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Research Note

Expert Finding System in E-Learning: Using Concept Maps

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Abstract— **Finding subject experts for problem solving is an important issue in e-learning environment. In e-learning environment there is no direct way to find the superior individuals. The current methods like analyzing the discussions or considering the learner actions need a lot of data or have some limitations. In this work, concept maps are utilized to define the experts in an e-learning environment. Concepts maps are graphical explanation of the meaningful relationship among the concepts. 35 M.Sc. and B.Sc. students participated in this work. The test design, implemented software, results and conclusions are described in detail in this article. The novelty of this work is the application of concept maps to find the experts, the combined presented models for concept map construction, and presenting a research methodology in this area.**

Keywords- e-learning; concept map; expert finding; concept map assessment

I. Introduction

A. Problem Definition

Finding subjects experts for problem solving and answering the questions is an important issue [1, 2]. Recognizing subject experts among other students in a class is one of the techniques to ask questions about a particular section of the course. One of the problems in e-learning environment is that the students don't know a superior in their class to refer to and ask their problems. Some methods try to solve this problem by creating interactive groups to discuss the problems and then by analyzing the discussions [3, 4, 5] or by utilizing social network analysis and visualizing experts opinions or text mining [6] try to find the subject experts . But discussion groups can't be used effectively in e-learning environment. Based on an inquiry from students who attended in virtual classes, some of the drawbacks are: the less interactive characteristic of discussion groups in e-learning environment, lack of trust to the other students' answers, distortion from the real question, not having enough time to read all the discussions, deficiency of an expert to lead the discussions toward reaching an effective result, not having a direct referee for asking from, and so on.

Hence, a collaborative tool known as Concept Map (CM) was employed to identify the subject experts in a course an e-learning environment. CM presents the individual's conceptual model of knowledge [7] and has been widely used in traditional classes for teaching, learning, detailed evaluation of knowledge progress, and even assessing the individuals' knowledge level in specific domains [8, 9]. In addition to its application in learning and teaching, there are several methods to score the CMs or classify them in order to understand the expertise of the persons who constructed those CMs [10, 11, 12].

Utilizing the proposed technique solves some of the problems named for discussion groups, and additionally, identifies the subject experts. Some other advantages of this method for supporting instructors could be as follows: automatic assessment and scoring of CMs, providing a platform for collaborative activities for sharing the superior CMs among each others, and developing the map.

B. Concept Map

Concept Map is a graphical explanation of one's perception about a subject in a particular domain [13]. CM shows the knowledge structure of individuals know as conceptual model by means of a graph of concepts (showing in rectangles or circles) and the relationship between the concepts (drawing lines between them). CMs are characterized by means of:

Concept(s): whatever is being perceived from the events, objects, etc.

Node: Presentation of each concept in a rectangle or a circle.

Link: A Line for meaningful connection of two related concepts (nodes).

Linking Phrase: A descriptive label being placed on a line to clarify meaningful relation between two concepts.

Proposition: A Meaningful description which is extracted from two concepts and their linking phrase and shows a piece of knowledge.

Cross link: A link between two different domains of a CM.

Domain: A part of a CM which presents unique and different part of a complex knowledge.

Fig. 1 explains CM in the form of a CM. To clarify this map, consider two concepts of "Concept Map" and "Knowledge representation" which are linked together with a linking phrase: "a visual tool for". These three phrases provide a proposition with the meaning of: "Concept Map is a visual tool for knowledge representation". This is a satisfying method for visual presentation of a small piece of knowledge.

II. LITERATURE REVIEW

A. Automatic Learner Assessment

Automatic learner assessment systems are different according to their environment or aspect of learning to be evaluated. One the researches that properly explain the learning assessment techniques, its characteristics and some other related issues is Jeanne P. Sewell and et al. paper [14]. The online assignments, quizzes, SCORM modules, tests and etc. are some of the techniques classified in this paper. A wide range of automatic learning assessment systems assess the learners' essays [15]. For example in Andreas Papasalouros and et al. work an ITS (intelligent tutoring system) was extended to automatically set a knowledge base and then generating multiple choice questions. By using the correct/worn answers, the feedbacks were generated and the education decisions were made [16]. Some of these systems help the teachers to evaluate the L1 (first language) or L2 (second language) learners and their essays. These systems utilize lexical statistics or regression analysis with different features to assess the learners' essays [17]. In other essay assessments text mining techniques are used too [18].

Other phase of assessments in e-learning environment are those relating to the game based learning, which use Petri Nets or other methods to detect the learner's misconception [19].

In addition to the mentioned methods, natural language processing technologies are used for semantic assessments too [20].

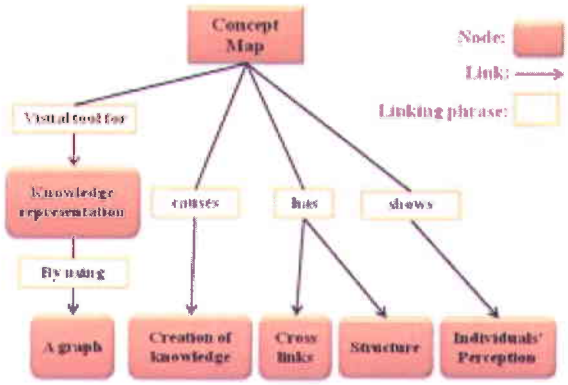

Fig. 1. Concept map showing explanations of CM

B. CM as an Assessment Tool

From the age of three individuals learn new concepts in a process of linking between the new concepts and the ones previously known. Therefore, having a structured form of concepts shaping the knowledge and all relationships between the concepts is an important issue. CMs could be used to represent the structure of individuals' knowledge and the relationships between the concepts just fine [11, 21]. Hence, it is considered as a means to evaluate one's knowledge. Any change in the knowledge structure of a CM could be a representative of a new development and thus could be evaluated. This evaluation could be a measure for successfulness learning and/or teaching processes [7, 10]. Till now, many assessment methods have been established based on CM evaluation, and modified through the time [22, 23, 24].

In addition to learning environment, CMs are used in other areas such as business to gain individuals' knowledge, share individuals' knowledge, and visualizing learning styles and so on [12, 25, 26].

In some cases, instead of traditional tests CMs have been used as an assessment tool for scoring the students. But so far no application has been reported utilizing CMs for finding experts in a specific subject domain. According to our studies no other application or method that finds experts in e-learning environment utilizing CMs exists. Up to now, two techniques in collaborative environment for CM assessment have been introduced in by Kardan & et al. These techniques have been combined with tagging to make benefit of user's short descriptions [27, 28].

C. Assessing CMs

To evaluate individuals' knowledge by utilizing a CM, some methods are used for scoring the CM itself. In this form of scoring, the nodes (concepts) and their relationships in conjunction with some other criteria are assessed. In some of the common methods, the CM is scored meaningfully; the meaning of *propositions* and their correctness or their levels of importance in the CM are assessed [8]. In some other methods, the characteristics of CM are assessed without considering any meaningful relation among the *propositions* [7, 8, 11, 22]. Also the visual characteristics of CM are shown to be a proper criterion for measurement. Some components of CM such as cross links, hierarchy of CM, and the number of resources attached to CM could be considered as a measure for differentiating the knowledge level of ones who are their constructors. These features are verified to be a good classifier for the expertise level of their constructors and therefore they could be utilized in the process of expert finding [11].

Some parameters for CM assessment in three resources compared with parameters used in this paper are shown in Table 1.

Table 1. Comparison of CM assessment parameters in this work and three main resources

Parameters used for CM assessment	Resource [7]	Resource [11]	Resource [10]	In this work
CM volume	✓			✓
Ruggedness	✓			
The ratio of the correct propositions	✓			
Links' weight	✓			✓
Hierarchy		✓	✓	✓
Links		✓		✓
Number of branching points		✓		✓
Number of cross links		✓		✓
Number of linked resources		✓		✓
Scoring the propositions			✓	✓
Scoring the cross links			✓	✓
Scoring the linking phrases				✓
Concepts' weights				✓

III. DESIGN AND IMPLEMENTATION

As stated in the previous parts, CM visually shows the knowledge structure of its constructor, and it is widely used to assess individual's knowledge level. This could be led to utilization of CM as an experimental environment in the process of expert finding with emphasis on his/her expertise. Therefore, it could be a suitable solution to the problems being mentioned in the introductory section of this paper.

A. Novelty

Developing the method utilizing CM to identify the qualified members in an e-learning environment is the most significant novelty of this work. In addition, in opposition to the most reported researches in which CM have been used as an assessment tool, a specific methodology for assessment have been introduced. In previous works, in each research a scenario for assessment is utilized and no specific process is regulated. Hence it is difficult to find out a rule for the works being done previously. In this paper a methodology with the aim of expert finding in a specific domain is presented which is completely fitted for the e-learning environments. In addition to the mentioned novelties, other innovative improvements presented in this work could be as follows:

- Presenting a research methodology in this domain
- Establishing a framework for designing the test part
- Describing the parameters necessary for the CM assessment
- Using three models for CM to assess the students' knowledge

B. Research Methodology

Each assessment technique using CM provides different types of information about different aspects of learning [7, 22]. Hence, it is important how to ask the individuals to construct the CMs. The details of the scenario being decided for this research will be described in the following subsections.

1) Participants and the Subject

35 students from the M.Sc. and B.Sc. courses with emphasis on Information Technology as the major were chosen to participate in the research process. According to our previous inquiry, the most important problem to these students (who are attending in virtual classes) is the lack of being familiar with each other. Therefore, they could not recognize the students who are superior in a subject matter and could be referred to get support for solving the problems. The subject

chosen for expert finding in this research was Electronic Commerce (EC). This is due to the fact that firstly the number of concepts related to this subject are more enough for necessity of expert finding, and secondly most of the participants have a similar knowledge level about the subject and are familiar with Electronic Commerce.

2) Constructing a Reference CM

The main concepts of an EC course were extracted and weighted by two subject experts in related domain. The weights are digitized from 1 to 5 which show the importance of the concepts. For example, a concept with weight of 5 has more important details for being learned. Since the relationships are important parts of a CM, the relationship between the concepts were weighted too. Then a reference CM was constructed using the weighted concepts and their associated relationships. The reference CM is a CM usually made by experts or the course instructor. This map could be used as a reference for comparing the CMs made by the students and the reference CM.

3) Test Design

The reference CM contains so many concepts and is too large to be navigated. Hence, for better navigation and the easiness of the students' interactions it was decided to separate the reference CM into seven other CMs. Also, a semi-constructed sample of CM was used to cover the following causes: 1- there are a large number of concepts in the CMs, 2- the test is an arbitrary activity and the experiment should be in some way being completed by the students. Semi-constructed CMs are a kind of CM used in researches. In this kind of CM, the scheme of the CM or the concepts and linking phrases are presented to the students. The students should place the concepts in the empty nodes or make the map by themselves. Some other challenges that should be considered in test design procedure are as follows:

- Easiness of navigation through the CMs
- Motivating the students to complete all parts of a test
- Deciding about the concepts which is better to be deleted when constructing a semi-constructed CM
- Extracting rules to use the CMs

Some of the solutions found for the above challenges are:

- Separating the reference CM to sub-CMs. Each sub-CM is about a main subject in EC and they all are linked to the main CM.
- Using different colors for every node in the main CM which is linked to another CM. In this way, the students can better distinguish the CMs and navigate through it.
- All the concepts, linking phrases and the cross links with high weights were identified in the semi-constructed CM.

4) Pre-test for Participating in the Research

Knowing how to construct a CM is an important feature for correctly showing one's real perception in a CM. Hence introducing CMs and training the students about how to make them was an important step in our research. In this work, the CMs and necessary steps for its construction were introduced to the participants by means of a computerized CM construction tool.

The second important point to be considered is the ability of the participants to construct a CM. Therefore, a pre-test was taken to make sure about the participants' readiness. The pre-test can decrease the probable noises in the results, arising from unperfected CMs. The computerized tool for CM construction was the CmapTools made by IHMC (institute of human machine cognition). We used the IHMC Public Server (2) to share the reference CMs for the students participating in the testing process. This decision helped us to reduce our restrictions regarding necessary time and place for the participants.

5) Classifying the CMs and Introducing Models

To express the model in an efficient way, the CMs were classified into three groups according to the number of concepts with weight of 4 or 5, CM structure, number of nodes, number of links, number of cross links and number of resources associated to the CM. The proposed models for assessing the individuals' knowledge utilizing CMs are:

Model 1: A semi-constructed CM is presented in which number of suggested concepts is equal to the number of empty nodes and the participants are asked to complete the map.

Model 2: A semi-constructed CM in which the number of suggested concepts is more than the number of empty nodes is presented and the participants are asked to make the map correctly.

Model 3: For a semi-constructed CM only the concepts are suggested and the participants are asked to construct the CM. themselves. In this model the root node and some important nodes are drawn and the place of other nodes should be recognized and defined by the students.

These models are hypothesized to be able to show the knowledge level of the individuals well. Since the construction and completing of the third model is harder than the second model, and in the same way the second model in respect to the first model. Utilizing of these models which were proposed by Hendijani and Kardan (2010) [29] was judged to be a proper model for assessing the knowledge level of the students.

In this part, a brief description of the procedure being used to construct the CMs and the test designs is presented.

C. Selecting Parameters for CM Assessment

In assessing the CMs, there are two major assessments methods: structural and meaningful. The former examines the structure of the CM and the latter considers the meaning of the propositions used in the CM. In different reported researches, specific parameters are chosen for these two kinds.

In this work, the both assessment methods were used. To identify the expertise of individuals, the chosen parameters should really demonstrate one's knowledge. As stated before, the hierarchy of the concepts is an important issue. Because in a well constructed CM, the more general concepts are in the first levels, and the detail or more important ones are placed in the lower levels [26]. The parameter used in assessing the CMs examines the concept hierarchy is the ***"Level difference of the concepts"***; which shows the misunderstanding of generality of concepts by the students. When a concept is not placed in the right position, some negative point is subtracted from the total score.

The other meaningful parameter used here is ***"The correctness of the concept place"***. In the scoring, if the position of a concept is not correct but other concepts under its position are placed the right position, a negative point is subtracted just for the incorrect concept. The other parameters considered in this work are: 1- ***concepts' weights, 2- weight of linking phrases, 3- number of nodes placed incorrectly, 4- level difference of concepts, 5- number of redundant nodes, 6- number of missed nodes and 7- number of links and their weights***.

The structural assessment parameters in this work are: ***1- Depth of the CM*** (like the graph depth it is defined as the distance from the root)**, *2- Number of branching points*** (number of branches from a node or a linking phrase) and ***3- The number of cross links***. These parameters were used and verified in the work done by Alejandro Valerio and et al. for classifying the CMs to different levels of expertise without considering the subject domains of the CMs. In [11] the CMs were classified into seven levels ion which the highest level showed the CMs constructed by experts. In this work, we used similar parameters for the structural level classification. This classification is useful for the third proposed model for CM construction. In addition, the demonstrators for level classification could be quantified by the instructor who could be user of our system.

IV. SYSTEM IMPLEMENTATION

Software named as *Concept Map Assistance* has been implemented by .net framework. This system can automatically assess the CMs and return a list of names and their scores of CMs. The two measurement factors (structural and meaningful assessments) were used to define the final score and with the help of given formulas. The formula can easily be changed by the course instructor.

The scenario of usage of *Concept Map Assistance* is as follows.

The professor installs the reference CMs in the system. Then all of the concepts and the linking phrases which should be shown are weighted by the course instructor. The students' CMs (drawn by CmapTools) are given to the software too. Then the assessment process will be started and a list of scores is shown to the course instructor; which contains the students' names, their scores for the meaningful and structural assessment, and the total CM score for each of them.

In the meaningful assessment the students' CMs is compared with the reference CMs. This is an important issue because in the meaningful assessment the position of nodes, the concepts in each node, and the structure of the CM should be considered meaningfully. The steps in meaningful assessment algorithm are as follows:

1. *Start from the root of the reference CM.*
2. *Compare each node with the student's CM.*
3. *If the place of the node in student's CM is wrong, record a negative point. (This point is multiplied by the weight of the node and by the weight of the node in the formula (c in formula 1)).*
4. *Find the wrong node in the student's CM.*
5. *Find the difference between the right level of the node and its current level.*
6. *If one node is not in the student's CM, record a negative point and the node's weight. ("Missing node"). (e in formula 1)*
7. *If in the student's CM there is any redundant nodes, record a negative point for each one. (g in formula 1)*
8. *If there is a node linked to a resource in the reference CM, find this node in the student's CM.*
9. *If there is a link in the student's CM too, record a positive point.(h in formula 1)*

For the meaningful assessment a formula is given to the system which contains these five factors and the weights of the nodes for each factor. Concept Map Assistance contains the default formula which is defined in formula 1.

***Formula 1*: CM score** = Max – c – e – g + h

Max = I * II * III

I: sum of weights of the empty nodes that should be completed by the students

II: maximum of the difference level

III: number of the nodes that should be completed by the students

For the structural assessment in Concept Map Assistance, there is a table in the setting page. The user can define the conditional parameters for entering each level of the structural assessment. The setting page of the software and the main page are shown in Fig. 2 and Fig. 3 respectively.

V. RESULTS AND DISCUSSION

As stated before, 35 students were participated in testing experiment. The semi-constructed CMs were completed with the students and a multiple choice question test was taken too. The test was used as an evaluation tool for the proposed method. The test was a classified test and in each part covered all the concepts of each CM. For each CM seven questions were designed in average. Since CM shows the relationship between the concepts very well, in the test design this point was considered. The evaluation was the process of considering and comparing the test and the CM scores.

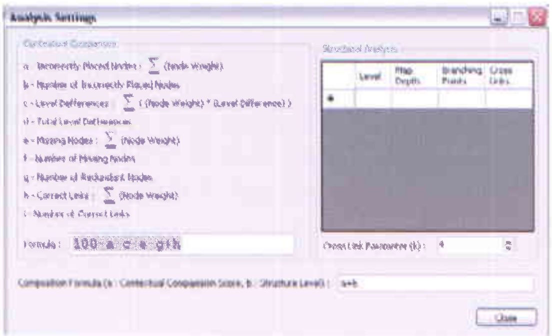

Fig 2. The setting page of Concept Map Assistance System

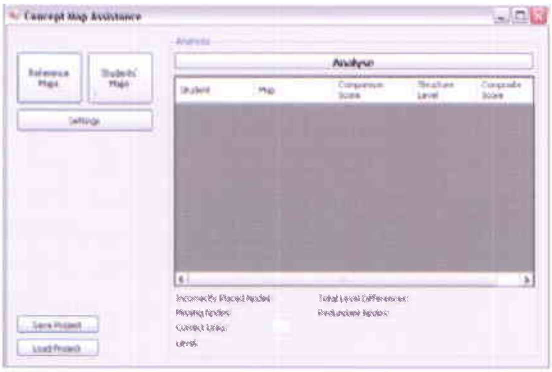

Fig 3. The main page of Concept Map Assistance System

It should be mentioned that because of the stated problems in the introduction section, the limitation of expert finding methods such as social networks analysis and the lack of data for e-learning, no evaluation method was found as a base method. Hence we tried to use the multiple choice questions test which has been used in some researches.

Shortly the results are determined with this process:

- Finding the normal score of the CM scores and the test scores in the range of [0-100]
- Matching the number of empty nodes (which should be completed by the students) with the number of questions in the corresponding test
- Finding the equality of the score for each empty node in the CM with one question in the corresponding test
- Considering the grade 15 out of 20 in the test for the experts: It means that the superiors have taken at least 15 out of 20 in the test.
- Finding an average for acceptable difference in the CM and test scores

A. Results

The results for two samples of CM-2 and CM-4 are shown in the form of column charts in Fig. 4 and Fig. 5 respectively. In each graph, the vertical axis shows the students' scores and the horizontal axis shows the students' numbers. The blue bar shows the CM score and the red bar shows the test score.

CM no. 2 is categorized in CM model 1. The acceptable difference average is 23.4 and the difference average acquired in the graph is 16.9. This shows that we can use the CM grades to rank the students according to their knowledge; and the higher grades are the superior students' scores.

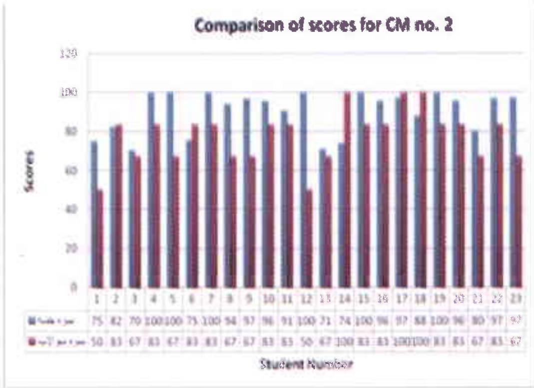

Fig 4. Scores of CM-2 and the related test

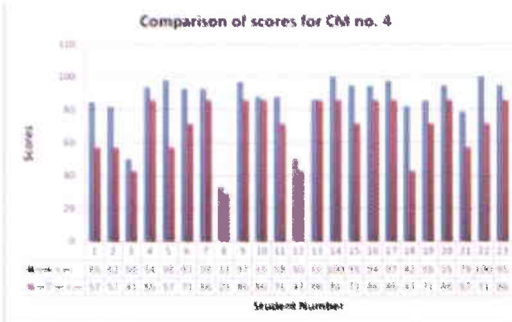

Fig 5. Scores of CM-4 and the related test

CM no. 4 is categorized in CM model 2. The acceptable difference average is 22 and the difference average acquired in the graph is 16. Hence, the grade difference between the two scores for each student is acceptable and the student with a higher CM grade is the superior student.

B. Discussions

We considered the test as an evaluation method. According to the superior identification rules in education, one who gains the grade of 17 out of 20 is believed to be a superior student. In this work, because of the test type (multiple choice questions) and few number of questions the probability of unwanted mistakes increases. Hence, we considered the grade 15 as the base for considering a student as a superior one.

The difference between the CM and the test grade for CM-2 is shown in Fig. 6. As can be seen, there are some noises and great differences between these two grades. For example, students number 1, 5, 9, 12, 14 and 30. These differences are varied from small to great magnitudes. Some reasons for the mentioned differences are:

- ***Difference in the resources.*** The resources being utilized in construction of a CM and are not the same as ones being used for the tests.

- ***Similarity of some choices in the questions***. This causes some mistakes when students are pressed for time.
- ***The learning/teaching characteristic of CMs especially in model 1 or 2***. For some students this case causes the higher grade in CM and the lower grade in the test.
- ***Considering weight for the concepts***. In this case, when a student doesn't know the meaning of a concept, he/she will do two mistakes in the CM. The weight for this kind of concepts is 4 or 5. Hence the student loses at least 4 to 10 points. This can be another reason that the grade 20 is an acceptable difference in the CM and the test grade.
- ***Drawing the links direction wrongly because of hurries***: this causes to lose the CM grade.
- ***Do not taking attention to the CM construction models***: this causes some noises in the results or causes to decrease some points in the student's CM.

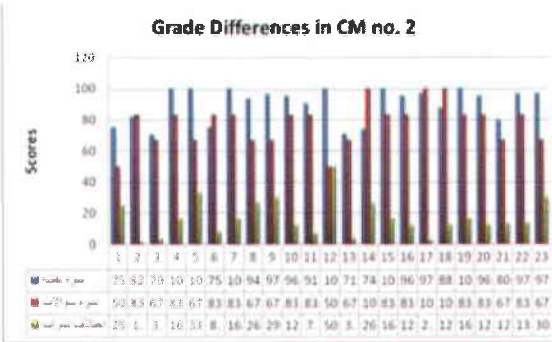

Fig 6. Grade differences in CM-2

C. *Important Parameters to Assess Expertise*

According to the definition accepted in this work, experts are those who can connect the concepts properly and know the different aspects of concepts very well [30]. The former is assessed by evaluating the CMs and the latter is assessed by considering the resources which are linked to the CMs by students.

The other expertise parameter considered here is the "difference level" factor in assessing the CMs. As stated before, this is actually the hierarchy characteristic of the CM and shows one ability and knowledge about the generality or detail of the concepts. This actually shows the structural knowledge of individuals about a subject domain. The student's proper knowledge structure and his/her ability to explain the concepts for other students are assessed by this factor which was one of our aims in this work.

VI. Conclusion

The obtained results show that there is a little difference between the grades of tests and the CMs which proves that CMs can show the students' expertise with the technique proposed here; and the CM assessment method used here is a proper method to show the expertise of students. In addition, some expertise parameters were assessed by this method. The class works and final grades of the students were matched to the gained results too. And the list of the superior students from the proposed method and the superior ones from the class were about the same; which verifies the achieved list by the *Concept Map Assistance* system.

The results show that the proposed method can assess the student's knowledge in different domain of subject very well. The parameters such as key words, key words' weights, utilizing resources, and considering the key words level are some other factors being utilized to assess the expertise. In addition, the proposed models for CM construction are effective in expertise assessment. Especially the third model shows the expertise of individual very well. This is due to the fact that students should position the nodes in a correct place. One of the noticeable results attained from this work is the learning characteristic of the first model proposed here, which can be used to enhance the students' comprehension.

By utilizing this method the instructors can use the CMs as an interactive tool for class assignments and also for declaring the list of the superior students. The instructors can also share the best CMs for other students and help them learning the concepts deeply. Other advantages of this work are: Automatic assessing of the CMs, Utilizing this method during the term, and Helping the students to learn

The proposed method do not have the limitations of the existing methods for expert finding: the existing expert finding methods need lots of discussions between the students or need the data about the relationships or resource usage during a long period of time.

VII. Future works

In this work, the meaningful assessment compares the exact concepts between the reference CM and the student's CM. The *Concept Map Assistance* system is not case sensitive. By means of natural language processing methods, in the cases that students using different words with the same meaning, the resulting noises could be removed. This work can be extended by:

1. Finding other expertise parameters which can be used in CM assessment for expert finding.
2. Adding trust models or using signal theory for evaluating knowledge change of students after sharing the CMs constructed with superior ones.
3. Weighting the resource categories and the relatedness of resources with the CMs as two other expertise parameters.
4. Expanding the difference level parameter and evaluating this factor and its importance by other methods like interviewing.

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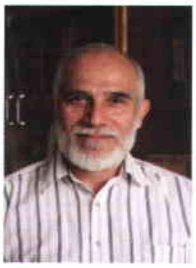

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