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Construction and analysis of educational assessments using knowledge maps with weight appraisal of concepts

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ABSTRACT

The rapid advance of information and communication technologies (ICT) has important impacts on teaching and learning, as well as on the educational assessment. Teachers may create assessments utilizing some developed assessment software or test authoring tools. However, problems could occur, such as neglecting key concepts in the curriculum or having disproportionate course topics distribution, when teachers create assessments or test items. This study proposes a novel approach, which uses knowledge map with appraisal of concept weights and other ICTs, and implements an assessment system KMAAS to help primary school teachers in Taiwan, or elsewhere, create educational assessments properly. When compiling an assessment, KMAAS ensures that teachers can include all important course concepts intended for assessing and maintain correct balance between course concepts among test items. It does so first by analyzing course material of the assessment range and displaying a concept-weight-annotated knowledge map which concretize and visualize the importance of and the relationships among concepts in the range. It then analyzes the test sheet which is being complied and displays another similar real-time updated knowledge map containing balance between course concepts among the test items. Teachers may cross-refer to these maps to help them adjust concept balances and even select appropriate test items from test banks. The system has being evaluated in both the accuracy of learning concepts extraction and the degree of user satisfaction, as measured by questionnaires given to the teachers who tested the system. The promising results confirm the feasibility of this system in helping teachers compile their educational assessments easily and precisely. Other results of the formative evaluations on techniques have being used to improve the system in order to make it more effective and efficient. The methodology and technologies KMAAS employed are all well developed and are domain independent, which makes it highly flexible to transfer to other course subject domain too.

1. Introduction

Computers and information technology have advanced rapidly in recent years, and computers are now widely used by educators to facilitate teaching and learning (Chou & Liu, 2005; Goodison, 2002). Computer technology allows for innovation in testing and assessment (Bonham, Beichner, Titus, & Martin, 2000) and significantly improves the assessment process for all stakeholders, including teachers, students and administrators (McDonald, 2002). Computerized testing has become a promising alternative to traditional paper-and-pencil measures, thanks to the rapidly decreasing cost of new computers with high processing speeds and large data storage capacities (Barak & Rafaeli, 2004). Much research has evaluated the systems or software tools designed for creating educational assessments and satisfying other test environments needs, such as assisting educators with the construction of assessments, providing data analysis tools for exercises or tests, helping to assess the performance of pupils at various levels, giving quick diagnostic feedback, allowing random item arrangement and improving the convenience and efficiency of computerized test administration (Conole & Warburton, 2005; Huang, Lin, & Cheng, 2009; Nuntiyagul, Naruedomkul, Cercone, & Wongsawang, 2008).

Educational assessment is an essential aspect of teaching. Researchers have observed that teachers in schools spend more than 35% of their time on assessment and more than 10% of their time on assessment-driven instruction (Conca, Schechter, & Castle, 2004). Studies show

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that for teachers to be effective, they must possess the assessment literacy required to administer and construct proper assessments in their classroom (Mertler, 2004; Popham, 2006). Generating good assessments depends on both the subjective appropriateness of test items and on the way the assessment is constructed (Hwang, Chu, Yin, & Lin, 2008). Some research argues that in order to select appropriate test items, educators must consider multiple criteria, such as the expected time needed for answering the testing, the number of test items, the specified distribution of course concepts to be learned, and the expected degree of difficulty of the test (Chamoso & Ca'ceres, 2009).

Computer-assisted assessment tools have become increasingly indispensable to instructors in primary and secondary education (He & Tymms, 2005); In Taiwan, commercial testing systems and assessment software tools are developed by textbook publishers and made available for primary and secondary educational institutions. Most of these systems allow teachers to construct assessments by selecting test items from item banks, either manually or randomly. However, such manual or random test item selecting strategies are inefficient and are unable to meet multiple assessment requirements simultaneously (Yin, Chang, Hwang, Hwang, & Chan, 2006). When instructors create assessments in this way, they sometimes neglect key concepts in the curriculum or have disproportionate course topics distribution in test items.

Researchers have shown that offering overview supports by providing access to relevant information greatly help people make decisions, solve problems, and avoid disorientation problems (Edwards & Hardman, 1999; Thomas, 2009). Graphic tools or map presentations can be used to create overview supports, restructure content, and deepen or elaborate knowledge of a subject (Zumbach, 2009). The forms of maps can assist people to refer to and facilitate information searches within a domain (Chen, Wei, & Chen, 2008). Knowledge maps provide a graphical representation of the relationships among concepts. They make certain aspects of knowledge more easily understandable (Speel, Shadbolt, Vries, Dam, & O'hara, 1999), and also aid in the acquiring of explicit information or tacit knowledge, illustrating how knowledge flows throughout an organization (Grey, 1999). "Knowledge Maps" could outline where important gaps in received knowledge exist, and have been utilized in the formulation of recommendations in support of a series of related research projects and workshops. An individual knowledge map briefing sheets are meant to serve as quick snapshots of information in key areas related to the use of ICTs in education (Trucano, 2005). Some researchers, such as Pirnay-Dummer and Ifenthaler (2010), build "SMD Technology", based on the theory of mental model and graph theory, use (a) graphical representations such as concept maps or (b) natural language expressions to analyze individual processes in persons solving complex problems at single quantitative measures and standardized representations for qualitative analysis and feedback.

In the sense that the knowledge map is a knowledge representation that reveals underlying relationships of the knowledge sources, using a map metaphor for spatial display. Knowledge maps can be used as primary reference for knowledge acquisition, adjunct aids to text processing or retrieval cues, which serve as scaffolds or supports to cognitive processing for they can reduce cognitive load, enhance representation of relationships among complex constructs, provide support for students whose verbal skills are weak, and serve as important props for communicating shared knowledge (O'Donnell, Dansereau, & Hall, 2002). Hence, it can save much effort with the outline of distribution by knowledge maps assisting; teachers can recall or comprehend more specified distribution of concepts weights when they catch from a knowledge map than when they stand on from textbooks and those teachers with new in-service often benefit the most. This study integrates knowledge maps into educational assessment systems. It builds a novel educational assessment system, called the Knowledge Map Assisted Assessment System (the KMAAS), which automatically constructs real-time updated knowledge maps with weight appraisal of concepts for creating effective assessments. The KMAAS harness a number of technologies like course concept extraction, knowledge maps, natural language processing, items categorization, and items retrieval. This study extracts important "keywords" from textbooks, teaching materials, and test items and uses them as the "nodes" to represent learning concepts in knowledge maps. The "concept weights" are a set of importance values weighted within the curriculum. The terms which directly indicate course topics are considered to play a more important role in assessments (Song, Wenyin, Gu, Quan, & Hao, in press). They are given a higher weight, by multiplying their original weight with a coefficient larger than 1.

When compiling an assessment, teachers always intend to include important course concepts in the assessing and to maintain correct balance between course concepts among test items. Using most of the assessment authoring tools to date or pencils and papers, however, problems could occur, such as neglecting key concepts in the curriculum or having disproportionate course topics distribution, when teachers create assessments or test items. The KMAAS can ensure that these mistakes do not happen. Teachers can first use KMAAS to analyze course materials of the assessment range and display a concept-weight-annotated knowledge map which concretizes and visualizes importance of course concepts and the relationships among these concepts in the range. They then select test items from item banks or create they own test items in a test sheet. In the mean time, KMAAS analyzes the sheet being complied and displays another similar real-time updated knowledge map to show the balance among course concepts in the test items. Teachers can cross-refer to these maps to help them adjust concept balances and select or create appropriate test items. In KKMAS, teachers can analyze and organize their collection of test items and assemble test items they want to use by comparing the weight appraisal of course concepts and their relationships on the knowledge maps. Moreover, they can generate exercises, assessments and tests, and then use the system to help adjust the balance of test items to match the course concept weights.

Although KMAAS was experimented in this study using a science course subject with its related items or assessments, it is not necessarily that KMAAS is confined to such a limited domain. The methodology and technologies KMAAS employed are all well developed and all domain independent. To transfer KMAAS to other subject course material, test items, and test sheets, would require no further labor work than download/upload and creating files.

The rest of this paper is divided into four sections. Section 2 is the literature review, briefly addressing the relation of concepts and test items and providing an overview of knowledge maps and test item categorization. Section 3 introduces the architecture of KMAAS and its component implementations. Section 4 provides a system evaluation and summarizes levels of teacher satisfaction with the system. Finally, conclusions in Section 5 are presented and suggestions are made for future research.

2. Literature review

Course concepts, knowledge maps, and test items categorization play an important role in this study. Researchers have been investing related technologies and have been getting various achievements.