Proceedings of the 5th WSEAS Int. Conf. on DISTANCE LEARNING AND WEB ENGINEERING, Corfu, Greece, August 23-25, 2005 (pp105-110)

Content Authoring System to Personalize E-Learning

Chao Boon Teo, Robert Kheng Leng Gay
Information Communication Institute of Singapore
School of Electrical and Electronic Engineering
Nanyang Technological University
Singapore 639798

Abstract: - The essence of e-learning lies in the personalization of learning experiences. While many learning systems are proclaiming ‘e-learning compliance’, these systems are only in the league of online training. This paper sees effective knowledge personalization, synthesis and its transfer as the key competitive differentiator that separates e-learning from online learning. Although learning personalization is an important aspect of e-learning, it is not realized. Most e-learning systems cannot deal with the open problems of learning personalization as learning demands are massive, extensive and diversified. However, this paper argues that learning in an open environment not only requires personalization support, it demands an even more effective approach to provide learner’s orientation and individualized access support. Hence, this paper proposes a novel content authoring system that incorporates learning personalization issues into content authoring. Through an elaborated process of identifying the learners’ learning preferences, current knowledge level and learning needs, the content authoring system aspires to provide a personalized learning experience that is able to customize and synthesize new knowledge into the learner’s existing ‘cognitive structure’.

Key-Words: - e-learning, concept map, distance learning, instructional design, knowledge management

1 Introduction

E-learning seeks to exploit information and communication technologies to improve learning. With its high versatility and ability to transcend geographical and time boundaries, a whole new learning concept is being adopted to enhance traditional learning.

While e-learning envisions significant learning improvements through advanced educational techniques, this paper surveys the literatures and identifies significant shortcomings [1, 2]. Although many learning systems are jumping into the e-learning arena and proclaiming their systems as e-learning compliance, what they are actually providing are pure online repositories. These online repositories, at its best, only act as an information gateway for learning materials retrieval without any consideration of enhancing the learning experiences.

More importantly, instead of designing reusable and learner-centric learning materials, many content developers are placing too much emphasis on the technological aspect (e-) of e-learning [3]. This has led to an appalling situation where most content developers are over-engrossed with show-casing their technology-enhanced presentation and placing little regards on imparting knowledge. While these technology-enhanced presentations charm the eyes and aid in knowledge retention, it should never be the governing consideration in content development.

This paper sees the essence of e-learning residing in the personalization of learning experiences. With the reduction or elimination of face-to-face interactions, learners have to assume full responsibility over their own learning. While this is not impossible, it is difficult. This problem is further amplifies by the need to face up to an extensive, massive, and diversified learning demands. While many e-learning systems are not addressing the open problem of learning personalization, this paper argues that learning in an open environment demands a more effective personalization approach to provide learner orientation and individualized access support.

Furthermore, although established providers of e-learning such as [4, 5] have introduced e-learning to the world, they have difficulties in understanding and establishing the ever-changing training needs of today’s learners. Without the ability to capture learners’ needs at real-time, these systems simply produce a one size fit all course and leave the learners to tolerate the homogenized, standardized subject matters. While it is possible to find excellent contents on about any subjects in these system, e-learning, unlike online training, is much more than just simple assimilation of learning resources.

This paper further augments that effective knowledge personalization, synthesis and its transfer is the key competitive differentiator that governs e-learning system. Hence, considering problems to existing e-learning systems and envisioning the shift in future e-learning direction from a content-oriented approach to a personalized learner-centric and knowledge synthesis approach, research into a new content authoring approach is needed. Extending our previous works on learning personalization [6, 7], a principled basis of content authoring is provided. Through an elaborated process of identifying learner's learning preferences, current knowledge level and learning needs, the content authoring system is about to capture learners' needs at real-time and provide a personalized learning experience that synthesize new knowledge directly into the learner's existing 'cognitive structure'.

This paper is organized as follows: Section 1 sets the context of this paper by summarizing some of our key research findings. Section 2 presents the skeleton content authoring system and key design issues. Lastly, this paper is concluded in section 3 and some future research work is suggested.

2 Content Authoring System

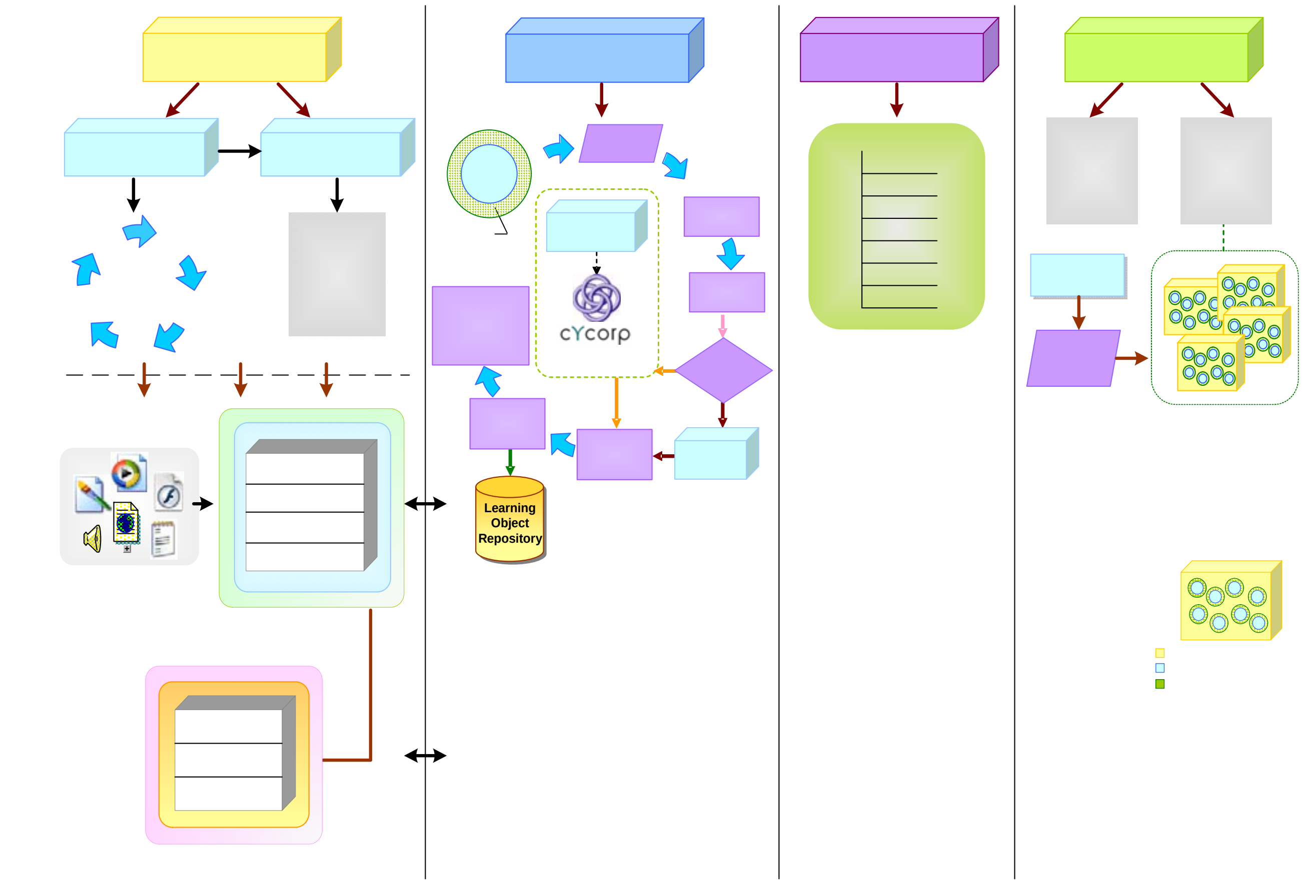

Fig. 1

Fig. 1 shows an overview of the content authoring system design. The system comprises of 4 modules, namely the Object Authoring Module (OAM), the Semantic Search Module (SSM), the Dynamic Concept Map Module (DCMM), and the learner Profile Management Module (LPMM).

2.1 Object Authoring Module (OAM)

The OAM is designed with the basic concepts of the ADDIE Model [1] and modified to cater to the learner-centric environment in the e-learning context. This model presents a systematic approach to develop the content of learning concepts. Once a concept is identified by the subject matter expert (SME), OAM will provide a content development template and guide the SMEs through the five modified instructional design process.

2.1.1 Analysis Phase

[1] ADDIE is an acronym for an instructional design that incorporates a process of **A**nalyzing learners, **D**esigning, **D**eveloping, **I**mplementing, and **E**valuating instructions.

1. Object Authoring Module

The main goal of this phase is to prepare a list of goals to remedy the problems. In an academic context, problems are seen as a need to educate the learners on a certain subject matter and thus, its remedy is to amass all related knowledge resources into a course to deliver the educational content. The goal is thus to outline a systematic content structure to deliver the educational goal. The development of the systematic content structure can be seen as a conceptualization of the relevant knowledge resources to fulfill a learning objective through a tangible concept map [2] roadmap. This roadmap couples with ontological engineering will ensure that the problem results in an appropriate concept map construction that correctly reflects the semantics of the underlying knowledge.

The concept map roadmap adopts XML Topic Maps (XTM) Version 1.0 Standard. XTM elements such as *<topicMap>*, *<topic>*, *<topic id>*, *<subjectIdentity>*, *<subjectIndicatorRef>*, *<baseName>*, *<baseNameString>*, *<variant>*, *<variantName>*, *<scope>* (both technical and conceptual), *<occurrence>* and *<association>* element will be drafted. Other important content design considerations such as course overview, domain, overall educational goals, scope (conceptual), target audience competency and learning preferences profiling will also be analyzed.

With these design considerations in mind, the course structure and individual reusable learning and information object (RLO and RIO)[3] can be identified. Next, the course tree hierarchy will be automated by the system. Lastly, any reusable learning resources will be identified by the system and presented to the content developer for possible repurpose.

At the end of this stage, the content developer will have a clear understanding of the course overview, its intended audience and the resources to reuse, repurpose or develop from scratch.

2.1.2 Design Phase

The main goal of this phase is to craft the set of educational goals into educational objectives by breaking down the goals into measurable learning objective. As opposed to educational goals which are a draft overview of the deliverables, the educational objective is a clear-cut and refined learning result. It is measurable and quantifiable for assessment to take place. It is also tangible so that the system can assess whether the learning resources meet a performance gap or increase knowledge and skills in a particular subject matter. These educational objectives will lay the foundation for the subsequent phases. Next, the basic structure of the RIO (preview, content, practice and assessment items) and RLO (overview, content and summary items) will be formed.

The technical aspects of the learning resources will be reviewed and finalized. XTM elements such as *<subjectIndicatorRef>*, *<topicRef>*, *<scope>* (both technical and conceptual), *<subjectIdentity>*, *<baseNameString>*, *<variant>*, *<baseName>*, *<variantName>*, *<occurrence>*, *<association>* and *<resourceRef>* element will be formed.

Metadata based on Dublin Core Metadata Element Set (DCMES) will also be formulated. The metadata will encapsulate the learning resources and act as a form of schemas.

2.1.3 Development Phase

With the design phase completed, the content for the RLOs and RIOs can now be developed. The goal is thus to develop the text, graphics, video and other content that is being designed and proposed in the design phase. As the main content of RLO is made up of RIOs, RIOs are usually developed first so that it can be sequenced to form the content of the RLO. However, this is not a standard sequence that must be followed. The development of RLOs and RIOs can occur in any order, or even simultaneously.

Each particular learning resource developed for the given subject (be it module, RLO or RIO) must be addressable by reference using a URI (Uniform Resource Identifier). The learning resource will be tagged as an *<occurrence>* element and the class of which the occurrence is an instance will be indicated via the *<instanceOf>* child element. The context as well as the learning resources presentation style within which the occurrence is valid is expressed using the *<scope>* child element. If none is present, there will be no preferences catering and the occurrence is always valid. Each learning resource will be given an *<occurrence>* tag if the scope or context is different.

For RIO, regardless of the object type, the preview, content, practice and assessment item will be developed as per designed in the design phase.

For RLO, the overview, content and summary item will be developed.

2.1.4 Implementation Phase

With the learning resources created, the goal of this phase is to distribute it to the learners. Before deploying the resources to the servers, all contents

---

[2] Concept map is exploited as a visual representation of the subject matters. It enables the sharing, exploring, gathering and synthesis of knowledge.

[3] RLO and RLO are terms borrowed from [8]. These terms referred to any digital resources that can be reused to support learning.

are verified by an independent group of advisors who will evaluate the developed content against its course objectives. Upon approval, the system will automatically generate the course concept map (sub_M-Map).

The system creates the sub_M-Map on a three level structure with the developed subject matter forming the centre level. Using the <*association*> element, the additional notes (<*occurrence*> element), the specificity index and the pre-requisite list, relationship between the learning resources are mapped automatically.

All pre-requisites concepts are first retrieved and mapped to the developed concept using the <*member*> element (sub-tag in the <*association*> element). The pre-requisites concepts will play the role of either an essential pre-requisite or supplementary pre-requisite concepts. Essential pre-requisite role states the concepts that must be mastered before the developed concepts can be learned while supplementary pre-requisite role lists the accompanying ‘good to know’ concepts.

The developed concept will form the next level together with other concepts that are listed in the additional notes (<*occurrence*> element). Roles such as ‘is associated with’, ‘contradicts’ and ‘is an example’ are used.

The last level lists concepts that reside at a higher conceptual level than the developed concept. These concepts are post-requisite concepts or concepts that utilize or further augment the understandings of the developed concepts.

All concepts in the concept map will be assigned a specificity index. This index defines the possibilities of reuse in other application domain and ranges from a scale of 0 – 10. Concepts that are general in nature will be assigned a low specificity index while concepts that are applicable only to a certain domain are assigned a high index value. Hence, depending on the learners’ preference, selected domain and SME’s constraints, different concept maps can exist for the same subject matter.

Upon generation of the sub_M-Map, it will be first sent to the course developer for verification before it is sent to the advisors for approval. Upon approval, the system will perform knowledge map synthesis automatically; that is, the sub-M-Map will be synthesized into the existing Subject Domain Master Map (M-Map). The M-Map, the learner’s Cognitive Map (C-Map) (discuss in details in DCMM) and the theory of learning dependency and knowledge gap will be used to generate the personalized learning routes.

2.1.5 Evaluation Phase

Although this phase is situated at the end of the model, evaluation is actually conducted at every phase. Besides evaluating the content against its course objectives, another goal of this phase is to use the existing content coupled with learner’s feedback to plan for reviews and updates.

2.2 Semantic Search Module (SSM)

The SSM is designed with the Semantic Web[4] Vision in mind and aims to prototype the Semantic Web ideas in the context of e-learning. This module transforms a simple search engine into an intelligent engine that is able to exchange and process information built on the foundation of high level logic and well defined semantics. This module will serve as a gateway between the learning resources and the outside world. This module is important as the efficiency of the whole system can be evaluated based on the speed, precision and ease of querying the learning resources. SSM is built based on the principal technologies of the Semantic Web. It also utilizes open source tools, such as Protégé-2000 and Amaya, to minimize the development time.

To enable efficient and accurate retrieving of learning resources, the system must process intelligent search capabilities that are based both on syntactic similarities with search and retrieval based on semantic content. Existing search engines which are based on traditional Information Retrieval (IR) technology, however, can only take syntactic information into account as IR technology is based almost purely on the occurrence of words. Hence, the retrieved search results often contain irrelevant information. This problem of inaccurate retrieval is made worse with the overwhelming amount of information in the Web. However, the availability of large amounts of structured, machine understandable information on the Semantic Web offers some opportunities for improving the traditional search.

Through SSM, this system aims to augment and improve traditional search result through the use of metadata, ontology and logics inference. The SSM will comprise of a basic and advance search.

The basic search uses a combination of meta-search and text indexing. Meta-search will require the learner to enter specific information and domain for each query. As opposed to Web searches where documents are of different formats and structures, the standardized ‘semantic’ structure of

[4] Semantic Web is an extension of the current Web in which information is given well defined meaning, better enabling computers and people to work in cooperation. It provides a common framework that allows data to be shared and reused across community boundaries.

the learning resources enable the system to rapidly search and retrieve it based on its metadata. Thus, it is possible for the SSM to incorporate a basic search that caters to a limited and precise scope of the query. With a specific scope identified, the search engine can be made to work very fast and efficient. For a start, the following domain of searches is proposed:

1. Author of learning resources (RIO/RLO/Course/Annotation)
2. Learning Resources (RIO/RLO/Course)
3. Annotations
4. Concept or Meta Map
5. Learner's Profile or Expertise Concept Map

After specifying the domain, the basic search will then make use of text indexing to extract out the content words. Once the content words are captured, the system will use the associated domain ontology as well as the meta-classification to capture the exact semantics of the query, thereby identifying the exact concept and eliminating all other synonyms terms.

Next, depending on the nature of the query, the machine-interpretable definitions of the basic concepts in that domain and their relations among them can be retrieved.

Although the basic search is fast and efficient, it puts some constraints on the learner as it requires them to have some basic understanding of the query topic in terms of the queried data's domain and concept terms. Thus, the system also incorporates an inference engine to provide some form of intelligent reasoning through the use of the advance search. Using the advance search, the learner is free to enter a string of query texts without any constraints. The inference engine which is based on semantics using mathematics (latent semantic indexing) and logics reasoning (description logics) will then be invoked to provide reasoning. Instead of pure text-based matching, the inference engine will perform an analysis of the collection of the content words, its relative weightage in the knowledge base, its cohesion with other concepts and the way the concepts are semantically connected. After analyzing the results, the system will present the results of the query in the form of a meta-concept map, highlighting the requested concepts and its associated parent- and sub- concepts and their relations.

The main building blocks of this module will be metadata (Resource Description Framework (RDF) and DCMES), ontology (Web Ontology Language (OWL)), annotation (RDF, XLink, XPointer) and Logics and Inferences (Description Logic (DL), OWL DL, Natural Language Processing (NLP), and Language Engineering).

2.3 Dynamic Concept Map Module (DCMM)

This module provides the tools and platform for visualising the learning resources in the form of a concept map. Each learning resources is presented as a node and any two nodes can be linked by a proposition that states some meaningful relationship between the nodes. Using the Upper Cyc Ontology as a classification guide, each domain of knowledge will house all the associated concepts pertaining to a one domain in a single map. This map will act as the master map and depending on the request of the user, different abstraction level can be displayed. For example, if the learner wishes to view the conceptual view of certain concept, the system will only retrieve the meta-map of that particular concept.

Besides generating the visual and navigation interface, this module is also responsible for creating personalised learning paths. Learning personalization is formulated based on the concept of learning dependency and is being catered for in two stages.

Learning dependency is a human-centered approach to the mapping of knowledge structure; that is, it is necessary to master knowledge 'X' first before knowledge 'Y' can be mastered. Thus, learning dependency establishes some form of a learning sequence which states that certain pre-requisite concepts must first be mastered before some higher level concepts can be learned. For example, in the control engineering domain, to fully master the concept of stability, the concept of Routh-Hurwitz Stability Criterion, Relative Stability and Stability of State Variable Systems must first be acquired before the learner is able to appreciate the concept of stability. Each concept is depicted as a learning node in the M-map and contains the full and complete (explicit) knowledge that is required to comprehend a particular learning concept.

The first stage generates the exact learning paths that the learner has to take to master a particular concept. These paths will be generated dynamically based on the learner's expertise (through mapping with his cognitive structure) and the requested concept's expertise. Initially, each new learner will be given an empty academic record categorizes by the subjects domain that is offered by the system. Each domain is an externalization of the learner's cognitive structure (C-Map). The C-map initially empty will be filled with each successful acquisition of knowledge (through the completion of post-assessment). Thus, an exact learning path can be mapped easily by comparing the M-map with the learner's C-map. The next stage is to select the type of learning approach to present the content. As a learning objective is realized with different content approaches and assessment styles based on the Index of Learning Styles (ILS), the system will dynamically match the learner's preferences to the ILS and select the type of learning experience that best suits the learner.

2.4 Learner Profile Management Module (LPMM)

This module keeps a record of the learner's preferences as well as his past academic record categorized in terms of domains as specified by the Upper Cyc Ontology. The learner's academic record is stored as a concept map form and can be seen as an externalization of his cognitive structure for each particular domain. Upon completion of the post-assessment of any new course or concept, the newly acquired knowledge will be incorporated into his cognitive structure map.

The novel approach of tapping into the learner's cognitive structure and externalizing it provides an efficient and automated way of creating a personalization of learning path. Using the cognitive structure map as a comparison with the whole domain map, the system will be able to map out the possible personalized learning routes.

Besides managing the cognitive structure map, this module also records the learner preferences. Learning preferences are individual differences and preferences in learning. This is an important factor that will influence the learners' and SMEs' comfort with innovative thinking, problem solving and study skills. It is being observed that being aware of the preferences and developing acceptance of these preferences fosters effective interaction in both the teaching and the learning process. Too often, unnecessary gaps exist in different learners and thus, affecting their performance and achievement. In today's world of rapid expansion of needs for a well educated population, it is essential that the instructional approaches incorporate means to address these issues and change the teaching approach to suit each individual's needs.

As the system deals with science education, the Index of Learning Styles will be adopted to assess the preferences of the learners based on a four dimension (active/reflective, sensing/intuitive, visual/verbal, and sequential/global) learning style model.

3 Conclusion

This paper describes existing research works to integrate personalization issues into e-learning. Extending our previous works on concept maps [6, 7], this paper further augments the approach and realizes our proposed methodology through the implementation of the content authoring system. Although extensive research work is being placed on the system design, due to the length constraints, this paper only discusses the skeletal document that spans the entire design process of the system.

Using a concept map approach, this paper has showed how the vision of learning personalization can be achieved. The apparent difficulty of establishing learners' needs has also been solved by the system's ability to reconcile learners' needs (at real-time) to generate personalized course sequencing and offering.

Research effort will be ongoing to revise the system design to include new research methodology to personalize e-learning. We also aim to work towards benchmarking our knowledge system so that we can have a standard method to evaluate the effective of our system.

References:

[1] Miltiadis D. Lytras, Nancy Pouloudi (2001). 'E-learning: Just a waste of time'. Association for Information Systems, 2001 In Strong, D., Straub, D. & DeGross, J.I. (Eds) Proceedings of the Seventh Americas Conference on Information Systems, (AMCIS 2001) [CD Proceedings], August 3-5, 2000, Boston, Massachusetts, USA pp. 216-222.

[2] Pithamber R. Polsani (2003) Use and Abuse of Reusable Learning Objects. In JoDI - Journal of Digital Information, volume 3 issue 4. Themes: Information management. 2003-02-19.

[3] McCalla, G. (2004). The Ecological Approach to the Design of E-Learning Environments: Purpose-based Capture and Use of Information About Learners. Journal of Interactive Media in Education, 2004 (7). Special Issue on the Educational Semantic Web. ISSN:1365-893X.

[4] Blackboard Learning System, http://www.blackboard.com/

[5] WebCT, http://www.webct.com/index.html

[6] Teo, C., & Gay, R. (2004). Concept-Based System Design to Personalize E-learning. WSEAS Transaction on Information Science and Applications, vol. 1, Issue 5, pp. 1248-1255, November 2004.

[7] Teo, C., & Gay, R. (2004a). Concept Map Approach to E-learning. World Conference on E-learning in Corp., Govt., Health., & Higher Ed. 2004 (1), 2160-2165.

[8] Reusable Learning Object Authoring Guidelines: How to build Modules, Lessons and Topics, 2003, Cisco Systems, Inc.