CHAPTER 5

METHODOLOGY FOR ONLINE FORMATIVE KNOWLEDGE ASSESSMENT

In the software context, a Framework is known as a basic structure underlying a system which acts as guideline to software development. It facilitates the developers by providing concepts, description, procedures about the functionalities and processes of the system that is designed. The proposed OFKA methods are simple games that utilize gaming principles and extensive game theory. The following sections discuss the underlying concepts and algorithms of the proposed OFKA methods. The basic functionalities, notions and algorithms of both CCMG and CTG methods are discussed elaborately.

5.1 METHOD 1: COLLAPSED CONCEPT MAP GAME

The Concept Map (CM) is widely used for representing the internal memory structure of human beings. According to Novak (1993), meaningful learning is the process of adding of new concepts and propositions into a hierarchically arranged framework in cognitive structure. Novak’s argument is based on the assimilation theory proposed by Ausubel (1968). This meaningful learning subsumes more specific, less inclusive ideas under more inclusive concepts and propositions in cognitive structures.

The idea of Collapsed Concept Map Game (CCMG) method is to utilize concept mapping for online formative knowledge assessment by providing the collapsed concepts of the chosen topic through the concept
maps as a game. Anderson (2009) recommended that formative assessment should deal with the fundamental concepts that students need to know about a new topic, and how to place the basic information in its correct context.

As mentioned earlier, the CCMG is a simple concept game in which the nodes of the educator’s concept map are randomly collapsed and presented to the students. The students are expected to order the nodes (concepts) by applying their learning on the specific topic considered for the game. This idea serves as an assessment process to assess the knowledge of the students with respect to the topic chosen for the assessment. In order to motivate the students to think fast, a timer is used to record the time consumption to play the game. In addition, the timer is used to keep the students aware that they are being monitored. This might force them to avoid malpractices and perform an ethical assessment process. However, the time is not considered for analysis at this stage of the research work.

5.1.1 Framework for the Collapsed Concept Map Game Method

The following are the functionalities and steps included in the CCMG approach. The educator creates concept maps for every topic taught in the class using the OAMS. The maps are created for OFKA by identifying and defining relevant concepts and relationships among them. After the creation of the map the educator defines the assessment start and end date along with other necessary information. Once the assessment is added to the OAMS, an email notification will be sent to the students registered for that specific course. The students then login to the OAMS at their convenience and take the assessment. The students are given enough instruction and training on how to take the assessments. The students are expected to order the collapsed nodes and relationships with the help of the learning acquired during the conduct classes. A framework is developed to implement the
proposed Collapsed Concept Map Game (CCMG) and the same is presented in Figure 5.1.

This approach enables the student to use the acquired knowledge in ordering the map, thus, forces the student to recall his or her understanding on the topic. For every correct node and relationship, pre-defined points are added to the score and displayed at the end of the assessment task. The contents of the resultant map are analyzed in terms of valid nodes and relationships. For evaluating the resultant map, a simple map comparing algorithms called JSONcompare algorithm is followed. The nodes and relations of the resultant map are compared with the educator’s source map on one to one basis using the above algorithm. The results are stored into the database for future analysis. At the end of the assessment the students are provided with a feedback based on the performance. This system makes use of a simple instant feedback mechanism.

Figure 5.1 Framework for Collapsed Concept Map Game
The feedback to the educators enables them to understand the level of the learning achieved by the students and to take necessary steps in order to improve the learning where it deemed to be necessary. In case, more number of students reflected misconceptions on a same concept, then the educator must plan for remedial actions based on the feedback mechanism. Figure 5.2 presents a screenshot of CCMG on the topic chosen from Electronic Commerce course.

![Image](image.png)

**Figure 5.2  Part of Concept Map created for assessment on topic Secure E-Commerce**

In order to obtain the students’ view of this approach, a survey questionnaire is prepared and circulated at the end of the assessment. The questions are coined to obtain the participants’ view on usefulness of CCMG, the formative knowledge assessment method and usefulness of the feedback.

**5.1.2  Collapsed Concept Map Game Algorithm**

Algorithms are the step by step textual representation of a proposed solution for a given problem or task. In order to implement the CCMG approach as a software module, an algorithm was developed. As mentioned earlier, the CCMG is a simple concept game, in which the nodes of the maps
(i.e. concepts) are shuffled using a random function. The algorithm developed to implement this game is presented as below.

**Algorithm: Collapsed Concept Map Game**

**Input**: Source Concept Map

**Method**: CCMG method

**Output**: Score, Time Taken, Feedback, Source Map.

**Step 1**: Let $C = \{c_1, c_2, \ldots, c_g\}$ be a set of concepts from the student’s concept map.

**Step 2**: Let $R = \{r_1, r_2, \ldots, r_h\}$ be a set of relationships from the student’s concept map.

**Step 3**: Let $SC = \{sc_1, sc_2, \ldots, sc_g\}$ be a set of concepts from the source concept map.

**Step 4**: Let $SR = \{sr_1, sr_2, \ldots, sr_h\}$ be a set of relationships from the source concept map.

**Step 5**: Read the source map.

**Step 6**: Explore the number of concepts and relations.

**Step 7**: Initialize timer $T=0$.

**Step 8**: Initialize score $S = 0$.

**Step 9**: Collapse the nodes randomly.

**Step 10**: Load canvas & Collapsed map.

**Step 11**: Allow user to reorder the nodes.

Stop timer on submission.

Store the student map.

**Step 12**: Perform comparison of source map with student map.

For all concepts if $(C_i = = SC_i)$ then $S=S+1$.

Repeat until last node.

**Step 13**: Compute final score $S$.

**Step 14**: Generate and Display Feedback.

**Step 15**: Show the source map for reference.

**Step 16**: Exit.
The algorithm was implemented using the JavaScript and JSP. As mentioned earlier, the contents of the map are stored using the JSON structure into the database. Evaluating the student’s map is easily achieved by using the standard algorithm called JSONcompare. It compares each node and relation of the source map with student’s map on one to one basis. Based on the comparison the maps are evaluated and scored.

5.2 METHOD 2: CONCEPT TREE GAME

Concept Tree Game (CTG) is based on Concept Map (CM) and the Extensive Game Theory (EGT) which is similar to tree structured game. The EGT is normally a game of multiple players, minimum two players up to a maximum of n players. Here, the CTG is designed to have two players, Player 1 is the system and player 2 is the student who is to take the assessment. 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. The player can select one path using the allowed set of actions in the present node. The concept map constructed for the assessment is defined as Concept Tree. The idea of concept tree game is similar to extensive game tree in which a finite number of nodes and links are used. As mentioned earlier, in CTG the nodes represent the concepts at node level and links represent relationships between nodes respectively.

5.2.1 Framework for CTG Method

A framework for the proposed Concept Tree Game (CTG) is developed. At the start of the game, a tree is initialized with the root node and then used to play the game where the player constructs the tree using his knowledge on the topic chosen for the assessment game. The player is
provided with a group of concepts and relations from which he/she can select an appropriate one to make the move. The system will act as the opponent player to the student (assessee). Upon on the completion of the student’s move, the system will make its move from the allowed moves mentioned earlier. It may be an insertion of node (concept) or a relation (link) to the concept tree. Then the student will be allowed to play his or her move as per the rules. Figure 5.3 represents the framework of CTG method.

Figure 5.3 Framework of Concept Tree Game

The concepts and relations added by the player to the concept tree are compared with the source concept tree. The feedback system will generate feedback to the students based on the score. The CTG’s functionalities are defined and presented in Table 5.1.
Table 5.1 Definitions of Concept Tree

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The game is a concept tree construction game</td>
<td></td>
</tr>
<tr>
<td>Number of players permitted : two</td>
<td></td>
</tr>
<tr>
<td>Allowed actions are {addnode, addrelation, skip, quit}</td>
<td></td>
</tr>
<tr>
<td>Addition of each node (concept) gets a payoff (1 point)</td>
<td></td>
</tr>
<tr>
<td>Addition of each link (relationship) gets a payoff (0.5 point)</td>
<td></td>
</tr>
<tr>
<td>Each node or link represents a set of possible action for the players</td>
<td></td>
</tr>
<tr>
<td>The payoffs are displayed after every move</td>
<td></td>
</tr>
<tr>
<td>The final scores are displayed at the end of the game along with the feedback</td>
<td></td>
</tr>
</tbody>
</table>

Further, a timer is used to record the time consumption to play the game. The timer is used in order to keep the students aware that they are being monitored. This might force them to avoid malpractices and perform an ethical assessment process. However, the time is not considered for analysis in this research work.

5.2.2 Formal Definition of Notions in Concept Tree

The strategic game model for the CTG specifies the set of players, their allowed actions, and their preferences. In this study, the number of players are two and their allowed moves are: addnode, addrelation, skip and quit {C, R, S, Q}. Further, in addition to the payoff, every valid concept or relationship will have a predefined score (concept: 1, relation: 0.5). 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. The players will not be allowed to add new nodes under the terminal node. If a node is non-terminal, then the player is allowed to perform his move. The link leading away from a node represents possible actions
available at that move (add relation or skip). After careful analysis, a modified EGT model which is finite in terms of nodes and relations has been designed and implemented. The notions that have been considered for this work are defined and presented in Table 5.2.

Table 5.2 Definitions of the game notions

- Let the number of game players be two
- Let the game be Concept Tree Game
- Let CT be Concept Tree
- Let \( w = \{C, R, S, Q\} \) be actions/moves permitted in a node or link
- Let \( C = \{c_1, c_2, \ldots, c_g\} \) be a set of concepts
- Let \( R = \{r_1, r_2, \ldots, r_h\} \) be a set of relationships
- Let \( \Sigma = C \cup R \)
- A tree over \( C \) and \( R \) is a set \( CT = \Sigma^* \)
- 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 \( w \in CT \), let \( Act(n) = \{a \in w \mid na \in CT \} \) be the “actions” available at a node \( n \).
- For \( y \in CT \), let \( Act(y) = \{r \in R \mid yr \in CT \} \) be the “actions” available at a link \( y \).
- A leaf (or terminal) node \( n \in CT \) is one where \( ch(n) = \emptyset \) \{ \( n \in CT \mid n \) is a leaf \} \}

If a game has a finite horizon and finite actions, then it is said to be finite. CTG is defined as a finite game in which the nodes, relations and players are finite. If each player knows all actions chosen previously and moves in each node, then the game is said to be with observable actions. The player can observe the opponent’s moves and react accordingly while playing CTG. As discussed earlier, the assessment game involved actions like adding of the concept words and relationship words to the map. The players could select the actions to be performed when their move is to be played. This
situation is considered as a best suitable option to analyze the situation, on how the players take decision when it is their turn to play his move. The actions chosen by the players and their predefined payoff are discussed below.

The EGT follows a tree structure to analyze the players move and the payoffs for each move performed by the player. Most of the examples discussed in various articles, provide one shot of the game with payoff. The CTG is played as a multiple shot game in which the EGT is applied to calculate the payoff and validity score, after the validation of the moves performed by the player. For example, if the player 1 chooses to add a node to the concept tree then the pay off will be \{1,0\} as he is first to start the game. Next, the player 2 has to decide his move from the allowed moves. If suppose player 2 chooses to add a node to the tree then payoff will be \{1,1\}. An example of an extensive game tree representation of CTG, is presented in Figure 5.4.

![Figure 5.4 An Extensive Form Game Tree Representation of CTG](image-url)
It is important to note that the move performed, i.e. entering a label for concept or relation, will have to be validated and a validity score will be added accordingly as defined in Table 5.3. In this work, the repeated game (iterative) principles were applied over the EGT. The same procedures are applied for all the iterations of the game and the payoffs and scores are calculated accordingly. The moves performed by the students were observed and recorded for further analysis. The game was played based on the following procedure. The game was designed to have two players and four moves. The identified moves are addnode, addrelation, skip and quit. The player’s moves like addnode and addrelation get the assigned point to his or her score if and only if the added concept or relation is valid and the validation points will also be considered for the moves concerned. The rest of the moves such as skip and quit do not have any payoff assigned.

This scoring technique was introduced to the students playing the game. For every move by the students, the score was calculated and final score was arrived at the end the game. At the end of the game, the educator’s map will be shown to the students which will help the students to have a clear understanding on the topics and to rectify the misconceptions. The final scores for the students were calculated as shown in Table 5.3.

Table 5.3 Final Score Table for Player (Student)

<table>
<thead>
<tr>
<th>Move</th>
<th>Game</th>
<th>Payoff</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Add</td>
<td>Skip</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>{1,0.5}</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>…</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>∑a_i</td>
<td>0</td>
</tr>
</tbody>
</table>
5.2.3 **Concept Tree Game Algorithm**

An algorithm to implement the above defined CTG game has been developed. The notions defined in Table 5.2 were used for implementing the game tree and source game tree. The algorithm is presented below:

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**Algorithm: Concept Tree Game**

**Input** : Source Concept Map

**Method** : CTG method

**Output** : Score, Time Taken, Feedback, Source Map.

**Step 1** : Let \( C = \{ c_1, c_2, \ldots, c_g \} \) be a set of concepts from the concept map

**Step 2** : Let \( R = \{ r_1, r_2, \ldots, r_h \} \) be a set of relationships from the concept map

**Step 3** : Let \( SC = \{ sc_1, sc_2, \ldots, sc_g \} \) be a set of concepts from the chosen source concept map

**Step 4** : Let \( SR = \{ sr_1, sr_2, \ldots, sr_h \} \) be a set of relationships from the chosen source concept map

**Step 5** : Let \( P = 0 \) be payoff score; for each valid move where every \( c \) and \( r \) will get 1 and 0.5 point respectively

**Step 6** : Let \( T = 0 \) be score; for each valid move will get assigned point added to the score \( \{ C=1; R=1; S=0; Q=0 \} \)

**Step 7** : Initialize game by initiating the canvas with the title of the assessment as *root node*

   **Step 7.1** : Show concepts and relations for next move

   **Step 7.2** : Allow user to select any one from the list

**Step 8** : Allow the player to perform his move \( \{ C, R, S, Q \} \)

   **Step 8.1** : Recognize the move

     **8.1.1** : addnode()

     allow player to add a node \( c_i \) to the tree

     compute \( P=P+1 \)
compare the c_{i} with sc_{i}
if true then compute T=T+1
display P
break()

8.1.2: addrelation()
allow player to select from the list
allow player to add a relation r_{i} to the tree
compute P=P+0.5
compare r_{i} with s_{r_{i}}
if true then compute T=T+1
display P and T
break()

8.1.3: skip()
allow the player to pass / skip the move
compute P=P+0
display P
break()

Step 9: Feedback function
analyze the game logs
generate feedback
display the final score T=T+P
display the feedback
display the answer map
go to home page

Step 10: Quit()
Save the tree contents
Close the canvas
Exit
As mentioned in Chapter 3, the participants for this research work were selected using the ‘purposive sampling techniques’. After the experimentation of this CTG assessment method, a survey questionnaire was distributed to all students with an aim to obtain the views of the students’ toward the usefulness of the proposed CTG method.

5.3 CHAPTER SUMMARY

This chapter presented the architectural design of Collapsed Concept Map Game (CCMG) and Concept Tree Game (CTG) methods for online formative knowledge assessment (OFKA). Both the OFKA methods were explored with new algorithms for the assessment of knowledge. These methods were tested with selected groups of students that comprised of undergraduate and postgraduate students. A detailed discussion on experimental results of the proposed methods is presented in Chapter 6.