Journal of Theoretical and Applied Information Technology
10th July 2013. Vol. 53 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

OAMS - A GAME BASED ONLINE FORMATIVE KNOWLEDGE ASSESSMENT SYSTEM USING CONCEPT MAP

[1]KUMAR R, [2]SARUKESI K & [3]UMA G V
[1]Rajalakshmi Engineering College, Chennai, India
[2]Hindustan Institute of Technology & Science, Chennai, India
[3]Anna University, Chennai, India
E-mail :[1] rkumarnkl@gmail.com

ABSTRACT

The modern age of education has started to change the dynamics of design of assessment systems in a big way. The *e-learning* and *Mobile-learning* setups have opportunities to introduce new solutions that can automatically understand user intent which are the need of the hour for 21st century learning environments. To add to this, a novel approach for formative knowledge assessment (FKA) has been proposed and developed. A novel Concept Map and Game Theory based Assessment System OAMS has been proposed. OAMS is short form of **O**nline **A**ssessment **M**anagement **S**ystem and it has been tailored as a game based on Concept Map (CM) using a Modified Extensive Game Theory (MEGT). This system imposed demands such as definition of game notions, strategies for game, formative knowledge assessment system and feedback construction. This paper discusses the architecture of the OAMS and design of proposed games in detail. Two assessment tasks have been proposed; (i) Collapsed Concept Map Game (CCMG) and (ii) Concept Tree Game (CTG). An experiment has been conducted to test the CCMG approach. The experimental results show that the approach has been found useful for the learners as well as educators.

Keywords: *Knowledge Assessment, Concept Map, Game Theory, System Design*

1. INTRODUCTION

The Internet and World Wide Web provide huge opportunities to develop and deploy sophisticated online learning tools in the form of web-based educational applications. Nowadays there are several types of Learning Management Systems (LMS) available for educational institutions. Most of the LMS are web based applications addressing every element of a typical educational setup from course management to assessment.

Assessment is a very important process which aids the educators to gauge their students' level of understanding on a topic taught or learnt. Especially, Formative Knowledge Assessment is regarded as a very effective tool in the modern educational setups. Generally FKA is being done periodically during course in order to monitor the progress of students in terms of the acquired knowledge. This essentially helps the educators to plan or alter their lesson plan.

Concept map is a visual knowledge representation tool that helps to reflect the knowledge structure of the students. Novak [8] first proposed concept map in 1972 to assess and analyze the knowledge of school children. CM was developed based on Ausubel's assimilation theory which argues that learning happens by adding new concepts and propositions (knowledge) into student's existing knowledge. Novak and Canas [7] argued that "meaningful learning is a necessary prerequisite for developing individual's conceptual understanding". CMs represent knowledge in the form of a node and arc kind of diagram in which labeled nodes represent concepts of a knowledge domain and arcs showing relations between pairs of concepts. Proved to be effective for meaningful learning, concept maps are widely used as an aid in various educational activities such as teaching, learning (self and collaborative) and assessment. More recently concept maps have been used as an assessment tool in the classroom as well for online assessment [4,5,10,11]. A well defined framework for FKA based on CM integrated with fun and excitement in the form of a game would be good idea. Hence, OAMS has been designed to support the educators in conducting FKA periodically, using the gaming principles.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

This paper highlights the architecture of OAMS and proposed game based knowledge assessment approaches. OAMS has been designed as a web-based application through which the students have been made to take FKA periodically. The following sections present an overview of CM, architecture of OAMS, the game strategies, definitions of notions, a modified extensive game theory (MEGT) model, the assessment tasks identified for this system, the experimental results of CCMG approach and conclusion.

2. BACKGROUND

During the late 1990s the importance of FA was proposed [1] and FA is widely used in educational setups in order to ensure effective learning. Educators in higher education can use FA to help the students to learn effectively as it helps them to gauge the level of understanding of one student during the learning process.

Black and William [1] define Formative Assessment (FA) as "all those activities undertaken by teachers, and/or by students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged". There are several other definitions for FA [2] which discussed about the process of gauging the knowledge of students periodically with feedback on performance. Crooks[3] calls it as “Diagnostic Testing”, and defines it as “a range of formal and informal assessment procedures employed by teachers during the learning process in order to modify teaching and learning activities to improve student attainment”. FA tools and assessment outcomes provide a clear picture about the learning that took place among the students.

Nowadays, Game–Based Learning (GBL) approaches with interactive multimedia in much familiar in the modern learning environments. Many researchers suggest game theory based learning and assessment which motivates the learners to actively participate and learn and on the other hand, enables educators in providing interactive learning contents. It is evidenced that the future learning setups especially e-learning and m-learning will have game based learning applications in the near future. Wang [10] developed a web-based formative assessment system, named GAM-WATA based on quiz and multiple choice questions. The uniqueness of the design of system was a approach based ‘Ask-Hint Strategy’. The assessment turned into an online quiz game. During this study, different types of FA had been adopted and the e-Learning effectiveness of the students in the GAM-WATA group was found to be better than the others.

A survey [5] on usage of CM as a FA tool provides a broad understanding of CM, its effectiveness and usefulness in the educational settings like traditional, e-learning and m-learning. CM is regarded as visual knowledge representation tool which involves the use of graphical tools for organizing and representing knowledge [7] to improve student learning. CM has been used mainly as an instructional tool in the classrooms until recently. CMs have been used as instructional tools to encourage students’ learning and there has been several research studies conducted on the use of concept mapping as a technique for knowledge assessment [5]. However, in these studies, concept mapping had been used for summative purposes. Theoretically, the power of concept mapping lies in its ability to facilitate students to reflect their knowledge, understanding and skills. Hence the maps created are interpreted by the teachers, and observations are made about learning. However, more time consumption while creating maps had been reported as major setback. Further, the difficulty in developing concept maps has been reported in many studies as this task requires students to demonstrate higher level skills of synthesis. This is considered as a disadvantage of using CM as a formative assessment technique. This study therefore attempted to fill this gap identified in the literature. For the purposes of this study, a formative knowledge assessment approach using CM and a Modified Extensive Game Theory (MEGT) has been defined, developed and tested.

The authors have proposed a game theory based FKA framework called OAMS [6]. OAMS has been developed as a web-based application based on the gaming and concept mapping principles.

3. ARCHITECTURE OF OAMS

The architecture of the OAMS is displayed in Figure 1. It has three conceptual elements: the database server, the client application and the application server. The architecture is implemented by using the following technologies: Eclipse Juno, Apache Tomcat, MySQL, JDBC drivers and Java Swing. Apache had been chosen as web server which is a container of servlets. A servlet is a small Java interface, which runs within a web server.

Journal of Theoretical and Applied Information Technology
10th July 2013. Vol. 53 No.1

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

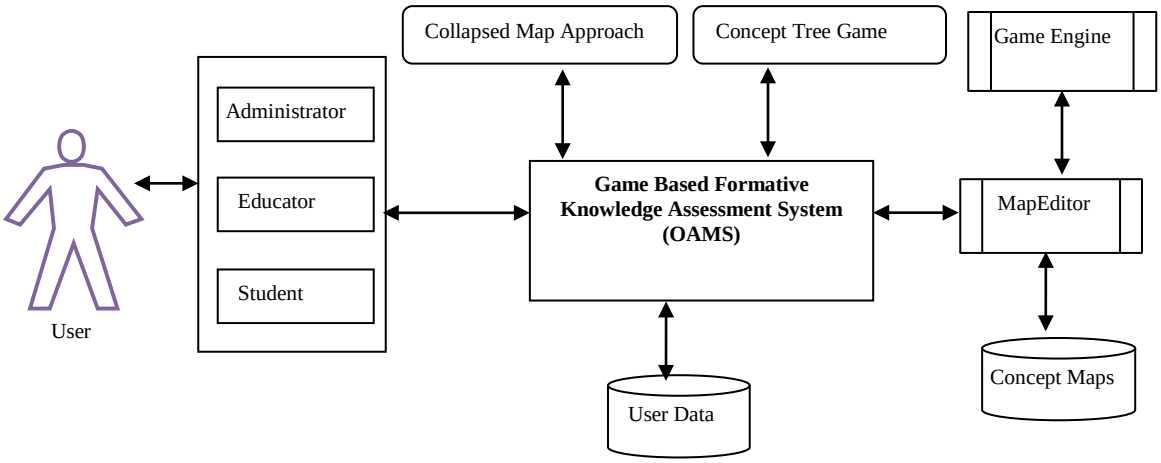

Figure.1: Framework of OAMS

Servlets receive clients' requests and respond to them across Hyper Text Transfer Protocol. A servlet is used to extend the capabilities of servers that host applications accessed via a request-response programming model. Although servlets can respond to any type of request, they are commonly used to extend the applications hosted by Web servers.

Eclipse Juno is a familiar IDE for java based web applications. Juno is based on the Eclipse 4.x platform. Eclipse Juno[14] includes a compatibility layer that allows existing Eclipse plug-ins and Rich Client Platform (RCP) applications to work on the new platform. To deploy and run a Servlet, a Web container must be used. A Web container[12] is a component of a Web server that interacts with the servlets. It is responsible for managing the lifecycle of servlets, mapping a URL to a particular servlet and ensuring that the URL requester has the correct access rights. Apache Tomcat [13] is an open source web server and servlet container developed by the Apache Software Foundation (ASF). Tomcat implements the Java Servlet and the JavaServer Pages (JSP) specifications, and provides a "pure Java" HTTP web server environment for Java code to run. Apache also supports PHP and MySQL for web applications to be hosted.

MySQL has been popular because of many good reasons; MySQL is open-source RDBMS software and a very powerful program which can handle a large subset of the functionality of the most expensive and powerful database packages. MySQL can also work on many operating systems and with many languages. More importantly MySQL is customizable. The open source GPL license allows programmers to modify the MySQL software to fit their own specific environments.

The application on the client side implements both conceptual layers i.e. client functionalities, panels, CmapEditor and other components of the user interface and models, which manage views by relating them to data. The user's actions in the user interface like pressing of buttons, entering text into a text field, viewing assessments, editing profile, creating maps and others are examples for events. The client application handles different events and calls services of the application server. Called services are executed remotely on the application server, which acts as a controller. Implementations of methods are stored on the application server and the client side does not know anything about them. Thus direct connections between the database and the client application are eliminated, which prevents the system from an unauthorized access.

The web server receives remote calls from the client and redirects them to the appropriate servlet. The information about a servlet is included in the remote call. The servlet handles a call and launches the appropriate method needed for the communication with the database or for the execution of event. The server does not use MySQL queries to perform data manipulations. The application is secure enough because the database server is opened for connections only from the server and this will not allow any other person from outside to access the data directly.

3.1 CmapEditor

CmapEditor is a java servlet program written for providing the users with concept mapping

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

functionalities using a predefined canvas. The included functions are; add node, add relationship, drag a node, drop node, change the relationship label, change the node's label, change the start and end point for the link. This editor allows the educators to create concept maps for the topics and store them into the database. Also, it allows students to view the assessment task in the form of collapsed map and facilitate them for reordering the concepts and relations. Further, it acts as the gaming zone or field.

4. KNOWLEDGE ASSESSMENT TASKS OF OAMS

The OAMS has been designed to perform two assessment tasks which are basically game based approaches using CMs. (i) Collapsed Concept Map Game (CCMG) and (ii)Concept Tree Game have been defined as the identified assessment tasks of the system. A brief description of the processes involved in each task has been presented below;

1. Collapsed Concept Map Game

Collapsed Concept Map Game (CCMG) is a simple game based assessment approach for formative knowledge assessment. The idea behind this game is to present the educators CM by randomly shuffling the concepts and relationships in the map. Hence, it is strongly believed that the students made to apply their learning or knowledge acquired during the learning process to reorder or rearrange the concepts and relationships. For reordering the concepts and relationships the drag and drop feature is helpful. For changing the relationship, the start and end points of the link has to be modified. The reordered map will certainly reflect the understanding of the student on the topic selected for assessment. The reordered map is compared with the original map. This approach is designed to give automated feedback to the students based on the performance on the assessment task. A collective analysis will be sent to the educator on the performance of all the students on the specific topic chosen.

For simplicity of the approach the concepts and relationships have been collapsed using random approach. An algorithm has been developed for this randomly collapsing the concepts and relationships of the map chosen for assessment. However, there are several questions to be addressed:

- What methods will allow the system to determine which concepts are to be collapsed?
- How does the system know when the learner has met difficulties?
- Whether the system should track multiple attempts made (number of moves) for a specific concept
- What should the system do with concepts which the learner has incorrectly ordered a concept map?

The system has to be explored further to address the above issues in order to solve them and make the system more intelligent.

2. Concept Tree Game

Concept Tree Game is based on the extensive game theory which is tree structured game. Each move in the tree among nodes will gain a predefined playoff to the player. The EGT is normally a game of multiple players from minimum *two* players up to maximum *n* players. CTG is defined as a two player game to be played by adding concepts as nodes to the tree and relationships as links between nodes. The following sections briefly describe the processes involved in the game.

As the CMs are generally hold hierarchical structure when representing the knowledge [8], it is very easy to incorporate the game theory strategies with slight modifications and improvements on the original EGT. The extensive game form theory proposes to have minimum of two players and maximum *n* number of players. Initially, it has been decided to have two players in this model.

Table 1. Definitions of Concept Tree

• The game is a tree construction game
• Number of players: two
• Addition of each valid vertex (or node as concept) gets a point of choice for a player.
• Addition of each valid link (or arc as relationship among concepts) gets a point of choice for a player.
• Each node or line represents a set of possible action for the players.
• The scores (payoffs) are specified at the end of every move.
• The final scores are specified at end of the game along with the feedback.

Players will be the students who are to take the assessment. The term Vertex of the tree represents a node of CM and can be replaced with labeled node

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

(concept) and the unlabeled lines or arcs has been used as labeled arcs (relationship among any two concepts) as in CM. The game is based on a finite set of concepts and relations identified for a topic from the course that is being taught. The topic chosen for the FKA must be taught very recently.

4.3 Definitions and Strategies

For simplicity and ease of modeling, the definitions of notions for finite extensive game form proposed by Sergiu Hart [7] have been used as a base for this work. The strategic game model for the CTG specifies the set of players, their allowed actions, and their preferences. In addition, it specifies the order of the players' moves and the actions each player may take as next move. In this study, the number of players is two, their allowed moves are {c, r, s, cl, egl, q} where as the actions are { addnode, addrelation, addexample, skip and quit}. Every valid move will have the score as one point, link and example, two points for a crosslink.

The first move of the game is identified with a distinguished node called the *root* of the tree. The nodes represent the possible moves in the game and can be terminal or non-terminal. If a node is said to be terminal node if it holds an example from the topic chosen for assessment, then the players will not be allowed to continue further from that node by adding a new concept under it. The path ends at such a node with a specific outcome. If a node is non-terminal, then it can be chosen by the player, who has to act at that move. The edges leading away from a node represent the choices or actions available at that move (add relation).

Table.2 Descriptions of moves allowed

Move	Description of the Move
c	Allows player to add concepts in the node of tree
r	allows player to add relationship label to the link
s	allows player to skip the action
cl	allows player to add crosslink among nodes
egl	allows player to add example to the leaf node
q	allows player to quit the game

3. Formal Definition of Concept Tree

As mentioned earlier, this game is based on the EGT. A detailed study to explore the basics of EGT was carried out. After careful analysis, a modified EGT model which is finite in terms of nodes and relations has been designed and considered for the game. An attempt to define the notions formally was performed and notions that have been considered for this study are described and presented in table.3. The EGT has been proved by many game theorists; hence, proving this model may not be necessary. However, further studies in this direction would be thoughts for future research.

5. EXPERIMENT AND RESULTS

In order to evaluate OAMS based on its functionality and acceptance, a qualitative study had been carried out. A group of 33 students from a post graduate level course had been involved in this study as participants and the authors of this paper acted as researchers. An assessment from the course electronic commerce had been chosen and added to the system. For initial study purpose the CCMG approach alone had been considered for this experiment. A CM for the chosen topic had been added to the system by the researchers.

Table 3. Definitions of the game notions

- Let the game players be two
- Let the game be Concept Tree Game
- Let $C = \{c_1, c_2, \ldots, c_g\}$ be a set of concepts
- Let $R = \{r_1, r_2 .. r_h\}$ be a set of relationships
- Let $P = \{P1=0, P2=0\}$ be playoff scores ; for each valid move where every *c* and *r* will get 1 point added to the score
- A tree over *C* and *R* is a set $CT \subseteq C$ and of nodes $n \in C$ such that: if $n = n'c \in CT$, then $n' \in CT$ *and* Pi=Pi+1, similarly, the links $y \in R$ such that: if $y = y'r \in CT$, then $y' \in CT$ *and* Pi=Pi+1
- For a node $n \in CT$, the children of *n* are $ch(n) = \{n' \in CT \mid n' = nc$, for some $c \in CT\}$
- For a link $y \in CT$, the children of *y* are $ch(y) = \{y' \in CT \mid y' = yr$, for some $r \in CT\}$
- For n $\in CT$, let $Act(n) = \{c \in C \mid nc \in CT\}$ be the "actions" available at node *n*.
- For $y \in CT$, let $Act(y) = \{r \in R \mid yr \in CT\}$ be the "actions" available at link *y*.
- A leaf (or terminal) node n ∈ CT is one where ch(n) = ϕ. Let LCT = {n ∈ CT | n a leaf}.

Then the system sent automatic e-mail notifications to the registered participants with basic guide lines for the assessment task like start date, end date etc. The participants then logged in to the system, viewed the assessment and took the assessment. Based on the performance during the assessment task the participants had been provided with the score and feedback. The score had been calculated as follows; every correct positioned concept (node) will be assigned with one point and the same for relationship. This has been achieved by comparing the participants' reordered map with

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

the researchers source map. The comparison is a structural comparison i.e. node to node and relationship with relationship between selected pair of nodes. The feedback has been given based on the performance.

At the end of the task, a survey questionnaire has been given to the participants. The questionnaire included questions on the perceived acceptance of the participants and their experience. The response on the questionnaire has been presented below in table 4.

Table 4. Response To The Survey Questions

SDA = Strongly Disagree; DA = Disagree; NANDA=Neither Agree Nor Disagree; A=Agree; SA=Strongly Agree

Survey Question	SDA	DA	NANDA	A	SA
This CCMG approach made the assessment activity more interesting than the traditional tasks	0.0	0.0	6.1	45.5	48.4
I think this approach can help me view the contents from a new perspective	0.0	6.1	6.1	63.6	24.2
I like the CCMG approach adopted in this assessment activity.	0.0	0.0	12.1	54.5	33.3
I expect to assess my learning on other subjects with this approach.	0.0	0.0	9.1	63.6	27.3
I think this learning approach makes me to understand where I am	0.0	0.0	12.1	54.5	33.3
The feedback given helped me to improve my learning	0.0	0.0	21.2	45.5	33.3

From the analysis of the survey response, it is learnt that the majority of the participants expressed that the approach is quite impressive and interesting. Many participants mentioned that they are excited to have this kind of game based assessment task. The perceived acceptance is represented by close to 94 %, of the participants. Hence, this can be concluded that the participants have accepted this system of game based assessment. 91 % of participants responded that they are willing to use the system for further assessments. The responses to other questions were represented with a high degree of acceptance. However, the responses to the question on the use of feedback with a percentile of 21.2 % against NANDA thus indicated that the participants have reflected the dilemma of not being able to decide the usefulness or other factors pertaining to the feedback. Hence, further studies needed to explore and analyze the causes.

6. CONCLUSION

This paper reports the development of a web based formative assessment system using CM and MEGT with an advantage to present the learners with tasks appropriate to assess their knowledge level. CM had been successfully used as a core element of assessment system incorporated with game theory. Authors believe that usage of MEGT over the maps provides possibility to issue tasks with different topics to assess the knowledge acquired. At the moment the analysis of the described formative knowledge assessment using MEGT and CM is at its early stage. A study towards designing a new FKA tool was carried out. The model based MEGT and CM was defined, designed, developed and was successfully tested. Further, based on the positive findings of this study, the authors confirm that some of the assumptions proposed earlier were realistic. The proposed OAMS shall;

- make the students take the assessment actively
- create positive attitude towards effective learning
- help the professors to assess the level of the knowledge of students in stages
- help to increase students' understanding on the course topics
- help to motive students on collaborative learning and knowledge sharing

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Future research pertaining to this study would be to conduct studies in order to further analyze on the impact of the model in various aspects. The preliminary results of the study were encouraging towards further developments.

REFRENCES:

[1] Black, Paul, Wiliam, Dylan. "Assessment and Classroom Learning". *Assessment in Education: Principles, Policy & Practice* 5 ,1998,1.

[2] Cowie, Bronwen, Bell, Beverley. "A model of formative assessment in science education". *Assessment in Education* 6: ,1999,101–116.

[3] Crooks, T. The "Validity of Formative Assessments". *British Educational Research Association Annual Conference, University of Leeds*,2000.

[4] Kumar R, Sarukesi K, Uma G V, "Assessment of Understanding using Concept Map: A Novel Approach", International Journal of Computer Applications, Volume 54 No.4, September 2012

[5] Kumar R, Sarukesi K, Uma G V, "Exploring Concept Map and Its Role As Knowledge Assessment Tool (2009-2012)", International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 2, Issue 4, April 2013 PP: 1534-1540

[6] Kumar R, Sarukesi K, Uma G V, "A Framework for Formative Knowledge Assessment System", International Journal of Scientific Research, Volume: 2, Issue 5, May 2013, pp: 242-244

[7] Novak, J. D. & Canas, A. J. "The Theory Underlying Concept Maps And How To Construct And Use Them". Technical Report IHMC CmapTools. Florida, Institute for Human and Machine Cognition.,2008.

[8] Novak, J. D. & Gowin, D. B. *"Learning How to Learn"*. New York, NY: Cambridge University Press. 1984

[9] Sergiu Hart, "Games in Extensive and Strategic Form", Chapter 2 of Handbook of Game Theory, Vol I., 1992

[10] Wang, T. H.. "Web-based quiz-game-like formative assessment: Development and evaluation". *Computers & Education, 51*(3), 2008, 1247-1263.

[11] Ruiz-Primo MA, Shavelson RJ (1996) "Problems and issues in the use of concept maps in science assessment". J. Res. Sci. Teaching 33 (6) : 569-600

[12] http://www.java-books.us/servlets.php

[13] https://en.wikipedia.org/wiki/PHP

[14] http://www.sitesetter.info/2012/07/eclipse-juno-release-makes-java.html