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Automated Evaluation Framework for Student Learning using Concept Maps

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Abstract-** The paper develops the concept map based framework for Student learning evaluation. The main attention is devoted to automatically calculate the student understanding about the particular topic using concept maps where concept maps are visual representation of understanding of any topic. We use Markov chains technique to calculate the score of student understanding and also use XML parsing technique to compare and evaluate the concept maps. The feedback generated by this framework gives the score of student understanding about the topic and is given to the teacher and student so that it will be useful to validate the knowledge and grasping power of students. The final result will be in terms of interactive UI rather than simple graphs.

Index Terms—Concept Map, Java, XML parsing, Student learning, Finite Markov chain, learning evaluation.

1. INTRODUCTION

Aconcept map is a type of graphic organizer used to help students organize and represent knowledge of a subject. Concept maps begin with a main idea (or concept) and then branch out to show how that main idea can be broken down into specific topics. When created correctly and thoroughly, concept mapping is a powerful way for students to reach high levels of cognitive performance. A concept map is also not just a learning tool, but an ideal evaluation tool for educators measuring the growth of and assessing student learning. As students create concept maps, they reiterate ideas using their own words and help identify incorrect ideas and concepts; educators are able to see what students do not understand, providing an accurate, objective way to evaluate areas in which students do not yet grasp concepts fully. Example of concept map is shown below Fig. 1.

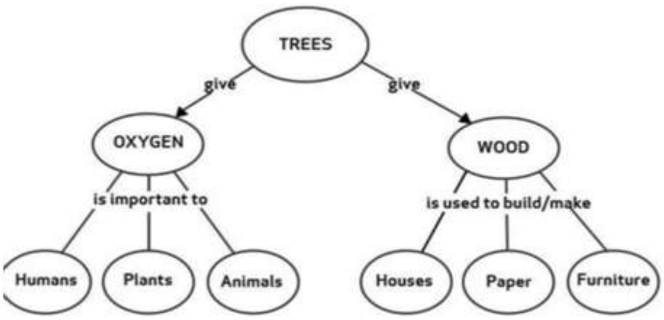

Figure 1: Concept Map Example

The researcher G. Pankaj Jain and P. Gurupur, Jennifer L. Schroeder and Eileen D. Faulkenberry[1] have developed a tool called as AISLE: Artificial Intelligence-Based Student Learning Evaluation. The main purpose of this tool is use automatic evaluation of student understanding of a particular topic of their study using concept maps. They have used probability distribution to calculate the scores for student understanding while another group of researchers Varadraj P. Gurupur, G. Pankaj Jain and Ramaraju Rudraraju have developed the similar tool by using Markov chains instead of Z-score probability distribution. Unlike AISLE, this

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tool is able to successfully process concept maps with circular chains of concepts.

We are now developing a framework to evaluate the student's understanding for a particular topic using the concept maps and calculate students score about that particular topic in a user interactive UI form. When a particular topic is taught to student by a teacher, a concept map is utilized to determine what student knows about a subject rather than using more traditional forms of assessment such as multiple-choice exams or theory papers. This framework would evaluate the concept map and estimate if student has captured enough concepts from the given topic and then it will be easy for teacher to evaluate the student's understanding for the topic.

The former aim of this project is to build a framework which can understand the student psychology in learning process by using concept maps.

This framework can reveal to both students and teachers the quality and the level of development of conceptual understanding for any domain and at any grade level. It also gives teachers more accurate and more authentic insights into the student's thinking rather than traditional methods of testing.

The system has twofold benefits in the context of the integration of technology into the traditional educational process:

- To promote student's knowledge self-assessment, and
- To support a teacher in systematic assessment of student's knowledge and the improvement of learning courses.

This used in the following way: A teacher defines stages of knowledge assessment and creates concept map for all of them by specifying relevant concepts and relationships among them in such a way that a concept map of each stage is nothing else then an extension of the previous one. After the knowledge transfer, a student builds his own concept map based on corresponding topic.

The tool constructs the XML from concept map developed by student and concept map built by instructor and compare both the XML using XML parser. Then it does comparative analysis using Markov chains to calculate the score. Markov chains can be used as a method of measuring predictability and pattern recognition.

2. RELATED WORK

Even though concept maps have been used in many different areas or sectors but still its applications in educational area are limited. Some of the researchers have established their work related to concept maps to rich educational datasets that approach from course management scheme such as Intelligent Knowledge Assessment System, Personalized Assessment System Supporting Adaptation and Learning (PASS), Knowledge Assessment System etc.

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IEEE will do the final formatting of your paper. If your paper is intended for a conference, please observe the conference page limits.

2.1 Evangelia Gouli, Agoritsa Goroulou and Maria Grigoriadou, A coherent and integrated Framework Using concept maps for various Educational Assessment

Define Through concept mapping researchers have found that students were aware of the fundamental concepts of subject matter and evaluation task in the assessment activity gave the student a chance to become active participants in their own learning and to refine their knowledge by evaluating their own work. By using this system, the amount of time needed to identify the student's performance according to traditional exam was comparable. When the assessment framework is applied in the classrooms, the results are positive providing useful information as far as combination of various assessment tools and support of other forms of assessments are concerned.

2.2 Lukasenko and Alla Anohia-Naumeca, Feedback in the concept map based Intelligent Knowledge Assessment

In this paper, a coherent and integrated framework for educational assessment purposes, serving various assessment functions, is presented. The framework named AssessToLearn uses concept maps as the main tool of the assessment toolbox and provides a basis for the design of assessment activities. The paper presents results of efforts of researchers from the Department of Systems Theory and Design to implement different kinds of feedback in the developed intelligent knowledge assessment system which is based on concept maps. The main attention is devoted to the implementation of various kinds of feedback intended for promotion of effective learning and informing of a teacher about student's progress. The feedback is considered from three points of view: feedback generated automatically by the system and given to a student and to a teacher and feedback provided by a student using questionnaires embedded into the system. The calculation of the concepts mastering degree and composition of the text summary informing a student about the best and the poorly known concepts within a task is described.

2.3 R. Castles, Knowledge maps and their applications to students and faculty assessment

The traditional model for formalized engineering education begins by providing some sort of instruction and reading assignment for students to learn concepts and information, providing exercises aimed at reinforcing concepts and providing further illustration and insight into the concepts, and then assessing student knowledge formally through graded assignments and exams. The classic view of such learning is that it exists in an isolated environment; that is to say that all instruction about a particular concept comes from the material presented within the confines of the course and all assessment within the course should evaluate only the concepts presented by the instructor or contained within the assigned reading. This model, however, fails to capture the incredibly detailed process undertaken by students raised in the internet generation who have access to vast digital resources, many of which are not introduced into the learning process by the instructor.

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2.4 S.C. Lin, A new structural knowledge based on weighted concept maps

A weighted concept map is a concept map which assigns a weight to each proposition in a concept map to represent its importance. This study proposes a new assessment with qualitative comparison founded on a weighted concept map. The study proposes a comparison method with weighted concept maps. The student's concept maps are contrasted against expert concept maps to find out student's learning states, and then indices are given to students according to their learning states for a given proposition. That will help students construct their concept maps

2.5 G. Pankaj Jain, Varadraj P. Gurupur, JenniferL. Schroeder, and EileenD. Faulkenberry, Artificial Intelligence Based Student Learning Evaluation: A Concept Map

It is basically a Web-based application which makes use of the concept maps as a tool for knowledge assessment. A semantic unit of a concept map is a proposition. The system has two goals in the context of the integration of technology into the traditional educational process:

(a) To promote student's knowledge self-assessment, and

(b) To support a teacher in systematic assessment of student's knowledge and the improvement of learning courses.

*A teacher defin*es stages of knowledge assessment and creates Concept Maps for all of them by specifying relevant concepts and relationships among them in such a way *that a Concept* Map of each stage is nothin*g else then an extension of the* previous one. During knowledge assessment a student is given a Concept Map based task to solve. The student solves the Concept Map based task corresponding to a current assessment stage. After a student has submitted his/her solution, the system compares a student's Concept Map with the teacher's one and generates feedback. The system presents questions to the user and generates an analysis using the answers provided to these quest*ions. The system uses a well-defi*ned structured approach in gathering the required information and performing the required analysis. Moreover, this system provides feedback to the student as well as the teacher.

2.6 Varadraj P.Gurupur a, G. Pankaj jain b, Ramaraju Rudraraju, Evaluating student learning using concept maps and Markov Chains

This paper is alike the AISLE tools which is mentioned earlier. The researchers have developed a tool which will evaluate the student learning evaluation using the Markov chain. The tool used gives a depth of understanding of student about a particular topic taught by teacher or an instructor and also helps the instructor or teacher to evaluate the performance of students which are enrolled for the course.

3. EXISTING SYSTEM ARCHITECTURE

Existing tool i.e. AISLE performs the learning evaluation of concept maps using three main modules. Fig. 2 shows the existing system architecture

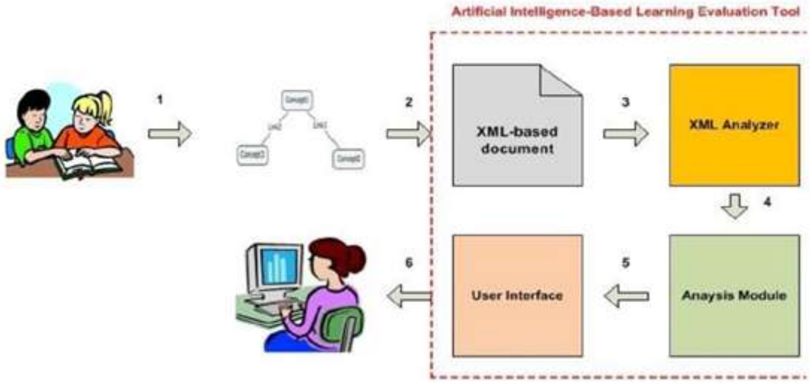

Figure 2: Existing system architecture

These modules are as described below:

a. XML Analyzer Module

- Student develops concept maps from the topics under study
- The concept maps are converted into XML documents by using java and XML parser.
- The XML analyzer parses the XML document

b. Markov Chain Analysis Module

- Generated XML files are then came to Markov Chain analysis
- It collects the required data and develops the hierarchy
- Analysis is done by this module and sent to the user interaction module

c. User Interaction Modules

The analysis report is given to the instructor in the form of charts or graphs.

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4. METHODOLOGY

The tool works as below:

1. In a classroom, the teacher or instructor teaches a particular topic to the entire students.
2. After completion of topic, teacher tells to construct the concept maps on the taught topic
3. Each student then constructs the concept map and submits the same.
4. Teacher are also said to build the concept map on the given topic. Teacher's concept map will act as the base concept map.
5. Next our module XML analyzer module runs and converts the concept maps into the XML files by extracting the concept maps. XML files are parsed and compared with base concept map.
6. Analyzer module then sends the summary to the results to the user interaction module.

4.1 CALCULATIONS

Calculation technique for this tool is described below:

4.1.1 *Concept map analysis*

Concept maps developed by students are given to the XML analyzer module. The Cmap tool is used to construct the concept maps. Java, XML parser is used to extract the concept from concept map and build the XML document form them.

In the Concept map, there are basically three levels-

- Gist level : In a concept map, there is supposed to have only one gist level element and that is root node or subject of the topic
- Support level: These are concepts after the root node
- Detail level: The concepts which are linked to the support level are details nodes.

The scoring system is developed for all the concepts that are present in the concept map.

The algorithm for scoring is as follows:

Scoring Algorithm:

- *read score [count (Concept level)]*
- *for j: 0 to (count (Concept support) + count (Concept detail) do*
- *score[j] = 5*
- *Sum: sum of all scores in each level*

XML Dom parser is used to collect the information from generated XML file for any concept maps. The values from these XML can be extracted on below basis:

- Number of concepts in the hierarchy
- Number of relations that connects to different level in the concept map hierarchy
- And the score that is calculated to each concept map in the hierarchy (Score)
- sum: sum of all scores in each level

TABLE I

STATES AND THEIR TRANSITIONS USED IN CONCEPT MAP

States	Meaning	Conversions
Concept	Key element of the topic: represents the number of concepts present in hierarchy	The transition exists between state concept to relation, score and itself
Relation	Supporting key element to the concept: Represents number of relations in the hierarchy of the concept map	The transition does not exist for state relation to state concept as there are no relations at the Gist level. However, transitions exist for state Relation to state Score and itself
Score	Calculated for each concept in the hierarchy of concept map	Transitions exist between state score to concept, relation and itself

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4.1.2 *Finite Markov Chain Analysis:*

A Markov process is a random process for which the future (the next step) depends only on the present state; it has no memory of how the present state was reached. Markov chain model includes the below specification with respect to concept maps:

- Identify possible states
- Identify possible transition between the states
- Probability calculations

At every instant in step n from the concept map, the Markov chain will always be in one of states. A process starts in one of the states and moves from one state to another state which is termed as "transitions".

The table 1 shows the states and their transitions used in concept map for FMC:

Fig. 3 shows the three states for any concept map with their respective transitions of going from one state to another with respect to their levels.

A Based on Fig. 3 of state transition diagram, the transition matrix or Markov matrix P is given as

$$P = \begin{bmatrix} p(\text{Concept}, \text{Concept}) & p(\text{Concept}, \text{Relation}) & p(\text{Concept}, \text{Score} \\ p(\text{Relation}, \text{Concept}) & p(\text{Relation}, \text{Relation}) & p(\text{Relation}, \text{Score}) \\ p(\text{Score}, \text{Concept}) & p(\text{Score}, \text{Relation}) & p(\text{Score}, \text{Score}) \end{bmatrix}_{3x3}$$

$$= \begin{bmatrix} \frac{1}{21} & \frac{10}{21} & \frac{10}{21} \\ 0 & \frac{10}{20} & \frac{10}{20} \\ \frac{5}{105} & \frac{50}{105} & \frac{50}{105} \end{bmatrix}_{3x3}$$

Where P is the transition matrix of a Markov chain. The first step transition of this Markov chain is given as

$$P_{ij}^2 = \sum_{k=1}^{3} p(i,k)p(k,j)$$

Where P2 ij is the (i, j) element of the transition matrix [P2].

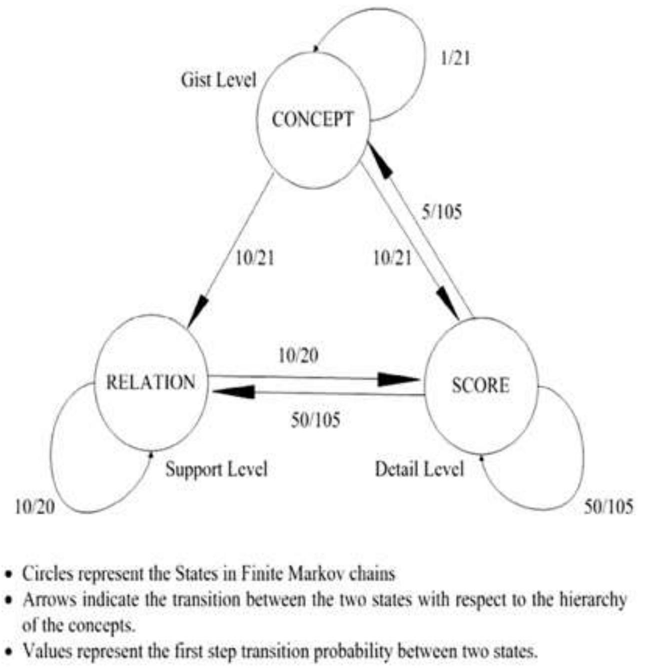

Figure 3: Transition state diagram for the concept map

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Hence from the below,

$$P^2 = \begin{bmatrix} 0.024 & 0.487 & 0.487 \\ 0.023 & 0.488 & 0.488 \\ 0.024 & 0.487 & 0.487 \end{bmatrix}_{3x3}$$

Similarly, Pn(i; j) is the nth step transition probability between the states i and j is the (i, j) element of the nth power of matrix [P]. Since [Pm+n] = [Pm][Pn], this means that as

$$P_{ij}^{m+n} = \sum_{k=1}^{3} p_m(i,k)p_n(k,j)$$

Where i, j are the states and k is the intermediate state between i and j. Here m, and n are the number of transitions.

The above equation is known as Chapman Kolmogorov equation.

If the chain is repeated for a very large steps n, the Markov chains eventually enters a steady state, in the sense that the transition probabilities will become steady at certain value. By continue the process for the Markov chain until we reach 32 steps. FMC converges to a certain value i.e., Pn(i; j) > 0 in each state. Here, we can confirm the following:

Pn converges as n -> ∞

- For each column j, the transition probabilities pn(1; j); pn(2; j) and pn(3; j) should all tend toward same value.
- lim n-> ∞ (P)n exists for the transition matrix [33] [34] and is independent of state

Hence, the matrix is as

$$P^{32} = \begin{bmatrix} 0.024 & 0.487 & 0.487 \\ 0.024 & 0.488 & 0.488 \\ 0.024 & 0.487 & 0.487 \end{bmatrix}_{3\times 3} .$$

The stationary value for each row in transition matrix shows the information measurement that is measured for each state in the concept map. Summation of all the transition probability values in a row is always approximately equal to one and this value does not depend on previous states. To perform the required analysis we add all these values to a particular column.

The first column indicates the Gist level, the second indicates the Support level and the third column indicates the Detail level for the concepts. The stationary vector A1 for this concept map 1 after adding all the values is given by:

A1 = (0:072 1:462 1:462)

4.2.3 *Evaluation of concept maps*

To understand above all discussions, we will take an example: Consider a tutor has explained about the Operating system in a class of computer science. Below Fig. 4, Fig 5 and Fig. 6 are the concepts maps build by the tutor, student 1 and student 2 respectively as

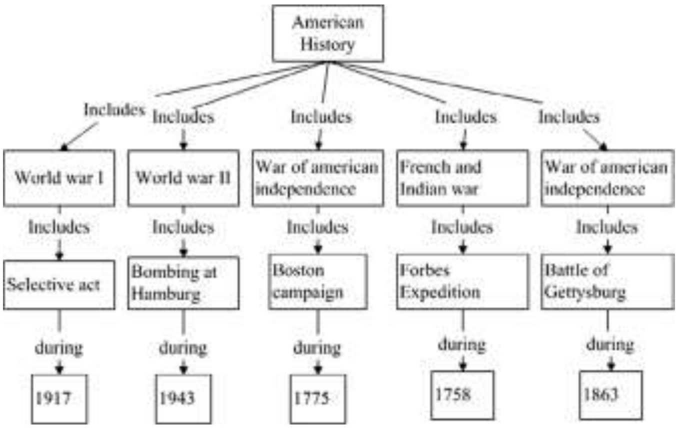

Figure 4: Concept Map by Tutor

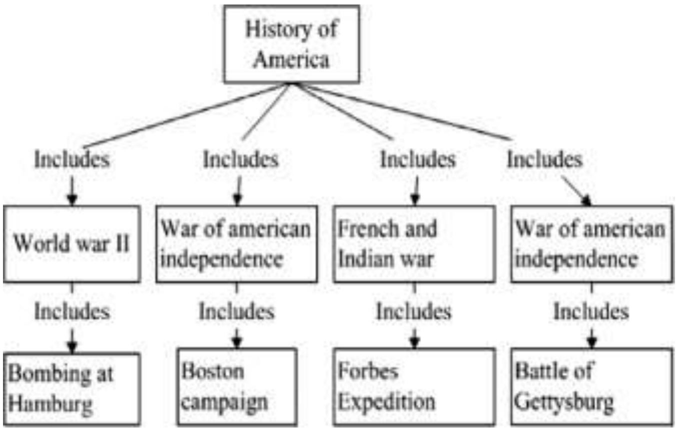

Figure 5: Concept Map by student

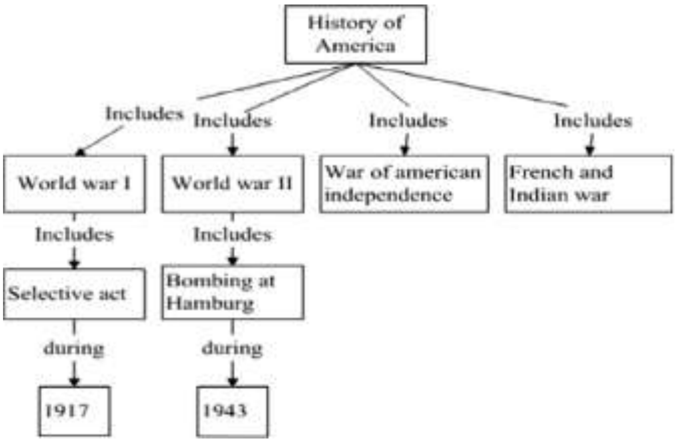

Figure 6: Concept Map by Student 2

For the above concept maps, the transition matrix is calculated and stationary vectors are developed for each of these concept maps. Fig. 7 shows the comparison between concept maps depicted in above concept maps.

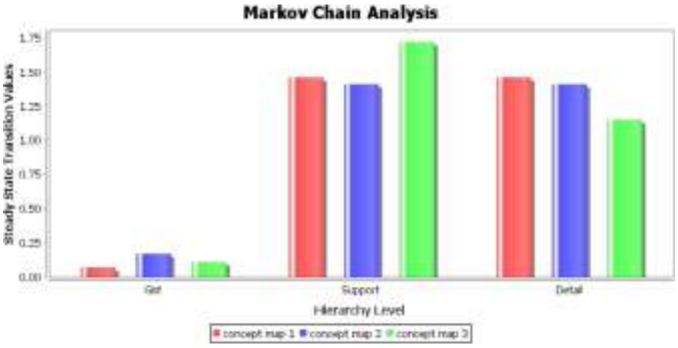

Figure 7: Bar graphs by Markov chains

Fig. 7 shows that concept map by student 3 has higher number of concepts when compared to concept map by student 1 in the hierarchy. This indicates that both concept maps by student 1 and 2 have the same amount of depth in the concepts but there is clear difference in the hierarchy represented in them. For example, concept map by student 2 goes two levels deeper from the root node while concept map by student 1 has three levels of depth from its root.

Fig. 7 depicts the bar graphs providing a comparison between concept maps 1, 2, and 3. From Figure, it is seen that concept map 1 has a higher Detail level indicating that it has better information in terms of the details covered when compared to the other maps considered for comparison. However, it has the least value at the Gist level. This indicates that the concept map 1 has higher connectivity with the root node. The concept map 3 has higher length in Support level which indicates that the concept map has not much depth information though it has more number of concepts in the hierarchy.

Parameters used while evaluating concept maps- Below parameters are used to evaluate the concept maps:

- Details level length - The High detail level means depth in the information that is present in the concept map.
- Gist level length - Low length indicates the strength in terms of connectivity of the root node concept for the concept map. A higher level of Gist and a lower level of Detail indicate that many concepts were not covered in detail.
- Support level length - Low support level length indicates supporting strength for concepts in concept maps. The length of supporting concepts should be lower than detailed level concepts

5. EXPERIMENTAL RESULTS AND ANALYSIS

Researchers [1] have carried out the experiment on the student which are enrolled to two different courses and found that students represented their knowledge in a better than the traditional way of evaluation. One of the experimental results generated is shown as Fig 8:

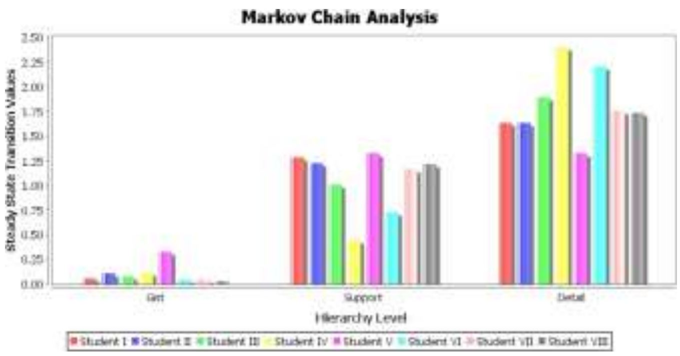

Figure 8: Bar chart distributions for the concept maps developed by students[1]

5.*1 Observations on the Use of AISLE for classrooms*

Based on the experimentation explained in above section below are the some observations-

- Use of AISLE considerably reduces the time involved in assessing a student's understanding of a topic in study for the instructor.

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- Allows for the comparison of multiple students understanding on a given topic, such that the instructor can assess how much variability there is between students.
- Provides an overall picture on the depth of a student's understanding of the topic.
- The technique used for assessment works well when the concept map developed by the student involves a good use of hierarchy. However, more sophisticated methods may be required to assess concept maps that do not involve hierarchy in representing information using concept maps.
- The method used to assess concept maps does not work very well when the concept maps submitted by the students are not hierarchical in nature.
- The validation of the concepts contained in the concept maps has to be done manually by the instructor.

5.2 *Teachers Reaction to AISLE*

As indicated before, AISLE was tested with two undergraduate classes in computer science. The instructor for these courses requested the students, who volunteered for the project, develop concept maps based on a homework question.

The following observations were identified by the instructor:

1. The scores the students made on the regular homework question somewhat reflected the observation made on the graph generated from AISLE
2. The instructor also identified that AISLE could be used to validate the testing and grading procedures carried out in the course

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6. ADVANTAGES AND LIMITATIONS

The above discussed tool or system has some advantages and limitations. They are listed below:

6.1 Advantages

- The tool can be effectively used in identifying the level of a student's understanding of a particular topic using concept maps and Markov chains.
- The tool and the method associated with it will be useful for instructors in identifying and assessing their ability to induce good understanding of topics and improve their teaching methods.

6.2 Limitations

- For large number of students, maintaining the graph is a complex process and also it is much confusing to know their gaps in understanding in the topic.
- Need for stronger user interface to display the results of students.

7. PROPOSED ENHANCEMENT FOR IMPLEMENTATION

By looking at the limitation of the existing AISLE tool, we propose to have an interactive UI to display the result of student. We introduce the new module to the existing system as 'Result analysis Module'.

7.1 *Proposed system architecture*

Our proposed system architecture is shown in Fig.9:

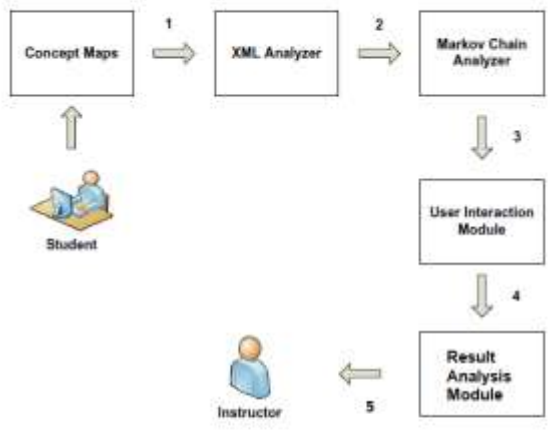

Figure 9: Proposed System Architecture

Our module will contain

- Concept wise result of each student
- Position of the student among his classmates
- Strong and weak concepts of student in understanding the topic

The module will give benefit over the existing system.

- Instead of having graphs and charts, we will have a more user friendly UI design to show the understanding of the student
- It will also work in the evaluation process of large number of students

CONCLUSION

A tool is described for the purpose to evaluate the student understanding about a particular topic by using concept maps and the Markov chains. The tool compares the concept map developed by students to the concept map developed by teachers by using Java and XML parser to extract the information form concept map to the XML document. The tool used is beneficial to both students and teachers in identifying and assessing their ability to induce good understanding of the topic and improve the teaching methodology respectively. Finally we have inducing a new module to the existing system to view the result of students in a more interactive manner.

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