Transforming Competence Structure to assessment questions and feedback for a Self-Study System

Athitaya Nitchot, Lester Gilbert
ESS Group, Electronics and Computer Science
Faculty of Physical and Applied Sciences
University of Southampton, UK SO18 2NU
{an08r, lg3}@ecs.soton.ac.uk

Onjira Sitthisak
Information Technology Group,
Faculty of Science,
Thaksin University, Thailand
onjira.sitthisak@gmail.com

***Abstract*—Currently there are many self-study and self-assessment systems available for learners. Some self-assessment and adaptive systems were designed based upon the idea of traditional user modeling. These systems are at risk of inconsistently modeling the user when estimating a learner's knowledge level and do not support the learner's intended learning outcome. This paper proposes a competence-based system for self-study and self-assessment. It can generate a possible learning path guiding the learners based on their chosen competences, suggest study materials from the Web, design assessment questions and generate feedback for learners after completing an assessment. The infrastructure of our system is mainly considered from a structure of competence which identifies the relationship between learner's competences. The benefit of our system is that it requires the appropriate competence structure to be embedded within the system.**

Keywords-component; Self-study, Self-assessment, Competence Structure, Competency Model, User Modeling

I. INTRODUCTION

Nowadays there are several sources of online materials, e-assessments and feedbacks available on the Web. However, some types of these systems could suffer from the problems of not supporting a learner's intended learning outcome, inconsistency in estimating the learner's knowledge level and not supporting lifelong learning. The aim of this paper is to propose a self-study and self-assessment system for the learners based upon their competences. For our research, a competence indicates the learner's intended learning outcome based upon the different contexts of learner performance. There is a competence structure which is considered for identifying the parent-child relationship among the learner's competences. As a result, our system only requires the appropriate competence structure to be embedded within it, and this is a major advantage of our approach. The reason is the design of a competence structure can be conducted by one person. The structure can be embedded within a system and used by many learners for learning within particular knowledge domains. Other types of systems could face problem of high development costs due to the updating knowledge within the system and there are also the other problems which are mentioned at the beginning of this introduction. The structure of this paper is as follows. Firstly, we discuss the existing models of users and competency. Secondly, we discuss the notion of competence structure in literature. Thirdly, the system design will be illustrated. Fourthly, the consideration of the generated assessment items from learner's competences will be given. Fifthly, there will be an illustration of how to provide feedback after the assessment session. Lastly, the conclusions and future works will be given.

II. MODEL OF USERS AND COMPETENCY

This section discusses on the current design of user modeling and competency model based on a pedagogical approach.

A. *User Modeling in Literature*

The User Model is known historically as a user profile and is also known as a student model in the Intelligent Tutoring System (ITS) [1]. The user model represents the level of individual users' knowledge and behaviour and this level affects their learning and performance [2]. Adaptive systems use the benefits of user models in order to adapt their contents and navigational possibilities to the particular user. There are six popular fields: the user's knowledge, interests, goals, background, individual traits and context of work [3]. Whereas, for many years, the focus has been on the first five fields, the context of the user's work is a relatively new research direction within AHS. The user's knowledge normally refers to the subject being taught or the domain represented. It focuses on the subject-based information rather than the learner's intended learning outcomes. User interests refer to personal interests for example, personal style. A goal (or task) represents the immediate purpose for a user's work within the adaptive system and focuses more on the subject matter. The user's background describes the set of features related to the user's previous experience, for example, the user's profession, job and work experience. 'Individual traits' is the aggregate name for user features that together define a user as an individual, for example, personality traits (introvert/extravert) [3]. The context can be viewed as user location, physical environment, social context and affective state [3]. Of the six fields for modeling users, none of them refers to competency or competence (or the intended learning outcome incorporated within the context).

User models are generally divided into two main categories which are the overlay and stereotype models [4]. In terms of overlay modeling, the user's state of knowledge is described as a division of the expert's knowledge in that domain [2]. The user is described through a set of attribute-value pairs where values are quantitative, such as percentage, or qualitative such as 'good' and 'excellent'. Overlay models are powerful and flexible; they can represent a user's knowledge of individual topics. But overlay models have a problem of initialization [5]. An overlay model requires a fixed set of attribute-value pairs. It is very hard to identify values for all users when new values are found [6].

B. Drawback of User Modeling

Kobsa [7] discusses the application of user modeling and makes the point that the user modeling components draw mostly on assumptions about the user, which may not necessarily be correct. User modeling therefore inherently involves the risk of misunderstandings. In addition, the authoring process of creating the user model is difficult since this is a complex task, good models of users are deficient and there are no standardized approaches to adaptive techniques in the system.

Sitthisak, Gilbert, and Davis [8], highlighted similar problems for adaptive assessment, for example the inconsistency of adaptive assessment systems in estimating a learner's knowledge level. Another problem is the issue of supporting lifelong learning in adaptive assessment systems since there are difficulties in updating rules, content and assessment within these systems. To briefly explain this problem, when the learner reuses the adaptive system, it does not update its user model. In addition, the estimate of a learner's knowledge in current user models does not readily render it compatible with an interoperable format and this in turn leads to problems supporting lifelong learning.

There is also a problem of generalization with the overlay model and the less powerful stereotype model, which are described in the previous section. Moreover, the six fields for modeling users (a user's knowledge, interests, goals, background, individual traits and work context) normally do not refer to a learner's competences or intended learning outcomes, which are important to the pedagogical design of e-learning systems. Hence, the current user modeling in AHS does not suit the requirement for the design of the system in this research. This system is designed to recommend study material links to learners based on their competences (or learning outcomes), which are not included in the six fields for modeling users. In addition, there are limitations over the current techniques for modeling a user (overlay and stereotype).

C. Competency Modelling in Literature

There are existing competency standards, for example IMS RDCEO [9] and HR-XML [10]. Their data models are minimalist but extensible to defining competencies or learning objectives.

IMS RDCEO provides five elements in the information model: identifier, title, description, definition and metadata. However, there are some disadvantages to this competency model, such as the oversimplification of the concept of competency and the lack of provision for an adequate semantic level to support intelligent decisions; it does not take into consideration explicitly important elements such as the knowledge and skills of learners [11]. Nor, in addition to this, does it support a common language of competency.

HR-XML consortium's competency schema has nine components: name, description, required, competencyId, TaxonomyId, CompetencyEvidence, CompetencyWeight, Competency and userArea. HR-XML competency can refer to knowledge, skill, ability, attitude, behaviour or a physical ability.

A discussion of these two competency standards is given by Sampson and Fytros [12]. The discussion introduces some drawbacks to these competency standards, such as the titles and descriptor elements in these models not being directly machine understandable. Moreover, both standards adopt a competence description but do not take a proficiency level into consideration, although it is important to the competency concept [12].

The proficiency level in this competency model refers to skills, knowledge, and attitudes. However, the meaning of proficiency is still vague. It can be either skills or knowledge. This is incompatible with considering an intended learning outcome as a combination of capability (skill) and subject matter (knowledge).

The proposed model for this research draws on the multidimensional competency model (called COMBA) proposed by Sitthisak, Gilbert and Davis [13]. This considers the learners' learnt capability instead of their knowledge level and views competences and learnt capabilities as a multidimensional space [13]. The COMBA model (figure 1) consists of three major components: subject matter, capability, and context.

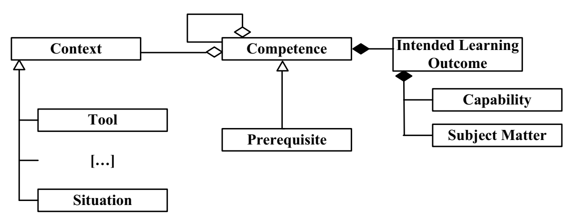

Figure 1: Competency Model Derived From COMBA model Proposed By Sitthisak, Gilbert, and Davis [13]

D. This Research Approach to COMBA Model

There are three main reasons why a COMBA competency model should be considered in this study. First is the issue of a machine-processable, sharable, and modifiable representation of learner competence. Each individual learner's competences have been clearly defined with a competency model. From each element of a learner's competence, he or she can be connected to a prerequisite (or parent-child) relationship and formed as a structure.

Second is the navigation of a competence structure or network. In this research, this is done by identifying different ways of assessment paths and searching online quiz, based on a learner's competence. Navigating the structure offers various routes for providing learners with assessment paths or questions.

The third issue is the identified context of a learner's competence. Learners may have differing levels of proficiency in relation to a given intended learning outcome, depending upon the types of context. The defined context of a competence distinguishes the competence from the intended learning outcome

E. Other Issues (User Control a Metacoginition)

User control (or learner control) refers to the potential for a learner to direct the learning activities and decide when they want to learn [14]. User control may be categorised into indirect and direct user control. Indirect user control is when the user has a small degree of control and must follow what the system provides [15]. Such systems are AHS and ITS systems. Direct user control is when the user has more control. The system in this research is designed for direct user control, where learners can express their competences, and the system offers study material links based on these competences. Learners can decide whether the study materials are relevant and restart with other competences if necessary.

Metacognition refers to the knowledge and awareness of one's own cognitive processes and the ability to control those processes [16, 17]. Learners sometimes do not plan their learning activities, fail to monitor their learning or manage their learning by engaging in help-seeking behaviour [18]. Self-reflection occurs after each learning effort and normally involves self-judgement and self-evaluation [19]. Some ITS systems also support the 'ask' part, which provides assessments or tests after the learning has happened.

This research proposes a system for recommending study materials from the Web, providing the self-assessment and feedback. The system supports direct user control, where users (or learners) have a greater degree of control. Users can identify their learning outcomes and receive links for these outcomes. In addition, the system also supports metacognition and self-reflection.

III. COMPETENCE STRUCTURE

The competence structure specifies the range of competence elements/nodes for a particular knowledge domain and highlights the relationship between competence nodes. Each node must comprise capability and subject matter. In this case, the competence node can also refer to an intended learning outcome node. When each node comprises capability, subject matter, and context, this node can be referred to exclusively as a competence node. Considering a competence structure in this study, makes it possible not only to identify the relationships between learner's competences, but also to navigate through a structure.

A. Samples Structures of Competences

Competence structure can be represented in several data structures such as tree structure, graph, concept map, and so on. Each competence node represents one competence which is the combination of capability, subject matter, and context. Some competence nodes may be composed of only capability and subject matter. In such a case, these competences can refer to intended learning outcomes. There are some existing competence structures. One sample is a tree of nursing competencies from the UK Royal College of Nursing introduced by Sitthisak, Gilbert, and Davis [20]. This competence structure is shown in figure 2. The relationship between nodes is parent-child with no ordering on the same level. A parent-child relationship identifies what the learner must be able to do before something else can be learned. The nodes in this structure are all intended learning outcome nodes, which are independent of the context. Some competence nodes in this structure, for example C11, C12 and C10, are in a shaded area called 'prerequisite'. One competence node (C22) is a common competence node of the C20 and D competence nodes. The relationships between competence nodes are 'enabling' relationships. For example, in order to do 'A' learners should be able to do 'D'.

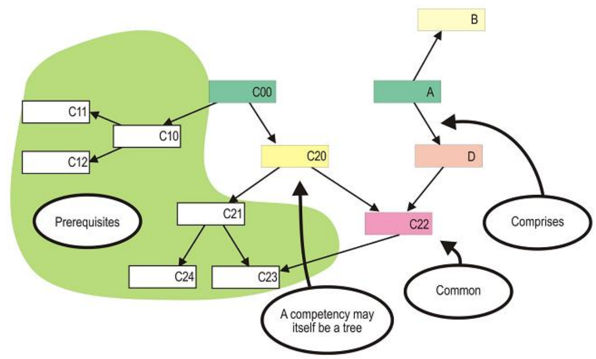

Figure 2: Nursing Competency Tree from the UK Royal College of Nursing [20]

Another competence structure was developed by Iskandar, Gilbert, and Wills [21]. This competence structure is shown in Figure3. Similar to the competence structure in figure 2, the nodes in figure 3 are also all intended learning outcome nodes, which are independent of the context. There are three types of relationship: optional, required and precedence. Here, a 'required' relationship is similar to an 'enabling' relationship in figure 2.

In this research, the sizes of competence structures are categorized as: small, medium, and large. Small competence structures contain 1 to 20 competence nodes. Medium competence structures contain 20 to 100 competence nodes. Large competence structures contain more than 100 competence nodes. The size of the two examples of competence structure given (figure 2and figure 3) is small.

Apart from these two competence structures, there are other competence structures which were designed from different aspects of competence. One competence structure was developed by Kickmeier-Rust, Albert, and Steiner [22] as shown in figure 4. One node represents a competence state which is a set of all available competencies of a person. The prerequisite relationships are defined within this set of competencies. Each competency in a state represents a problem or subject matter which a learner is required to solve.

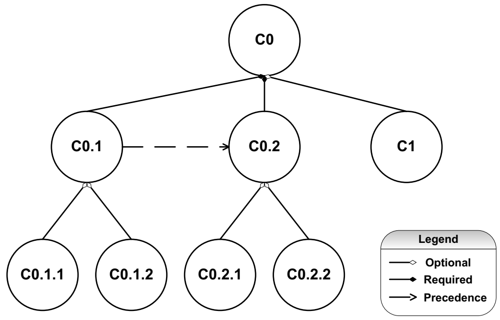

Figure 3: Conceptual Model of Learning Outcomes in the Motor Skill Domain [21]

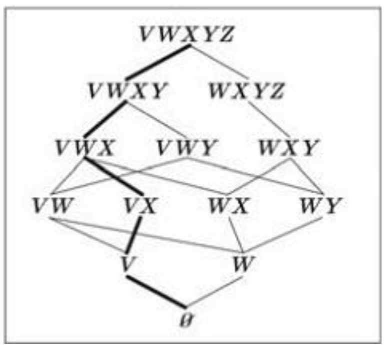

Figure 4: Competence Structure Established by the Prerequisite Function [22]

Another competence structure was proposed by Heller, Steiner, Hockemeyer, and Albert [23]. However, this structure represents a competence-based knowledge structure. It is extended from a knowledge structure as is shown in figure 5. They introduced two other sets of learning objects (LOs) and related skills for solving problems corresponding to each node within the structure. Nonetheless, this structure is based on the knowledge-based representation.

Unlike the competence structures in figure 2 and figure 3, each node of the competence structures in figure 4 and figure 5 represents a competence state comprising competencies. Here, a competency represents a problem-solving ability or an action verb, for example, stating the Pythagorean Theorem. The relationships between competence states are prerequisite relationships (or parent-child relationships). This type of relationship is similar to an enabling relationship in figure 2 and the ‘required’ relationship in figure 3. However, these relationships are represented as straight lines without arrows. The traversal of the competence structure is from bottom to top of the competence state. The learning paths are represented as bold lines in figure 4and arrow lines in figure 5.

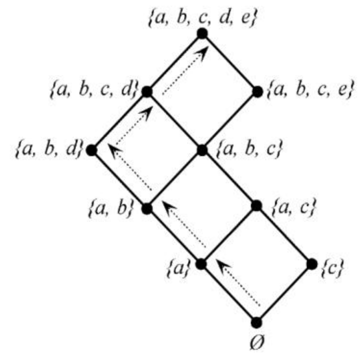

Figure 5: Overview of Knowledge Structure of Domain Q = “a, b, c, d ,e” [23]

In this research, the competence structures were developed in a similar way to the competence structures in figure 2 and figure 3. The nodes in a competence structure are called ‘competence’ nodes, which comprise capability, subject matter and context. However, some competence nodes may be composed of only capability and subject matter. Competence states are not considered in this research since they make it difficult to traverse a structure. Traversing between competence states in the structure is not only required but traversing between competencies in each state is also needed. It is easier to traverse from a competence node to another node where the nodes have only one competence.

The relationships in the competence structure in this research should be explicit. They are the parent-child relationships (or enabling relationships) and are represented as arrows, which point to the child competence nodes. This is to indicate that learners should master the child nodes before the parent nodes.

B. Competence Structures in This Research

There are two constructed competence structures in our research. They are based upon a mathematical highest common factor [26] and a photosynthesis for key stage 4 learners [27].

During the initial stage of structuring the competence elements of an HCF domain, different types of structures were considered, for example, a tree structure, a concept map, and a direct acyclic graph. A tree structure was the first to be considered. However, there is usually a root node in a tree structure, but the root node cannot be identified in this domain. Hence, the tree is not an appropriate competence structure for the HCF domain.

A concept map was the second consideration. The concepts are HCF, common factor and factor. These concepts need to be tagged with capabilities. The limitation of a concept map is that it is an undirected structure. Competences need a direction since the relationship between two competence nodes is an enabling relationship. A child competence must support a parent competence. Hence, the concept map is not an appropriate structure for competences.

A directed acyclic graph (DAG) was the third consideration – as shown in figure 6. A DAG is a directed graph with no directed cycles (Handley, 1994). The graph consists of nodes connected by edges. A DAG is a useful representation of the structure of competences in the HCF domain. A DAG does not require a root node and this is important since none of the nodes C03, C02 or C01 can be chosen as the root node for the competence structure. In addition, a DAG is directed and this supports the nature of a competence structure where one competence enables another.

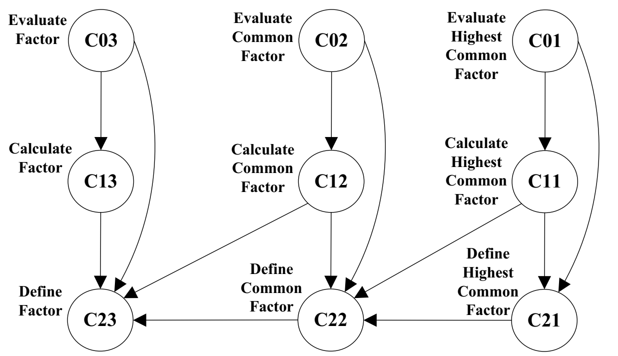

Figure 6: DAG Competence Structure of Mathematical Highest Common Factor

The size of this structure is small and it contains 9 competence nodes. There are three nodes that have no parents; these are nodes C03, C02 and C01. There is just the one leaf node, namely C23. To briefly explain the parent-child relationship between competence nodes, we can consider these examples. In order to achieve competence number C02, a learner must complete C12 and C22 beforehand. To attain C12, a learner must complete C23 and C22. To achieve C22, the learner must first achieve C23.

In order to design a more complicated and larger structure of competence, such as a photosynthesis domain for Key Stage 4 learners, the information on intended learning outcomes for the specific subject matter content of a course is required. Then an analysis of their structure into a categorization of subject matter content is conducted and each subject matter content is tagged with a capability and a context in order to get a structure of competence.

IV. SYSTEM DESIGN

This section discusses an overview of system design which suggests appropriate study material links from the Web to learners, generating the assessment questions and feedback after the learner obtains study materials.

A. The Consideration of Learner Competences

For this research, there are two kinds of learners' competences: desired and existing competence. Desired competence refers to the learner's intended learning outcome or the competence which the learner wishes to gain. The current or existing competence is the estimation of the actual competence of the learner. Firstly a sub-process must be considered for getting a learner's competences so that a system can generate keywords from corresponding competences.

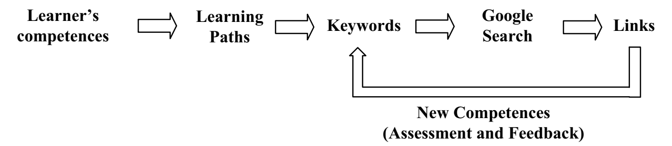

Figure 7: Overview of Process within the System

At this point, a structure of competences has been designed. The options for desired and existing competences, which will be chosen by the learner, depend on a structure of competences elements. Further details of how the system generates learning paths and keywords from learners' competence can be obtained in the next part. After the keywords are obtained, a system automatically obtains Google search results based on these keywords; the links from Google search will be suggested to learners. Once a learner receives appropriate study materials from the Web (links), then the system generates the assessment items based on the learning path. After the learner finishes an assessment session feedback will be provided for him/her.

B. Generating Different Learning Paths

From the system process in figure 7, there are two processes which deal with a competence structure:

- Obtain desired/existing competences from the learners
- Generate the search terms from desired/existing competences

Currently there are three possible cases of learning paths.

1) Learning Path 1 (Ignore All Gaps)

a) Obtain desired/existing competences from the learners

A system begins by providing a choice of desired competences to learners. Next is a list of existing competences which contains children (including children of children) nodes of desired competence.

b) Generate the search terms from desired/existing competences

The system sets a desired competence sentence (capability with subject matter) as the search terms without considering the nodes between desired and existing competences.

2) Learning Path 2 (Consider Some Gaps)

a) Obtain desired/existing competences from the learners

Same as learning path 1.

b) Generate the search terms from desired/existing competences

The search terms are considered based on a desired competence and some gap nodes between two chosen competences. The learner will be required to obtain study materials based on some gap nodes competences before reaching a desired competence.

3) Learning Path 3 (Consider All Gaps)

a) Obtain desired/existing competences from the learners

Same as learning path 1.

b) Generate the search terms from desired/existing competences

The search terms are considered based on a desired competence and all gap nodes between two chosen competences. The learner will be required to obtain study materials based on all gap nodes competences before reaching a desired competence.

V. Designing Assessment Items

This section mainly details the system to design the assessment items. The learner will be required to give an answer to a question after obtaining the study materials links. There are three possible cases of generated learning paths: 'Ignoring All Gaps', 'Considering Some Gaps', and 'Considering All Gaps'. The assessment items are generated based on the competence nodes the learner has visited. This is dependant upon the learning path the learner has chosen. By considering three possible learning paths, the discussion of designing assessment items is explained in the next point.

A. Cases of Designing the Assessment Items

There are two possible cases of designing the assessment items.

1) Case 1: Ignoring All Gaps

An assessment question is designed from a desired competence.

2) Case 2: Considering Some Gaps and Considering All Gaps

The first assessment question is designed from a first visited gaps node. The next question is considered from the next gap node and the last question is considered from a desired competence. The differences between 'considering some gaps' and 'considering all gaps' are that the assessment questions will considered from all gap nodes for 'considering all gaps'. While a learner is required to answer the assessment questions from some gaps nodes for 'considering some gaps'.

B. The Form of an Assessment Item

In general terms if the competence is "X", the assessment question is simply "Please X", where any general variable in X is instantiated as a specific value. For example, if a competence element is 'define a chloroplast', then an assessment item is 'please define a chloroplast'. The choices of answers will be in the form of multiple choice provided.

VI. Generating Feedback from Learner's Competences

This section gives the details of generating the feedback to learners. The feedback will be generated after the assessment process. The feedback is considered based upon the answers from a learner to the assessment questions (see section 4). If the learner gives the correct answer then the system would suggest he/she obtains study material links based upon next competence gap nodes. But if the learner fails to answer the question then the system would suggest to him/her that they should obtain study material links based upon the child node of current visit competence. The learner may need to obtain study materials links based on an existing competence if he/she fails to answer the question based upon competence node next to existing competence within a chosen learning path. In this situation, the learner may be required to re-answer the question based upon the competence node that he/she has already visited.

VII. Conclusions and Future Works

In this paper we describe our approach of designing a self-study system which provides study materials from the Web, generates the assessment items and provides the feedbacks after an assessment session. The competence structure is used to identify the relationships among competence elements. The advantages of a competence structure is to reduce the cost of updating knowledge within the system and to allow the learner to obtain study materials from the Web in order that they can achieve their intended learning outcomes. So far we have constructed two competence structures which are based upon knowledge domains: H.C.F (highest common factor, common factor and factor) and photosynthesis at key stage 4. Within our system design the learner is required to choose their desired and existing competence, and then the learning paths will be generated. The Google keywords are considered from a chosen learning path. The designed assessment questions are considered from a learning path. Finally the feedback will be given to the learner after the session of assessment. In future works we intend to conduct experiments to see whether our competence-based system is better than other systems (which would be a freely browsing study mode or a traditional search system) in terms of an intended learning outcome achievement.

References

[1] M. C. Polson and J. J. Richardson, *Foundations of intelligent tutoring systems*: L. Erlbaum Associates Inc., 1988.

[2] A. Kavcic, "The role of user models in adaptive hypermedia systems," in *10th Mediterranean Electrotechnical Conference (MELECON 2000)*, 2000, pp. 119-122.

[3] P. Brusilovsky and E. Millán, "User Models for Adaptive Hypermedia and Adaptive Educational Systems," *The Adaptive Web,* vol. 4321, pp. 3-53, 2007.

[4] M. Cannataro and A. Pugliese, *A survey of architectures for adaptive hypermedia*. London, UK: Springer-Verlag, 2004.

[5] H. Wu, "A reference architecture for adaptive hypermedia applications," Technische Universiteit Eindhoven, 2002.

[6] P. Brusilovsky, "Methods and techniques of adaptive hypermedia," *User Modeling and User-Adapted Interaction,* vol. 6, pp. 87-129, 1996.

[7] A. Kobsa, "User modeling: Recent work, prospects and Hazards.," *Adaptive User Interfaces: Principles and Practise,* 1993.

[8] O. Sitthisak*, et al.*, "Towards a competency model for adaptive assessment to support lifelong learning," presented at the TENCompetence Workshop on Service Oriented Approaches and Lifelong Competence Development Infrastructures, Manchester, UK, 2007.

[9] IMS RDCEO. (2002, 17/08/2009). *IMS Reusable Definition of Competency or Educational Objective - Information Model*. Available: http://www.imsglobal.org/competencies/rdceov1p0/imsrdceo_infov1p0.html

[10] HR-XML. (2004, 01/05/2009). *Competencies (Measurable Characteristics Recommendation)*. Available: http://ns.hr-xml.org/2_3/HR-XML-2_3/CPO/Competencies.html

[11] S. Baldiris*, et al.*, "Modelling Competency upon dotLRN," in *2007 OpenACS and dotRLN Spring conference*, Vienna, 2007.

[12] D. Sampson and D. Fytros, "Competence Models in Technology-Enhanced Competence-Based Learning," in *Handbook on Information Technologies for Education and Training*, ed, 2008, pp. 155-177.

[13] O. Sitthisak*, et al.*, "Transforming a Competency Model to Assessment Items," presented at the 4th International Conference on Web Information Systems and Technologies (WEBIST), Funchal, Madeira - Portugal, 2008.

[14] S. D. Bencomo, "Control Learning: Present and Future," in *15th Triennial World Congress*, Barcelona, Spain, 2002.

[15] J. Kay, "Learner Control," *User Modeling and User-Adapted Interaction,* vol. 11, pp. 111-127, 2001.

[16] A. Efklides and M. Vauras, "Matacognitive experiences in their role in cognition.," *European Journal of Psychology of Education,* vol. 14, pp. 455-584, 1999.

[17] R. E. Mayer, "Cognitive, metacognitive, and motivational aspects of problem solving," *Instructional Science,* vol. 26, pp. 49-63, 1998.

[18] R. Azevedo, "Beyond intelligent tutoring systems: Using computers as METAcognitive tools to enhance learning?," *Instructional Science,* vol. 30, pp. 31-45, 2002.

[19] B. J. Zimmerman, "Becoming a Self-Regulated Learner: An Overview," *Thoery Into Practice,* vol. 41, 2002.

[20] O. Sitthisak*, et al.*, "Transforming a competency model to parameterised questions in assessment," presented at the WEBIST 2008, Lecture Notes on Business Information Processing, 2009.

[21] Y. H. P Iskandar*, et al.*, "A Conceptual Model For Learning Outcomes in the Motor Skill Domain," presented at the 8th IASTED International Conference on Web-based Education (WBE 2010), Sharm El Sheikh, Egypt, 2010.

[22] M. D. Kickmeier-Rust*, et al.*, "Lifelong Competence Development: On the Advantages of Formal Competence-Performance Modeling," presented at the International Workshop on Learning Networks for Lifelong Competence Development, TENCompetence Conference, Sofia, Bulgaria, 2006.

[23] J. Heller*, et al.*, "Competence-Based Knowledge Structures for Personalised Learning," *International Journal on E-Learning,* vol. 5, pp. 75-88, 2006.

[24] D. Albert*, et al.*, "Cognitive Structural Modelling of Skills for Technology-Enhanced Learning," in *7th IEEE International Conference onAdvanced Learning Technologies (ICALT 2007)* 2007, pp. 322-324.

[25] B. S. Bloom, *Taxonomy of Educational Objectives, Handbook I*. New York: David McKay Co Inc., 1956.

[26] A. Nitchot*, et al.*, "Towards a Competence based System for Recommending Study Materials (CBSR)," presented at the 10th IEEE International Conference on Advanced Learning Technologies, Sousse, Tunisia, 2010.

[27] A. Nitchot*, et al.*, "Designing XML Schema of a Competence Structure from Course Intended Learning Outcomes," in *14th IASTED International Conference on Computers and Advanced Technology in Education*, Cambridge, UK, 2011.