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# Assessment of Student Understanding Using Concept Maps

**Alan Joseph, Aashay Polkamwar, Punit Parihar, Vaishakh Gulab, Mrs. Shweta Khopade**

*Abstract*— **In this paper we describe a system based on concept maps to access the level of understanding of a student. The main purpose of this project is to improve the use of artificial intelligence in assessment of student understanding using concept maps of a particular topic. A new system is developed based on Question-Tag in which a student answers questions on a particular topic and according to the answers marked, the concept mapping is done by the system. We calculate the probability distribution of the concepts identified in the concept map. The evaluation of the student understanding is done by analyzing the curve of the graph developed by the system and this is compared against the expert concept map.**

***Index Terms*— Question Tag, Concept Mapping, Probability Distribution.**

## I. INTRODUCTION

Concept maps are visual representations or diagrams that shows concepts or topics and the relationships between them in a hierarchical structure. The root concept consists of several subtopics connected to it, thus forming a tree of concepts. The root concept is the most general one at the top and the bottom most subtopics are the most specific ones at the top. We can show relationships between two concepts using linking phrases. Usually linking phrases are verbs depicting the relationship between the concepts. For eg. "Abstract data type includes tree". Here the linking phrase is includes which tells us the relationship between the concepts „Abstract data type" and „tree".

Concept maps are mostly used for constructive learning activities such as assessing a student"s understanding of basic curricular concepts. With the help of these concept maps, we can also give a person, feedback on how well he grasps the knowledge of a particular topic. It evaluates student learning better than multiple choice questions and is much more accurate as well as efficient.

Concept maps can be constructed by the students by linking each concept to another. A student must start from the root concept which is the most general and work his way down the map. He must complete the tree with as much as nodes as possible. This concept map is then compared to another concept map, which is created by an expert of that particular root concept. The results are then analyzed and feedback is provided to the student on his performance.

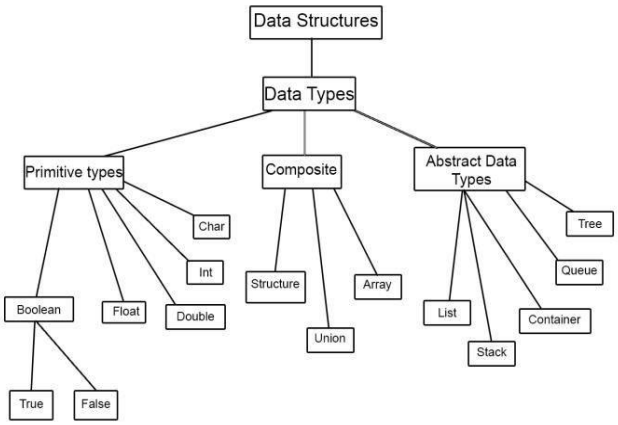


Fig: An example concept map

## II. RELATED WORK

### *A. Intelligent Knowledge Assessment System:*

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. Concept Maps based tasks can be divided in

- "fill-in-the map" tasks, where the structure of a CM is given to a student and he/she must fill it using the provided set of concepts and/or linking phrases, and
- "construct-the-map" tasks, where a student must decide on the structure of a CM by him/herself.

The system has two goals in the context of the integration of technology into the traditional educational process:

- To promote students" knowledge self- assessment, and
- To support a teacher in systematic assessment of students" knowledge and the improvement of learning courses.

A teacher defines 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 nothing 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 questions. The system uses a well-defined 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.

*B. The AssessToLearn Framework:*

Since the assessment of student learning is an integral and essential part of the processes of teaching and learning, and the concept maps are a valuable assessment tool which promote to the meaningful learning and have a great contribution to the knowledge construction process, a coherent and integrated framework in the educational assessment process has been proposed, referred to as *AssessToLearn*. The *AssessToLearn* framework consists of a three-step process consisting of principles from contemporary theories of learning. Considering concept maps as the main tool of the assessment toolbox, the assessment items may be implemented by employing various concept mapping tasks such as

- the construction of a concept map from scratch ("free construction "task), and/or
- using an available list of concepts ("concept list" task), and/or
- fill someblanks concerning concepts/relationships ("partial recall framework" task) (Tsai et al., 2001), and/or fill some blanks concerning concepts/relationships by using an available list ("partial recognition framework" task) (Tsai et al., 2001).

The three steps of the *AssessToLearn* framework are as follows:

1. Assessing students prior knowledge-Knowledge Activation
2. Promoting Construction & identifying conceptual changes-constructing & enriching knowledge.
3. Assessing knowledge construction-refining knowledge.

*C. Personalized Assessment System Supporting Adaptation and Learning (PASS):*

Some of the key contributions of this system are:

- Identification of prior knowledge of the student
- Diagnosis of concepts unknown to the student
- Identification of the growth in a student‟s overall understanding of the topic.

*D. Artificial Intelligence Based Student Learning Evaluation (AISLE):*

The main aim is to design a system which will help to evaluate the student‟s understanding of the particular topic by using concept maps. By use of concept maps the probability distribution of the concepts can be calculated, identified by the student. The evaluation of a student‟s understanding can be identified by analyzing the curve of the graph given by the calculated probability distribution. This technique makes extensive use of XML parsing to perform the required evaluation.

A concept map is a very good tool for teaching new concepts because it shows a relation between the already known concepts and the new ones.

The previous systems shown have implemented the assessment systems in different ways. The task that proves the knowledge of students has been paper based tasks and computer based tasks like filling empty or incomplete maps, Filling concept maps to the computer using IHMC tools [1] etc. Various other methods have been proposed like separating cards related to a particular concept from a stack of cards having related and unrelated concepts [4]. All of these suffer from some common drawbacks:

- Concept maps are difficult to understand and require practice.
- Students have to spend extra time to learn how to make concept maps
- Some students who are used to rote learning may find it intimidating.

It is for these reasons that a new system is proposed.

## III. IMPLEMENTATION

A concept is a good tool for teaching a new concept. But for evaluating student's understanding of a particular topic, they must have [4]:

- A task that bears evidence of the student's understanding and knowledge structure.
- A format for recording the response of the students.
- A scoring or grading system through which analysis of student's grades will be evaluated accurately and consistently.

*A. Assessment Task and Response Format:*

The previous systems define many methods for assessment. This system intends to overcome the drawbacks in the previous models. So a Question-tag based system is proposed.

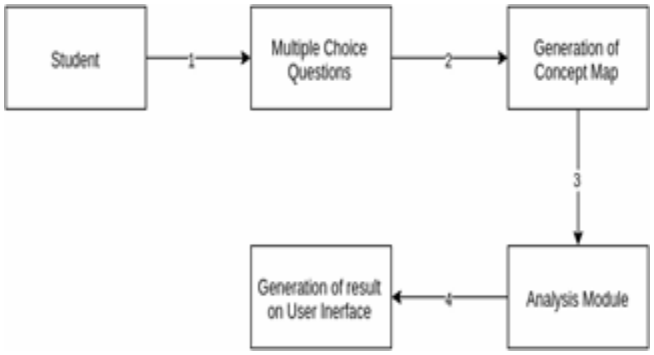


Fig: Architecture Diagram of proposed system

The proposed system consists of the following setup:

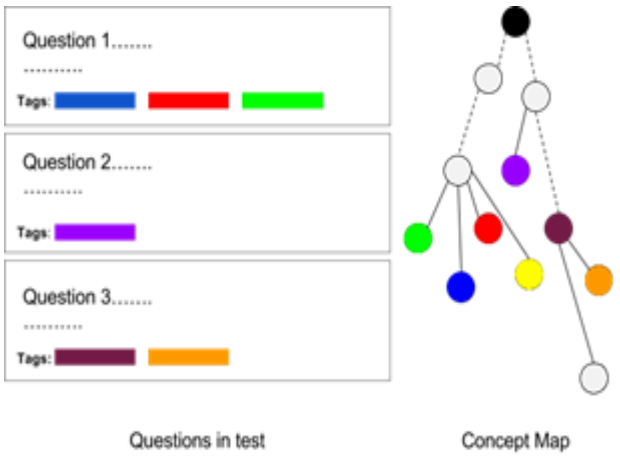


Fig: Proposed Evaluation System

The assessment system takes input as answers to questions. Every questions have one or more tags. These tags are nothing but the concept id of the concept which the question covers. If a student answers a particular question, then depending on the correctness of the answer, the student's grasp on a concept is measured.. An optimum number of questions are asked. Depending on the tags a concept map is created by the system in the back end.

### *B. Analysis of Concepts:*

The concepts in the concept map are each given scores randomly [1] depending on the level of the concept in the concept map. The level of the root node in the concept map is level 0. The next level is level 1. The level after level 1 is level 2. The concepts are all assigned scores according to the scoring algorithm [1].

And then they are given random scores based on [1], obviously the level 2 concepts will be highly scored than the levels above because it indicates deeper understanding of a particular sub concept. The depth of the hierarchy of the concepts indicate the depth of the student's understanding of a particular topic.

Based on the above scores Z-scores of a particular concept are calculated based on the formula below [1]:

$$z_{concept} = \frac{Score_{concept} - Meanofconceptscores}{StandardDeviation_{Score}}$$

This is called standardization of scores. The properties of standardizing the scores are as follows:

- Mean of scores is always zero.
- The standard deviation of scores is always 1.
- The distribution curve for standardized and non- standardized curves is the same.

The value of the z-score of a concept may be positive, negative or zero depending on whether it is above, below or equal to the mean of all concept scores.

To calculate the probability values of each concept present in the concept maps, following formula is used [1]:

$$P(z_{concept}) = \frac{1}{\sqrt{2\pi}} e^{\frac{-z_{concept}^2}{2}}$$

### *C. Evaluation of Concept Maps:*

The standard probability distribution of the concept maps developed by students is compared to the probability distributions of the concept maps prepared by the experts and both are compared.

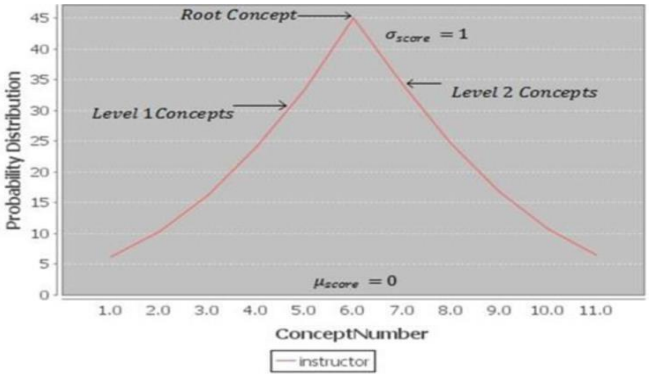


Fig : Line chart distribution for concept map

To evaluate the concept maps the parameters that play an important role are as follows:

1) Height of the curve, which represents the standard probability distribution value where the mean of the curve is equal to zero.
2) Concept number, which represents the numeric values assigned to each of the concepts in the hierarchy.
3) Leaning of the curve with the standard curve, which represents the depth of the topic or supporting concepts about the topic.

## IV. CONCLUSION

In this paper, we have proposed a new method to evaluate student‟s understanding using concept maps. This method is based on a Question-Tag based approach. This method seeks to eliminate the difficulties on previous implementations of concept maps which required the student to learn how to draw concept maps. This is not necessary in our proposed system because the assessment is done through question – answer format which the students are familiar with. The evaluation is done through comparing the student‟s concept maps with the expert concept map [1]. Thus our system eases student‟s effort as well as performs a proper evaluation.

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