Object-Based Learning with Concept Mapping Embodied Intelligent Agent

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Abstract

For effective learning, the teaching materials for the learning purpose should be comprehensible and appropriate for the learners. Moreover, the learners are expected to construct the concepts and relations of the learning materials so as to achieve the desired learning objectives. Concept mapping is a technique using graphs for representing knowledge in a structure according to different levels of abstraction and inclusion. The technique has been widely applied in many disciplines and various educational levels. This learning environment is intended to guide the learners toward general understandings of the topic they have to learn. In concept mapping with learning objects settings, learners are able to direct their own unique sequences of tailored instructions under their control. This paper shows how the concept mapping and learning objects can be integrated in the *Constructive Learning Model Embodied Intelligent Agent*. The authors propose learning objects as a form of resources, concept maps as representation of the instructional tool and intelligent agent as a means to assist learners to create a personalized learning environment.

Introduction

Learning is the process by which a learner receives and processes sensory information to store it in the memory for subsequent use. The information is either processed into the short term memory or long term memory if the information is used and practiced. Traditionally, teaching and learning are typically teacher-centered or orientation. Teaching in such mode was purely a transfer of information that helped the learners in memorizing learning's materials with the sole objective to pass examinations. The students or learners are not concerned with knowledge construction and applications. As such, the critical challenge for the educators is how to provide a learning environment that encourages and motivates learners to recognize the important concept of *meaningful learning*.

In this article, the authors suggest another learning approach. The approach utilizes web-based concept mapping as an instructional strategy and establishes an object-based constructive learning environment that promotes meaningful learning by embodied intelligent agent. The objective of this approach is to allow a learner to control the learning path, pace and/or contingencies of instructions. The approach also aims to help the learner to integrate concepts in new material with cognitive structures from previous knowledge. In the following sections, the theoretical discussion on how the concept mapping and learning objects could be used in computer supported constructive learning environments is presented. In addition, the paper also discusses how embodied intelligent agent can be used to improve learner retention, completion rate, and learner satisfaction.

Concept Mapping as an Instructional Tool

Concept mapping as an instructional tool was initially proposed by (Novak & Gowin, 1984). It is a technique for representing knowledge in graphs as networks of concepts. Networks consist of nodes and links. Nodes represent concepts and links represent the relations between concepts (Turns & Atman, 2000). The learners could use the characteristics of hyperlinks to navigate the nonlinear connections and search for different paths between the nodes to explore the contents in whatever order desired (Kommers & Lanzing, 1997; Rautama, Sutinen, & Tarhio, 1997) to assist learners in seeking out the "big picture" of the domain of the subject.

The Institute for Human and Machine Cognition (IHMC) at the University of West Florida has led a multi-year initiative on the development of tools in order to empower experts to directly construct knowledge models, through the process of concept mapping. IHMC (IHMC, 2005) CMAP Tools has been used for knowledge acquisition and knowledge sharing to create the sample of concept map shown in this paper. The tools facilitate the linking of a concept to other concept maps, pictures, images, audio/video clips, text documents, Web pages, etc. This enables users to navigate to relevant resources by browsing through concept maps.

Extensive research has been done in the area of understanding Concept Maps and their use as an educational tool, curriculum and pedagogical designs. There are numerous applications for concept maps including teaching (Darmofal, Soderholm, & Brodeur, 2002; Maguitman, Leake, & Reichherzer, 2005; Nuutinen & Sutinen, 2003), assessing student understanding and evaluating the effectiveness of a program (Larranaga, Rueda, Elorriaga, & Arruarte, 2002; Turns, Atman, & Adams, 2000; Walker, King, & Cordray, 2003; Willson, Williams, & Adamczyk, 1994), improving creative thinking (Darmofal et al., 2002), brainstorming ideas in education discipline and as a tool to support the design of instructional material (Turns & Atman, 2000).

Learning Objects as an Instructional Content

With the explosive growth of computer technologies, Internet and the World Wide Web, the phenomenon has spawned the development and extensive use of learning objects as a new approach to resource sharing among educators. According to Learning Technology Standards Committee (LTSC, 2000), learning objects are self-contained, modular pieces of course material appropriately annotated with metadata either in digital or non digital form which can be used or reused or referenced to support learning activities. They may be combined to form larger educational instructional content. As time passes, it has been suggested that object-based technologies will replace traditional instructional design approaches. More and more instructional contents have been developed specifically to be deployed as learning objects in multiple learning contexts. This is due to the potentials of learning objects and their characteristics of reusability, interoperability, discoverability, and manageability (CEMA, 2001; Singh, 2000).

Currently, there are many initiatives in building metadata to facilitate search, retrieval, and use of learning objects by learners or automated software processes. Examples of existing metadata standard are IEEE LTSC Learning Object Metadata (LTSC, 2000), Dublin Core Meta-data

(DublinCore, 1999) and IMS Metadata (IMS, 2001).

In this study, based on the object-based lesson framework proposed by Siong Hoe (Siong Hoe, 2002), a course can have as many chapters, lessons, and topics as required as shown in Figure 1. This course hierarchy and lesson plan structure is similar to any traditional learning approaches. The objective is to ensure that instructional designers are aware of all the factors and elements governing a lesson. From the lowest course hierarchy, each topic consists of two major components: Learning Strategies and Learning Contents. The Learning Strategies component consists of three pedagogy elements: Learning Objective, Introduction, and Summary, which are integrated in every lesson to provide complete and effective instructional knowledge. The Learning Content component consists of: Content page, Activity page, and Assessment page, which are the learning objects used by the learners to achieve the learning objectives.

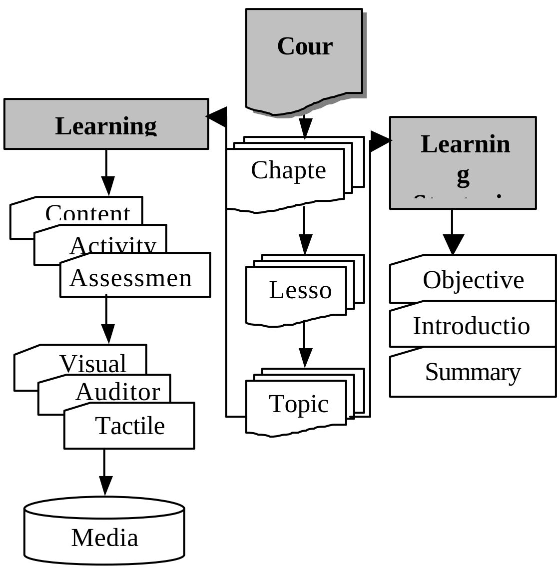

Figure 1: Course Hierarchy

Embodied Intelligent Agent

In the construction of embodied agents capable of expressive and communicative behaviors in the e-learning environment, an important factor is the ability to provide modalities and conversational facial expressions on synthetic faces. For example, animated interface agents are now being used in a wide range of application areas, including personal assistants, e-commerce, entertainment, and e-learning environments. Baldi (Massaro, 2003) for instance is a 3D talking head with accurate articulatory movements and facial expressions used for language training, in particular for autistic children and the hearing-impaired. Cosmo (Lester, Stuart, Callaway, Voerman, & Fitzgerald, 2000) is a pedagogical agent particularly keen on space deixis and on emotional behavior. Smiley (Okonkwo & Vassileva, 2001) is an animated agent used in a simple courseware to provide feedback to the students based on their progress in training. Steve (Johnson, 2000) is designed to interact with students in networked immersive virtual environments.

Aini (MBR, 2004) is another 3D animated intelligent agent which has been employed and has the ability to improve services by reducing reliance on live agents to provide the answers and information to service inquiries in e-commerce (Sing & Fung, 2003) and e-medicine (Sing, Fung, & Ph'ng, 2005) applications. In this experiment, Aini has incorporated personalization techniques in the e-learning environment by using technologies such as profile recognition, user configuration, click stream analysis, human touch interface, live interaction, multilingual knowledge base support, segmentation or rules based personalization and collaborative filtering. The 3D intelligent avatar used to represent autonomous ('intelligent', 'mobile' and 'constructive') agents and is intended to function as the mediator between agents and students.

Framework of the Proposed Learning Environment

In this study, we propose the use of concept mapping as an instructional tool to present the instructional contents which have been expressed in the forms of learning objects to provide a constructive learning environment. For example a Digital Systems course contains groups of concepts, which are typically divided into various chapters and lessons as shown in Figure 2.

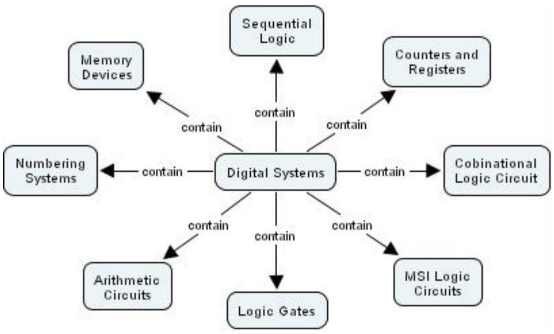

Figure 2: Digital Systems Courses Layout

Based on the course layout in Figure 2, each chapter contains a collection of lessons and topics which represent the knowledge or concepts to be learnt by the students. For example, the chapter on Logic Gates is composed of Basic Logic Gates and Other Logic Gates knowledge domains. Each of this knowledge component consists of various topics, such as AND Gate, OR Gate and NOT Gate as shown in Figure 3.

This hierarchical arrangement allows the representation of structural relations between course-chapter, chapter-lessons, lessons-topics, and topics-learning objects connections. In Figure 3, for example, logic gates (chapter) *is_part_of* digital systems (course) content. Relation **lessons-lessons** (basic logic gates and other logic gates) is interpreted as *is_a_component_of*. Similarly, for **lessons-topics** relations (such as AND gate and basic logic gates or NOT gate and basic logic gates) are interpreted as *is_a_type_of*. Then, at the lower subordinate level of the map, there are a variety of nodes interconnected either 'vertically' or 'horizontally' to the related concept(s). These nodes comprise learning contents (content, activity and assessment) and learning strategies (learning objective, introduction and summary) to facilitate learners' understanding of logic gates concepts. By looking at this concept map, the learner will have a macro view of the fundamental concepts to be learned in the digital systems course covered in the subject matter.

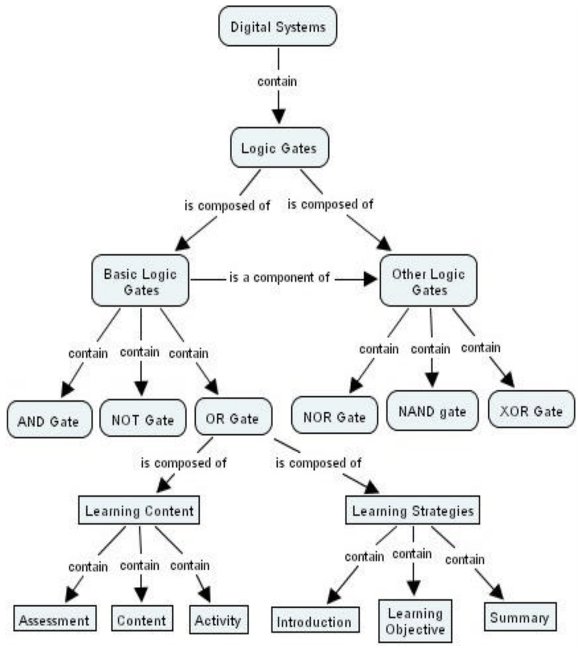

Figure 3: Digital Systems Concept Map

Implementation in the e-Learning Portal

An implementation allows software agents to support learning activity services in learning spaces. The proposed implementation uses the idea of knowledge portals in Figure 4 to support a body of domain knowledge and allows the knowledge to be selected for personalized learning needs. For example, material on Digital System is organized as a network shown in Figure 3. It divides knowledge into five levels and the final level is a learning object which consists of learning content and learning strategies. A learner can begin at one concept and then follows the links to see how the concept fits into the wider context.

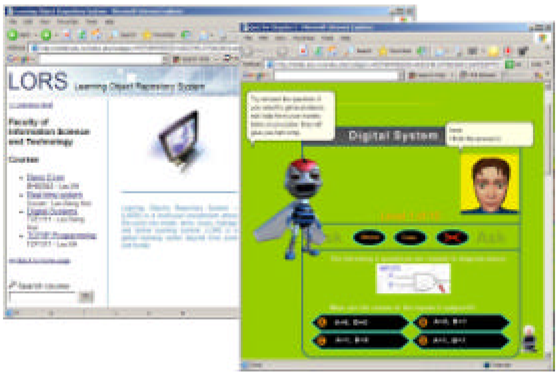

Figure 4: An Integrated Learning Object and Concept Maps Embodied Intelligent Agent in the proposed e-Learning Portal

A software agent given a learning goal will select the best commencing point in such a network and sets up an interface. On selecting a concept or process step, the student is assisted with a description and the student can then follow up with the subsequent self-learning services.

The main objective of this experiment was to determine whether adopting intelligent agent techniques improves the learner retention, completion rate, and learner satisfaction, and to reduce the learning time. To satisfy those needs, the agents must perform as a mentor with interchange tasks as peer or tutees depending on the learning progress and to provide help as needed. A mentor should not be an authoritarian figure (Driscoll, 2000), but rather a guide or coach with advanced experience and knowledge that can work collaboratively with the learners to achieve goals. Thus, the agent as mentor should demonstrate competence to the learner while simultaneously developing a social relationship to motivate the learner (Baylor, 2000) .

Basically, an intelligent agent is a collection of computer programs that employ artificial intelligent (AI) techniques to provide assistance to facilitators dealing with facilitation tasks as well as to participants dealing with completing assignments. It is possible that students will prefer embodied intelligent agent with customizable avatars because this provides the student with an alternative means of interaction. In particular, the agent can behave as someone who identifies or have empathy with the student.

The agent therefore plays an important role in monitoring discussion content in order to provide context sensitive help. The performance-based student model provides a basis for the retrieval of appropriate materials suitable to the student's knowledge state. Agent will determine the needs of students. Based on the student model and the keywords in the chat box, agent retrieves instructional materials based on design patterns when the student requests for it. Our system is a fully automated Internet-based learning system which holds the conversations with students in natural language and that simulates the discourse patterns of human mentor and some ideal learning strategies. In addition, the system also was designed to be an intelligence conversational partner that speaks, comprehends and able to act with emotion recognition.

In summary, this approach provides flexible learning environment to the learners so that they could acquire vivid mental images for any given module or sub modules. The learner can customize the learning path based on their learning needs. Each learning object presented in the concept map stands alone and links to other related topics to provide intrinsic meaning for each module.

Conclusion

Today's learning environment focuses on student-centered approach, whereby educators provide a self-directed learning environment to encourage and motivate the concept of meaningful learning. We believe this approach would provide a better approach to complement and supplement the learners' needs during the learning process.

This paper presents an ongoing research project on object-based approaches to e-learning. It is being investigated as part of a larger project. Results from the most recent study have indicated that the object-based learning with concept mapping embodied intelligent agent as described in this paper, is more promising than any other relationship schemes for both teaching and learning. The proposed architecture relies on the functionality of embodiment: the conversational protocols and conversation agent, the representations that are carried by embodied behaviors in the teaching learning process. In the future, we hope to improve the intelligence conversation embodied intelligent agent facility by incorporating advances in natural language understanding approach and network-based advanced reasoning to simulate human conversation in the object-based learning environment.

References

Baylor, A. L. (2000). "Beyond butlers: Intelligent agents as mentors". *Journal of Educational Computing Research, 22*(4), 373-382.

CEMA. (2001, 2 June 2005). *Learning Architecture Learning Objects Overview*. Computer Education Management Association. Retrieved, from the World Wide Web: http://learnativity.com/lalo.html

Darmofal, D. L., Soderholm, D. H., & Brodeur, D. R. (2002). *Using Concept Maps and Concept Questions To Enhance Conceptual Understanding*. Paper presented at the ASEE/IEEE Frontiers in Education Conference, Boston, MA.

Driscoll, M. P. (2000). *Psychology of Learning for Instruction*: Allyn & Bacon.

DublinCore. (1999, 30 June 2005). *Dublin Core Metadata Element Set, Version 1.1: Reference Description*. Retrieved, from the World Wide Web: http://dublincore.org/

IHMC. (2005). *IHMC CmapTools*. "Institute for Human Machine Cognition. Retrieved", 23 May 2005, from the World Wide Web: http://cmap.ihmc.us/download/index.php

IMS. (2001). *IMS Global Learning Consortium, Inc*. Retrieved, 30 June 2005, from the World Wide Web: http://www.imsproject.org

Johnson, W. L., et al. (2000). "Animated Pedagogical Agents: Face-to- Face Interaction in Interactive Learning Environments". *International Journal of Artificial Intelligence in Education, 11*, 47-78.

Kommers, P., & Lanzing, J. (1997). "Students' concept mapping for hypermedia design: Navigation through World Wide Web space and self-assessment". *Journal of Interactive Learning Research, 8*(3/4), 421-455.

Larranaga, M., Rueda, U., Elorriaga, J. A., & Arruarte, A. (2002). *Using CM-ED for the Generation of Graphical Exercises Based on Concept Maps*. Paper presented at the International Conference on Computers in Education (ICCE'02).

Lester, J. C., Stuart, S. G., Callaway, C. B., Voerman, J. L., & Fitzgerald, P. J. (2000). "Deictic and emotive communication in animated pedagogical agents". In J. Cassell & J. Sullivan & S. Prevost & E. Churchill (Eds.), *Embodied Conversational Agents*. Cambridge, MA: MIT Press.

LTSC. (2000). *Learning Technology Standards Committee*. Retrieved, 30 June 2005, from the World Wide Web: http://ltsc.ieee.org

Maguitman, A., Leake, D., & Reichherzer, T. (2005). *Suggesting novel but related topics: towards context-based support for knowledge model extension*. Paper presented at the 10th international conference on Intelligent user interfaces, San Diego, California, USA.

Massaro, D. W., et al. (2003). *Development and Evaluation of a Computer-Animated Tutor* *for Language and Vocabulary Learning*. Paper presented at the 5th International Congress of Phonetic Sciences.

MBR. (2004). *1st Malaysian Robotic Interactive Programme, The Malaysia Book of Records (MBR), A Tribute to Tun Dr. Mahathir Mohamad* (Gold ed.): R&D Communication Sdn Bhd.

Novak, J. D., & Gowin, D. B. (1984). *Learning How to Learn*. New York: Cambridge University Press.

Nuutinen, J. A., & Sutinen, E. (2003). *Visualization of the learning process using concept mapping*. Paper presented at the 3rd IEEE International Conference on Advanced Learning Technologies (ICALT'03).

Okonkwo, C., & Vassileva, J. (2001). *Affective Pedagogical Agents and User Persuasion*. Paper presented at the Universal Access in Human-Computer Interaction.

Rautama, E., Sutinen, E., & Tarhio, J. (1997). "Supporting learning process with concept map scripts". *Journal of Interactive Learning Research*, *8*(3/4), 407-420.

Sing, G. O., & Fung, C. C. (2003). "Intelligent Agent Technology in E-Commerce". In J. Liu & Y. Cheung & H. Yin (Eds.), *Intelligent Data Engineering and Automated Learning, LNCS,* (Vol. 2690, pp. 10-17): Springer-Verlag.

Sing, G. O., Fung, C. C., & Ph'ng, L. M. (2005). "Intelligent Agents for an Internet-based Global Crisis Communication System". *Journal of Technology Management And Entrepreneurship*, *2*(1).

Singh, H. (2000). *Achieving Interoperability in E-learning*. ASTD Learning Circuits. Retrieved, 3 June 2005, from the World Wide Web:http://www.learningcircuits.org/mar2000/singh.html

Siong Hoe, L. (2002). *Conceptual Model of Reusable Object-based e-Learning*. Paper presented at the European Conference on e-Learning (ECEL'02), London.

Turns, J., & Atman, C. J. (2000). "Concept maps for engineering education: A cognitively motivated tool supporting varied assessment functions". *Transaction on Education,*, *43*(2), 164-173.

Turns, J., Atman, C. J., & Adams, R. (2000). "Maps for Engineering Education: A Cognitively Motivated Tool Supporting Varied Assessment Functions". *IEEE Trans. on Education*, *43*(2), 164-173.

Walker, J. M. T., King, P. H., & Cordray, D. S. (2003). *The use of concept mapping as an alternative form of instruction and assessment in a capstone biomedical engineering design course*. Paper presented at the ASEE Annual Conf. and Expo, Nashville, TN.

Willson, M., Williams, D., & Adamczyk, P. (1994). "Evaluating Science INSET through Concept Mapping". *British Journal of In-service Education*, *2*(1), 121-130.