A Competence Model to Design Assessment Questions for Self-Study

Athitaya Nitchot, Lester Gilbert,
Gary B Wills

Learning Society Lab, School of
Electronics and Computer Science

University of Southampton, Highfield

Southampton, SO17 1BJ,
United kingdom

{an08r, lg3, gbw}@ecs.soton.ac.uk

Abstract

The value of a learning assessment is presumably enhanced by an effective e-learning system and the delivery of appropriate study materials which support learners' intended learning outcomes. Some e-learning systems are based on Adaptive Hypermedia (AH) and traditional User Modelling, but have a problem with their lack of support for learners' intended learning outcomes. The paper introduces a competence-based system for learners to retrieve recommended study materials from the Web, solving this existing problem in AH systems. Also, the system can provide assessment based upon the learners' chosen competences.

The paper introduces a competence-based system which provides appropriate study materials as links from the Web together with generated assessment questions. Some aspects of providing study materials have been explored within educational adaptive hypermedia systems, for example in intelligent tutoring system (Contreras, Galindo, Caballero, & Caballero, 2007). Most of these systems were designed using

embedded user modelling, however, which is inconsistent in estimating the learner's knowledge level, is not designed for supporting lifelong learning, and faces the difficulty of constructing models which adhere to standardized adaptive techniques (Nitchot, Gilbert, & Wills, 2010).

The design of the competence-based system identifies two types: current or existing competence, and desired competence. The current or existing competence is an estimation of the actual competence of the learner. The desired competence refers to the learner's intended learning outcome or the competence which the learner wishes to gain. After the existing and desired competences of the learner are established, the system derives links to recommended study materials, generates assessment questions based on desired competences, and derives new recommendations. A directed acyclic graph (DAG) represents a competences structure.

This paper is organized as follows. Section 2 describes the details of the competence model and its benefits. Section 3 illustrates the competence structure for a particular knowledge domain. Section 4 gives the overview of the system design and lists the functionality of the system. Section 5 describes the recommendation of study materials. Section 6 discusses generating assessment questions from the chosen competences. The last section summarizes the paper and gives ideas for future work.

2. Competence Model

"Competence" refers to the ability to do a particular activity to a prescribed standard (Smith, 1996). The concept of competence has been associated with an education system (Stoof, Martens, & van Merriënboer, 2007) and professional development. In an education system, competence could be used to describe final attainment levels of educational programs (Stoof, et al., 2007). In professional development, competences are considered as a criterion to select the most appropriate person for a given task (Eraut, 1994).

COMBA Competence Model

The proposed model for this research draws on the multi-dimensional competence model (called COMBA) from Sitthisak, Gilbert and Davis (2008). This considers the learners' "learned capability" instead of their "knowledge level" and considers competences and learned capabilities as a multidimensional space (Sitthisak, et al., 2008). The COMBA model is show in figure 1.

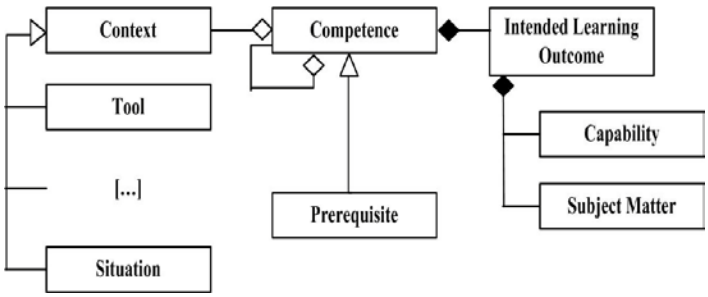

Figure 1: COMBA Competence Model (Sitthisak, et al., 2008)

From the COMBA competence model in figure 1, 'Competence' is composed of an 'Intended learning outcome' and 'Context'. An intended learning outcome comprises two key elements, 'Capability' and 'Subject Matter'. 'Capability' indicates what the learner will be able to do with the subject matter of the e-learning objective. 'Context' can refer to a tool and a situation. Other aspects of context mentioned in the literature include location, time, environment (De Jong, 2007), job, occupation, and task (Sampson & Fytros, 2008).

Benefits of COMBA model

Pedagogy Approach

The consideration of pedagogy emphasizes supporting the learner to achieve their intended learning outcomes. Consider the learning transaction illustrated in figure 2.

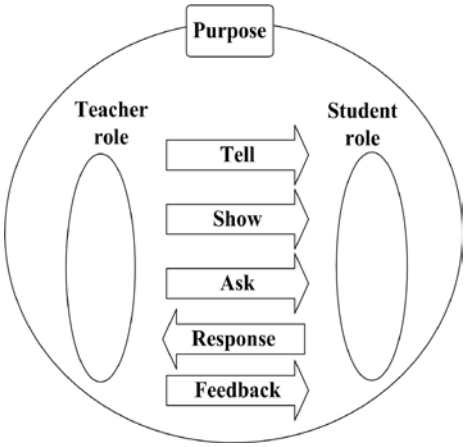

Figure 2: E-learning Transaction (Gilbert & Gale, 2008)

An e-learning transaction is a generalisation of Laurillard's conversational model (Laurillard, 1993) which is a model that describes the learning and teaching environment in higher education. The important component of the learning transaction (figure 2) is the purpose (or intended learning outcome) which is implied from the aim of the overall learning and teaching situation. From figure 1, it is obvious that the COMBA model incorporates the intended learning outcomes which can be formally described as the composition of 'capability' and 'subject matter'. Hence the COMBA model supports the pedagogical approach of the learning transaction. Furthermore, the COMBA model incorporates the idea of 'context' in characterising a competence. Learners may have differing levels of proficiency in a given intended learning outcome depending upon the context of their performance.

Consistency in Recording the Learner's Level of Performance

The levels of learner's performance are usually carefully specified in terms of the learner's capability and in terms of the context in which the performance is to be demonstrated. The implementation of the COMBA competence model in the proposed system concentrates on the learner's capability and not on their 'knowledge level', which is difficult to properly characterise or estimate in the absence of associated learner capability or context.

Life Long Learning

Consistency in recording the learner's level of competence leads to significant advantages in using the proposed system for lifelong learning, particularly when coupled with the ability of the competence model to be rendered in an interoperable form; for example by using COMBA extensions to IMS RDCEO or HR-XML. Such a system allows learners to use the system anytime throughout their life, where learners with different competence levels can obtain materials tailored according to their own competences without the need to restart from the same competence level again.

3. Competence DAG Graph

In this paper, consideration has been given to the knowledge domains of mathematical factor, common factor, and highest common factor. Referring to the competence model in figure 3, the knowledge domain is represented as a directed acyclic graph (Handley, 1994) to structure competence elements, comprising capability and subject matter. (Context has not been considered at this stage.) The proposed examples of subject matters are 'factor', 'common factor' and 'highest common factor'. The examples of capability are 'evaluate', 'calculate', and 'define', obtained from Bloom's taxonomy (Bloom, 1956).

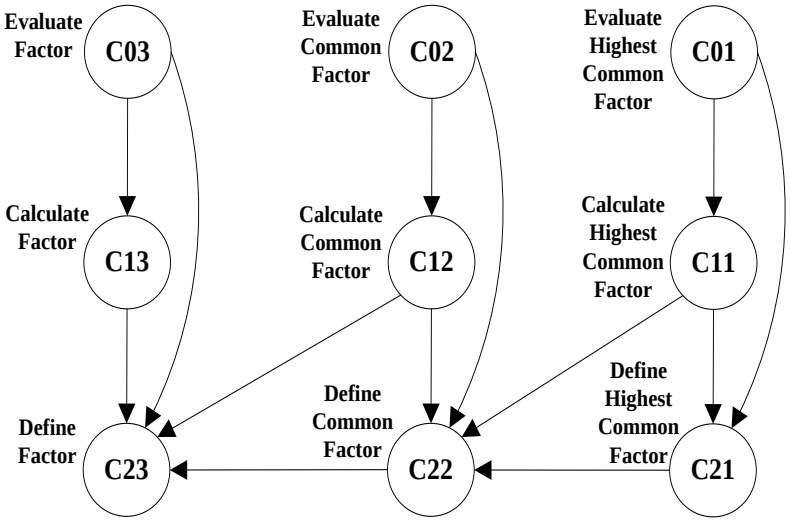

Figure 3: DAG Competences Structure

From the graph in figure 3 there are three nodes that have no parents; these are nodes C03, C02, and C01. There is just one leaf node, namely C23. To briefly explain the parent-child relationship between competence nodes, we can consider the example that, in order to achieve (parent) competence number C03, a learner needs to achieve (child) C13, and to attain (parent) C13, a learner needs to attain (child) C23.

4. Overview of Competence-Based System

The learning transaction of figure 2 illustrates five activities for student and teacher roles, 'tell', 'show', 'ask', 'response', and 'feedback'. The functionality of the system is based on these activities from the learning transaction, yielding:

- Recommended study materials from the Web.
- Generated assessment question.

Recommending study materials from the Web corresponds to 'tell' and 'show' in the learning transaction. The recommended study materials will be provided based on the learner's existing and desired competences. After the learner has studied the recommended materials, the system next generates an assessment question. This matches the 'ask' in the learning transaction. The generated assessment question is based on the learner's competences, using the same mechanism which recommended the study materials. After the learner responds to the assessment question, the system suggests the next competence to study. The details of these system functions are described in the next three sections.

5. Recommending Study Materials from the Web

The links to recommended study materials are based on the learners' existing and desired competences. This is important since the study materials should be appropriate for learners' achievement of their intended learning outcomes.

Overview of Process for Recommending Study Materials

Figure 4 illustrates the process for recommending study materials from the Web based on the learners' competences.

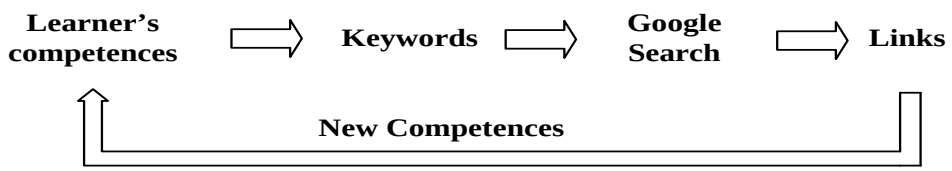

Figure 4: Overview of Process of Recommending Study Materials from the Web

Recommending materials starts by acquiring the learner's competences so that the system can generate keywords. From the keywords, the system obtains search results from an engine such as Google, being the links which will be suggested to the learners.

Obtain desired/existing competences from the learners

The system displays two lists of competences to be chosen by the learner, existing and desired competence. The competences in both lists are derived from the competence structure, such as that illustrated in figure 3. Initially, the list of existing competences contains all competences which are the child , and the list of desired competences contains all parent nodes. The learner then processes each of these initial lists, identifying and selecting those competences which they feel are 'existing' on the one hand, and 'desired' on the other.

Generate keywords from learners' competences

There are two cases to be considered: where the existing and the desired competences are adjacent nodes; and where there is at least one node between the existing and the desired competences. In the first case, since both competences are adjacent to each other, the keywords may be derived from a direct comparison of the two competences. If there are some nodes between the two competences,

however, the keywords derived from a direct comparison of the two competences would need to be adjusted from a consideration of the intervening competence nodes. The more detailed study of this case is a topic for future work.

Where the two competences are adjacent nodes, the system currently generates keywords by adding the Google search symbol "+" in front of relevant words from the desired competence, and adding "-" in front of relevant words from the existing competence. Using Google search symbols "+" and "-" is a first step in deriving search results which relate to the desired competence and which do not relate to the existing competence. The intention is that the search results should be study materials which are appropriate to a learner's needs or desires and not to what they have already learned or achieved.

Recommend next desired competence

The next desired competence is suggested as the parent node(s) of the previously chosen desired competence whose status is now "existing" or "achieved" after the learner has studied the recommended materials.

6. Generating an Assessment Question

In the section 5, the process of recommending study materials from the Web based on learners' competences has been discussed. Once learners study the recommended materials from the Web, the system assumes that they achieve their desired competence. This desired competence has its status updated to become a new existing competence, and a next desired competence recommendation made. It would be very useful if the system could provide an assessment of the competence to test whether a learner has indeed achieved the intended learning outcome.

The generated assessment question is based on the chosen desired competence. For example, a desired competence might be 'calculate factors'. The learner could be asked the question, "Please calculate the factors of 20". This question is constructed from the desired competence of 'calculate factor'. 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.

7. Conclusions

A competence-based system for self-study and self-assessment has been proposed in this paper. This system is based on a competence model which gives the benefits of supporting any pedagogical approach, consistency in estimating the level of learners' performance, and interoperability for lifelong learning. The intention of the paper is not to describe the final design of the competence-based system, but to introduce the concepts of recommending appropriate study materials from the Web based on intended learning outcomes and of generating assessment questions from learners' competence. The details of the processes within these functions have been prototyped but not finalised, and are the subject of future work.

References

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

Contreras, W. F., Galindo, E. G., Caballero, E. M., & Caballero, G. M. (2007). *An intelligent tutoring system for education by web*. Paper presented at the Proceedings of the sixth conference on IASTED International Conference Web-Based Education - Volume 2.

De Jong, T. (2007). Datamining context Retrieved 01/02/2010, from http://dspace.ou.nl/bitstream/1820/998/1/Datamining%20course%2006072007%20-%20Datamining%20context.pdf

Eraut, M. (1994). *Developing Professional Knowledge and Competence (Paperback)*. London: Falmer Press.

Gilbert, L., & Gale, V. (2008). *Principles of E-learning Systems Engineering*. Oxford, UK: Chandos Publishing.

Handley, S. (1994). *On the use of a directed acyclic graph to represent a population of computer programs.* Paper presented at the Evolutionary Computation, 1994. IEEE World Congress on Computational Intelligence., Proceedings of the First IEEE Conference on.

Laurillard, D. (1993). *Rethinking university teaching : a framework for the effective use of educational technology* (2nd ed.). London: Routledge.

Nitchot, A., Gilbert, L., & Wills, G. (2010). *A Competence-based System for Recommending Study Materials from the Web (CBSR)*. Paper presented at the 9th International Conference on Information Technology Based Higher Education and Training (ITHET 2010).

Sampson, D., & Fytros, D. (2008). Competence Models in Technology-Enhanced Competence-Based Learning *Handbook on Information Technologies for Education and Training* (pp. 155-177).

Sitthisak, O., Gilbert, L., & Davis, H. (2008). *TRANSFORMING A COMPETENCY MODEL TO ASSESSMENT ITEMS* Paper presented at the 4th International Conference on Web Information Systems and Technologies (WEBIST).

Smith, M. K. (1996). competence and competency : What is competence? How has it been reduced to competency? What is the impact on education and training? *Mark K. Smith*, from http://www.infed.org/biblio/b-comp.htm

Stoof, A., Martens, R., & van Merriënboer, J. (2007). Web-based support for constructing competence maps: design and formative evaluation. *Educational Technology Research and Development, 55*(4), 347-368.