displays some important issues. For example, something might be wrong if some students can get high scores but fail in certain simple questions. Also, the instructor might set a wrong answer to a problem that made no student answer the problem correctly. The Course-Problem table will reveal other possible problems. For example, the problems in the exam are not included in the course. Or not all the course units are included in the exam. Some course units might be skipped by the instructor. The Student-Course table demonstrated that if the learning content is well-designed. Students might have completed the course but failed in the exam of the course. Then the course might need to be re-designed or modified in the content aggregation tree. With the relation from the SPC table and SCORM specification integration, our system supported the instructor and the learner with a more user-friendly learning environment.

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