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SCARO: Sharable Curriculum And Reusable Objects

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Abstract

The World Wide Web provides unprecedented access to distributed information. The system presented in this paper provides means for publishing learning objects in human-readable and computer-processable forms with the goal of facilitating the sharing and reusing of learning material among disparate communities. The system adopts common concepts such as Dublin Core metadata specifications to improve access to shared information, and uses open source technologies from different vendors such as XML, Java Servlet Application Programming Interface (Java Servlet API), XALAN, eXist XML, and XMLRPC Application Programming Interface (XMLRPC API).

1. INTRODUCTION

The project presented in this paper started with the beginning of the new millennium, where the discipline of computing is definitely influencing and shaping almost every aspect of our life, including education. One decade ago, the WEB was not critical to education. However, nowadays, it became an integral part of the learning process. A huge number of educational institutes have some form of online courses. This number increases tremendously every day. The quality of an online course depends heavily on its learning material's content and the tools (including images, sound, video, animation) used to accompany the explanation of that learning material. Also, to cope with the rapid advances in the field, the contents of each course must be reviewed within short revision cycles. In addition, the continuous change in the discipline has broadened the synergy and the overlapping between courses. Moreover, courses must be stored efficiently using computer software that facilitates fast retrieval of their contents. All of the above made it necessary to search efficient approaches that fasten courses' design and

development, techniques that facilitates sharability between courses, and tools that support reusability of course's components and templates for publishing on the WEB.

Having all of these requirements in mind: templates, shareability, re-usability, learning-objects, computer software, the WEB, and efficient storage suggests that a promising solution would be to migrate to a database platform that facilitates short cycle development, sharing and reusing of learning material, and publishing to multiple formats. Wiesler [1] states: "Reusable content in the form of objects stored in a database has become the Holy Grail in the e-learning and knowledge management communities".

Next, we will briefly introduce the system in progress.

2. SYSTEM'S DESCRIPTION

The implemented system, Sharable Curriculum And Reusable Objects (SCARO), is a project within the framework of a larger project named DALE: Distributive Adaptive Learning Environment.

SCARO is designed with the goal of providing an efficient environment for course development and authoring that facilitates: developing and / or revising courses through short development cycles, sharing of course material, re-using of developed course material.

A course may be broken into chapters / sessions / units, each of which may be further broken into smaller learning modules, each focuses on a specific subject topic. Those learning modules may be named learning objects (to follow the terminology used in the field).

We begin with defining our learning objects. The definition of a learning object may differ from an application to another. Some applications may deal with a text page or with an image as a learning object. For our purposes it is defined as the smallest stand-a-lone and meaningful component / entity of a course that may be shared / re-used. A learning object, in our system, is composed of all of the following: text dealing with a specific topic, objectives / outcomes, assessment questions on that text, audio file (if any), video clip (if any). This makes our learning

object a complex one that is composed of more simple learning objects.

We use the eXtensibe Markup Language (XML) to define our learning objects. Since XML is structured, then it facilitates defining our complex learning object on the top of a hierarchical structure that represents simpler learning objects. In addition, XML supports and facilitates moving from creating and delivering large inflexible courses towards database driven objects that can be reused, searched and modified independently from their delivery media. Caton[4] says: "XML separates structure from content. It goes a major step further than HTML by providing explicit structure that makes it relatively straightforward to disassemble and assemble information. XML supports hierarchical structure, rich linking, metadata, and extensibility."

Caton[4] states: "The richly interlinked hierarchical nature of structured XML content maps directly to an object-oriented database. This translates to optimal performance and very low database administration requirements. True learning objects have inherent behaviors and can be used in many different contexts". Object-oriented databases could be very appropriate for this purpose. However, since the fund was to sponsor projects that use open source technology, we used the eXist XML database. Our learning objects are stored in eXist, which is available on a central server that may be accessed by all those who are involved in producing our courses. A concept that is related to using and storing learning objects is "metadata" which refers to a description of the learning object itself and its content. The metadata is important when many courses' authors share the same database of learning objects. An author of a specific subject may search the copy of metadata that is available to him/her locally or remotely to precisely decide on the learning object(s) that s/he may like to use. Then a program retrieves that learning object desired in question. However, in our case, our database will be available locally for internal staff then a course author may make a search and retrieve the learning object desired based on some defined criteria such as keywords. A learning object itself is composed of data and metadata, stored in the central eXist.

Our implementation enables the user to use an interface designed as menus

and forms to enter new learning objects and to search and retrieve already stored learning object to compose new chapters (or more complex learning objects or new courses). The system uses open source software for these purposes such as Java Servlet API, XALAN, and XMLRPC API.

2.1. Learning Objects

This project is concerned with designing and implementing a system that facilitates sharing and reusing learning units between courses (and between institutions as well). Developing an online course is expensive and is time consuming. Some courses of the same institutions may have some parts in common, and corresponding courses in different institution also have some common parts in common. So it is practical that those common parts be developed only once. If those common parts are even shared between several institutions then the saving in costs and in time is substantial. Each of those (sharable / reusable) parts is named a learning object. Downes [5] clarifies that "Although courses may share elements in common, it is rare to find two courses from two institutions that share the same, and only the same, set of elements. Thus, courses themselves are *not* suitable candidates for sharing". Hence, the units to be shared must be smaller than the complete courses. Many researchers have recommended that the unit to be shared be equivalent to what a learner may complete in one session. That unit is named, using the current terminology of the field, a "learning object".

In printed materials, a learning object may consist of object components such as a title, objectives, body text, exercises, model answers, ...etc. An online learning would have more components, in addition to those listed above, such as audio clips, video clips, ...etc.

In our system, a learning object is a structured object that consists of simpler basic objects (BO) as follows:

Title, learning object overview, objectives, body text, summary, test bank, and model answers for the questions in the test bank, instructor's manual, student's manual, activities / tasks for students, tools, references / resources, multimedia.

Some of those basic objects above are themselves structured ones, for

example: a test bank may consist of self-assessment quiz(zes), midterm / course work questions, final exam questions, supplementary exam questions, project, and model answers for all those questions. The references / resources object may be further divided into online resources and printed resources. The tools object may be furthering divided into software tools and hardware tools. Multimedia may be further divided into images, audio clip(s), video clip(s). ... Etc.

When we first started designing SCARO, the learning objects were the only component that was means to be shared / reused. However, soon after, we realized that some of the other simpler basic components object may also be shared / reused since they may not be specific to a certain learning object. For example, the exam bank may only be used to test a specific text or a specific learning object. However, an image or a video clip may serve more that one learning object, hence it may be shared or reused also.

Any sharable / re-usable object, whether it is a learning object or a basic object, must be marked with its metadata (introduced next).

2.2. Metadata

Metadata, is a term that has been literally defined as data about data. It is a set of elements that better describe an information object when storing it on a searchable media for the purpose of reusability and of sharing it with others. Gilliland-Swetland [9] defines metadata as: "the sum total of what one can say about any information object at any level of aggregation. In this context, an information object is anything that can be addressed and manipulated by a human or a system as a discrete entity. The object may be comprised of a single item, or it may be an aggregate of many items. In general all information objects, regardless of the physical or intellectual form they take, have three features - content, context, and structure - all of which can be reflected through metadata.

Hart [6] claims that: "Metadata serves many important purposes, including:

Data browsing,

Data transfer, and

Data documentation"

SCARO has three levels of objects that may be reused / shared. Those are: the basic object, the learning objects and the courses. Hence it was necessary to develop a metadate set for each object. For each object the metadata set includes elements such as: title, usability, category, keywords, description, ...etc.

There are two main issues that are associated with the usage of metadata: semantics and syntax. Semantics is concerned with the meaning of the elements of the metadata (e.g. title, author, ...etc.) and how they are structured and they are more human readable, while syntax is concerned with the grammars used to represent semantics and structure in a form understandable by the computer.

We have consulted standards and recommendations of the Content Standards for Digital Geospatial Metadata (CSDGM) [7], IEEE Learning Technology Standards Committee (LTSC) Standard for Information Technology -Education and Training Systems - Learning Objects and Metadata Working Group [11], Dublin Core Metadata Element Set - Version 1.1[10], TEI Guidelines for Electronic Text Encoding and Interchange [12], and the IMS Global Learning Consortium Inc[13].

One of the suggestions for defining metadata has been to define a 'Minimum Searchable Set' [8]: "i.e. the fields which Clearinghouse servers should index on, and which should be individually searchable". Most of the above groups and committees have standards for metadata that include a great set of elements. For example, there are over 300 elements in the CSDGM standard.

SCARO has adopted The Dublin Core Metadata Element Set (DC) [10] since it is a simple set of data elements that supports the search of a broad range of information objects over communication networks like the Web, and it is a commonly understood metadata set by related WEB applications developers. In addition, all elements of the DC metadata element set are optional (Weibel , Lagoze[14]), this allowed us to further narrow the elements of the metadata when needed since the system in its first stage is intended for inter-institution usage. When the system is generalized to be available for external institutions then we can add more elements. The Dublin Core Metadata Element Set (DCMES) [10] includes:

Title, Author/Creator, Subject /Keywords, Description, Publisher, Other Contributor, Date, Resource Type, Format, Resource Identifier, Source, Language,

Relation, Coverage, and Rights Management.

The Dublin Core Metadata Element Set primarily deals with defining the semantic aspects for describing a resource in an electronic environment. The syntax for representing the fifteen elements of the DCMES was let to individual developers.

2.3. The Database

The main goal of the implemented system is to enable sharing and reusing learning objects. To achieve this goal, efficient storage and retrieval mechanisms are needed, hence the need for a database. A database facilitates efficient storage, fast retrieval using indexes, security features, and multi-user access which is one of the main benefits from making learning objects sharable and reusable.

SCARO stores the learning objects in an eXist database. Metadata of learning objects are stored with the learning objects in the database. In addition, copies of the metadata will be stored on clients' computers to fasten the searching process and to reduce the overhead on the central database if the number of users increases. Metadata may be stored in a database or as discrete documents.

HART [6] states that: "Dciding between holding your metadata in a database or to produce discrete metadata documents for each data set is somewhat dependent on the variety and volume of your data sets, as well as how often they (and the metadata) are updated. This decision will determine which metadata tools are appropriate to consider
for use."

The copies of the metadata, if needed, will be stored in a database since they are expected to be subject to frequent use or change. For both, the learning objects and the copies of the metadata, it will be possible to develop SQL interface to query the database(s) directly. However, the current implementation provides a menu and forms interface.

2.4. The Interface

The interface facilitates the user contact with the database. The user may enter a new learning object or to search for and to retrieve a learning object. To enter a learning object, the user goes through a set of forms to fill. At the end the

user may browse the learning object and decide whether to submit it or to clear the entered data. Searching the database, at present, is limited to title search, author search, and a subject search. The search may be for an exact phrase or for a keyword.

3. IMPLEMENTATION

3.1. Open Source Tools

The implemented system, SCARO, is a project within the framework of a larger project named DALE: Distributive Adaptive Learning Environment. SCARO uses the following open source software tools (detailed information may be found in Appendix A):

a. Java Servlet API
b. XALAN
c. eXist XML
d. XMLRPC API

3.2. Architecture

The architecture is composed of three main components: interface, learning object workspace, and the database.

3.2.1. The interface

The interface enables the user to access a main menu to enter new learning objects and to enter a search request to retrieve learning objects that match searching criteria.

The main menu (and few other forms) are developed in HTML.

The pages used by the user to enter the metadata and the contents of a learning object (such as notes, quizzes, questions,...etc.) are developed in Java Server Pages (JSP). JSPs are capable of generating data dynamically and to dynamically count and number exercises' questions and quizzes' questions.

3.2.2. The Learning Object Workspace (LOWS)

This is a conceptual framework that lies at the heart of SCARO. This component consists of other services and software modules that mange the learning objects.

3.2.2.1. Java Servlets

In the LOWS we find Java servlets that are used to process the data entered and submitted by the user through the HTML forms and/or the JSPs.

One of the important servlets here is the ViewData servlet that uses the learning object bean (see below) to create and hold the XML version of the learning object. This XML vesrion is then stored in the database. Also, when a learning object is retrieved then it is retrieved from the database in the form of XML version. The ViewData servlet then converts the XML version (using XALAN and XSL – see below) to create an HTML version of the learning object to be displayed to the user.

3.2.2.2. Java Beans

The LOWS consists of a number of Java beans that help the Java servlets to function effectively. Those are:

Learning Object Bean: which is a class that is created when the user starts to enter a set of metadata of a new learning object. This bean uses other beans such as the question bean and the reading bean.

Question Bean: this provides the structure for each question entered by the user.

Reading Bean: this bean contains the data for each reading assignment entered by the user.

Count Bean: this bean is used by the JSPs that count objects that have multiple instances (e.g. number of links, number of assignments' questions).

Strip Markup Bean: an entered learning object is stored in the database in the form of an XML version. A generated XML file that contains some special characters (e.g. "<", ">", "&") may cause an error if stored directly in the database. This bean replaces those characters with their HTML representations before storing.
Cleanup Files Bean: this bean is responsible for garbage collection. It ensures that temporary files used during the processes of storing and retrieving learning objects are deleted when a process (and its transactions) is complete. When a learning object is created or retrieved a set of HTML files is created to facilitate displaying the learning object to the user. This bean scans the FTML directory every 30 minutes and automatically deletes unneeded files.

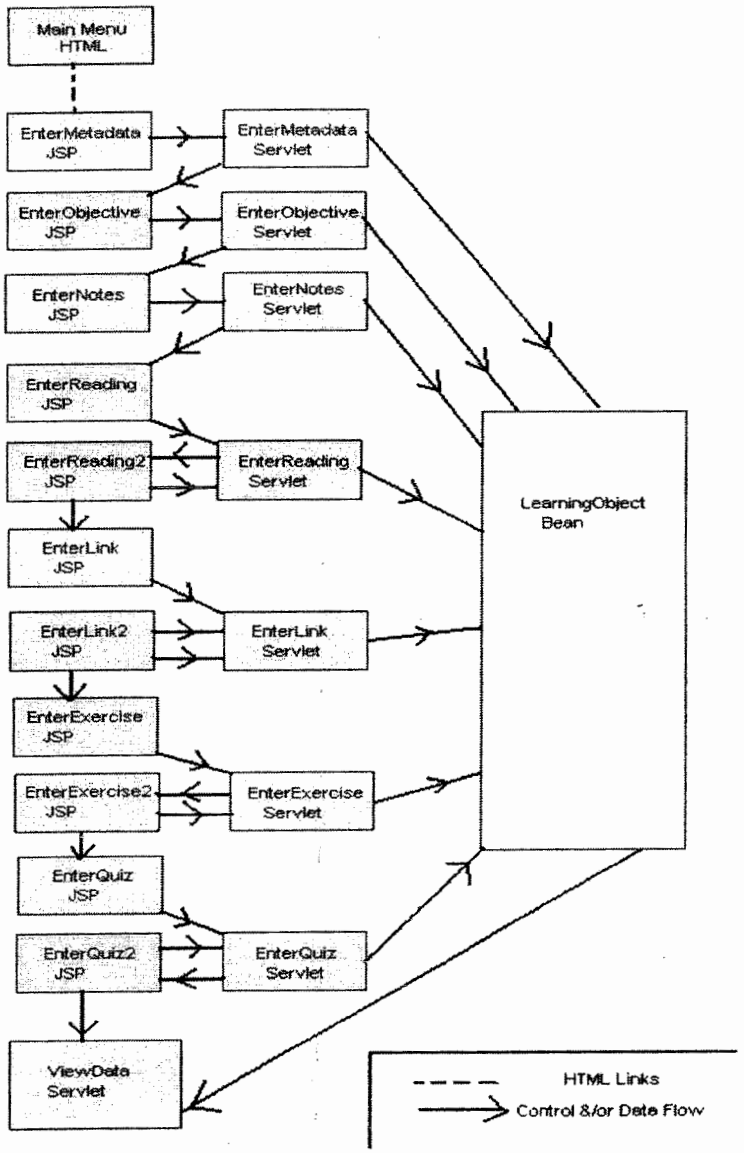

Figure 1 Functionality of the implemented system (SCARO)

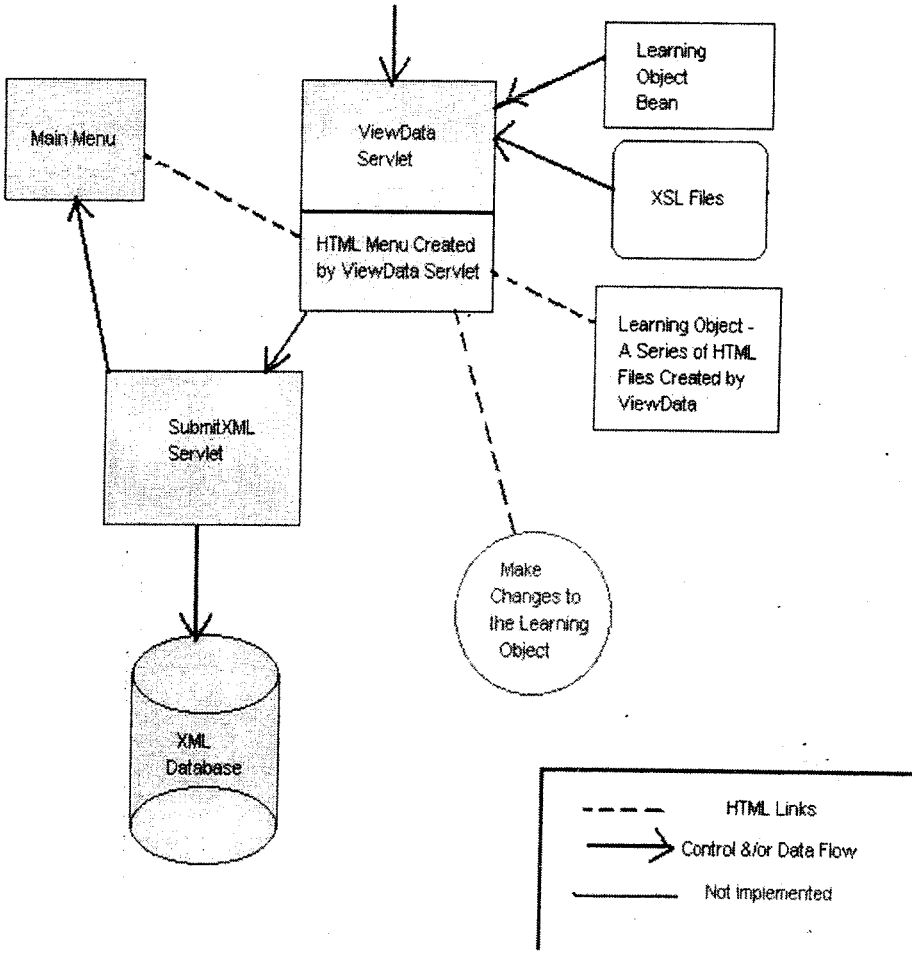

Figure 2 The SCARO procedure for creating and holding the XML version of a learning Object

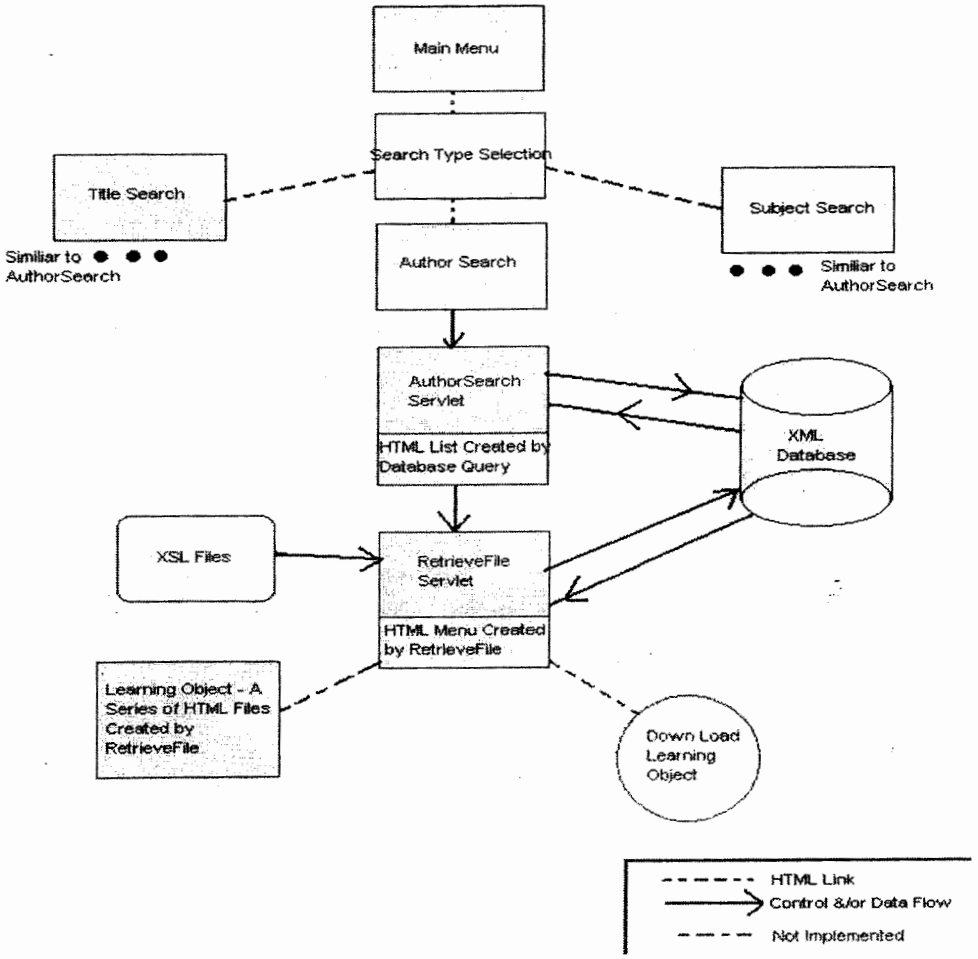

Figure 3 The SCARO search mechanism

3.2.2.3. XSL Stylesheets

Entered learning objects are stored in the database in the form of XML files. When a user enters a request to retrieve a learning object, the ViewData servlet uses XSL stylesheets to add HTML tags around the contents of the retrieved XML file and creates an HTML version of the learning object. Next, XALAN uses the XSL file and the XML file (in string form) to display a HTML version to the user.

3.2.3. The eXist Database

When a user enters a learning object, an XML version of the learning object is created and stored in eXist.

4. CONCLUSION

We have presented a system that uses open source technologies to define a web-based environment for designing, retrieving, reusing and sharing learning objects. The implemented system may be used as a reference model for applying current technologies, specifications and guidelines from various groups and vendors. SCARO is an example of systems that improve access to information on the web and which impose structural constraints to provide unambiguous representation of metadata for encoding, exchanging and processing of information that is to be shared or reused. The system also provides means for publishing information in human readable and machine processable formats for information sharing and reusing among disparate groups.

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APPENDIX A

The open source software tools used in the implementation of SCARO

1. Java Servlet Application Programming Interface (Java Servlet API)

http://java.sun.com

2. XALAN

http://xml.apache.org

3. eXist XML

http://exist.sourceforge.net

4. XMLRPC Application Programming Interface (XMLRPC API)

http://xmlrpc.helma.org

see also: http://www.xmlrpc.org

ملخص بحث (SCARO)

أن البحث المقدم يشرح التصميم و التنفيذ لنظام يهدف لتسهيل نشر و تداول المادة التعليمية عن طريق الإنترنت. إن العديد من الجامعات و المعاهد التعليمية تقوم بتأليف مذكرات تعليمية مصاحبة للمواد التي تقدمها و تقوم بنشرها و إتاحتها لطلابها عن طريق الإنترنت. و هذه المذكرات قد تحتوى على مادة مقروءة أو مسموعة أو مصورة أو على شكل مادة فيلمية. هذه المذكرات تتكلف مبالغ كبيرة. إن العديد من المواد التي تقدمها الجامعات تتشابه فيما بينها من ناحية المادية العلمية بل إن العديد من هذه المواد تستخدم نفس الكتاب المقرر. و بدلا من أن تقوم كل جامعة بتصميم مذكرات مشابهة لمذكرات غيرها من الجامعات و تتكلف نفس المبالغ الكبيرة في تنفيذها فان الإنترنت توفر بيئة مناسبة لان تتشارك الجامعات في تطوير هذه المذكرات و بذلك تتشارك في التكاليف و توفر في النفقات. غير أنه من النادر أن تجد جامعتين تقدمان نفس المادة العلمية على مدار كورس كامل. و لذلك فان المشاركة على مستوى مذكرات كاملة لكورس كامل غير مناسب. و لكن يمكن تقسيم المذكرات إلى أجزاء على مستوى محاضرات أو أصغر من ذلك (صورة مثلا). و يقوم كل أستاذ مادة باختيار المحاضرات التي يرغب فيها ليكون كورس كامل. هذا البحث المقدم يقوم بتوفير نظام يتيح لكل أستاذ أو مؤلف أن يقوم بإدخال مؤلفاته من محاضرات و ما تشتمل عليه من مادة مكتوبة أو مسموع أو مصورة أو مادة فيلمية على جهاز حاسب آلي مركزي و تكون هذه المادة متاحة لباقي الأساتذة و المؤلفين لاستخدامها مع غيرها من المحاضرات المتاحة لتكوين مادة تغطى كورس كامل. و يتم كل هذا عن طريق الإنترنت.

يتم تخزين المحاضرات على جهاز حاسب آلي مركزي (Server) متاح لجميع المشاركين. لتسهيل عملية البحث عن المادة العلمية و لتقليل الضغط على استخدام موقع واحد فان عدة نسخ من البيانات عن مواصفات كل محاضرة (Metadata) توجد موزعة على عدة مواقع قريبة من الباحثين و يتم استخدامها للبحث عن المادة العلمية المناسبة. و بعد تحديد المجموعة المحاضرات المناسبة فان النظام يتيح لأستاذ المادة الاتصال بجهاز الحاسب المركزي للحصول على المحاضرات إما كاملة أو أجزاء منها. وبعد أن يتم إنزال نسخ هذه المحاضرات على جهاز الحاسب الآلي الخاص بالأستاذ أو الجامعة فان النظام المنفذ يتيح لأستاذ المادة عمل التعديلات المطلوبة أو نشر هذه المحاضرات على موقع الجامعة على الإنترنت بصور مختلفة مناسبة لعدة مجموعات من المستخدمين مثل المعيدين و مساعدين الأبحاث و الطلبة.

لقد قمنا بالاعتماد في تنفيذ هذا النظام على البرامج المتاحة مجانا على الإنترنت (Open Source) و ذلك لضمان أن لا يحدنا ارتفاع النفقات عن تنفيذ هذا النظام و لضمان مشاركة أوسع من كافة المؤسسات التعليمية المهتمة بهذا المشروع. و لذا فان النظام المنفذ يستخدم تقنيات و برامج مثل XML, Java Servlet Application Programming Interface, XALAN, exist XML and XMLRPC Application Programming Interface.