Using a Recommender System to Suggest Educational Resources and Drawing a Semi-Automated Concept Map to Enhance the Learning Progress

Golsa Mirbagheri1*, Mojdeh Hakimian2* and Ahmad Agha Kardan3
1 Department of Computer Engineering and Information Technology Amirkabir University of Technology Tehran, Iran
2 Department of Computer Engineering and Information Technology Amirkabir University of Technology Tehran, Iran
3 Department of Computer Engineering and Information Technology Amirkabir University of Technology Tehran, Iran
*These two authors contributed equally to the work.

Abstract— Concept maps are effective graphical tools for representing and organizing knowledge of learners and diagnosing students’ misconception in educational environments. Considering the fact that constructing concept map manually is a complicated and time-consuming task and updating them is a boring job, they have not used widespread in educational environments. So constructing these maps in a semi-automated way is a preferable method. Another problem that learners in the e-learning environments may have is the growing amount of information and educational resources on the internet. Therefore, the use of guiding systems to introduce the resources to users is becoming more and more popular. Also, it’s better if the materials proposed to the learners be in accordance with the level of their knowledge and learning situation. To end this, our paper suggests the construction of concept maps in semi-automated way and the use of a recommender system to propose appropriate resources. To make the learning guidance more understandable to the student, this study defines some fuzzy systems.

In this paper, proposed recommender system suggests some resources to the users and then the users take part in the related test. Once the test is carried out, the users’ learning level in each concept is determined and the initial concept map is drawn using the concepts which have been learned. Then this map is completed by the feedbacks given from the system to the learner, in each step and in this way the learning process completes. This procedure will continue until the completion of the concept map and the learning process finish.

Index Terms—Recommender system; concept map; e-learning; fuzzy logic; assessment; feedback presentation

I. INTRODUCTION

The growing amount of information on the web and internet has made it quite a difficult job for the users to make informed decisions about choosing appropriate resources and information. This problem has caused the researchers to try and find a solution to overcome this major difficulty of the new era, known as “Information Overload”. One of the proposed solutions is making use of recommender systems.

Also concept maps provide very useful tools for the visualization of a person’s summarized a knowledge. It can be difficult to properly identify the concepts and the relationship between them, therefore, there is a need of methods capable of doing so. Concept maps have numerous applications in educational fields. As an example, these maps have been used as tools of showing a learner’s previous knowledge of the educational concepts and consequently can aid in the learner’s better and deeper learning in the following steps [1].

Different definitions of recommender systems have been proposed. In one of these definitions, RS is a subset of DSSs (Decision Support System) and is defined as an information system which is capable of analyzing the past behaviors and offering recommendations for the current problems [2,3].

In fact, these systems simulate the process used in everyday life and execute it automatically. In other words, it is the same procedure in normal life where an attempt is made to find people with similar interests and ask them about their choices. The recommendations proposed by the recommender systems may have two results in general:

1. Helping the user in making a decision (like helping him make the best choice out of the options available ...)
2. Increasing the user’s knowledge of his field of interest (by providing the opportunity for the user to get acquainted with newer related items)
A person’s knowledge is in fact a network of concepts and each of these concepts are known in different extents by that person. A Concept map is a space which enables us to know about the person’s learning status regarding these concepts. Other methods that are used, to assess the concepts, consider them as a whole, while a concept map tries to make an assessment of all concepts separately. Concept maps have many applications in educational systems such as: assessment of people’s knowledge, searching for information, aiding in knowledge sharing,
being used to show learning methods, engineering of processes with similar trends, etc.

The main goal of the present study is to help the users of e-learning environment make the best choices for enhancing their learning in the shortest time by receiving suitable recommendations related to their characteristics. Since in this method construction of concept map is semi-automated, it offers numerous benefits such as enticing the learners for using the concept map, raising the level of learning, viewing the people’s real understanding of the concepts, presenting suitable feedbacks to improve the learning process, simplification of concept map construction procedure, etc.

A. Necessity and definition of the problem

First, “Information Overload” is one of the problems faced by many students in eLearning environments. Checking too many websites to get information about the latest resources is a very time-consuming job. Shortage of time, costs and confusion are the main problems that the learners face. An appropriate solution which provides the possibility of accessing the desired resources with less cost and time is using the recommender system.

On the other hand, concept maps are very useful tools in educational environments; however, they are not being extensively used. The main difficulty of the concept maps is that they have to be constructed by learners or teachers and it is not a simple and quick visualization tool because of the formal rules that have to be abided by. It can be difficult to properly identify the concepts and the relationship between them. Therefore, learners do not show the tendency to use this tool for learning goals.

In other words, the user will be confused by the huge amount of information. To avoid such a case, the user's confusion must be reduced by receiving suggestions relevant to his choice. Finally, the learning process takes place in a better way by viewing the concept map related to the learning status and receiving the feedbacks [3-10].

II. BACKGROUND

In this section, we will present definitions for concepts and expressions which are essential for a better understanding of this paper.

A. Recommender system

In order to fully understand the recommender system, first we need to focus on four basic concepts.

Target user (main user): In the recommender systems, the target user is defined as the one for whom the current recommendation in the system is being processed and prepared.

Recommender system: In order to overcome the problems caused by the huge amount of information, recommender systems are presented as a solution. Other than presenting the users’ desired information, these systems also try to personalize each user’s experience of using the web. In the most popular categorization, three types of recommender systems are considered: content-based method, Knowledge-based method and collaborative filtering method. Often a fourth type is also introduced known as Hybrid recommender.

Collaborative filtering method of recommender system: One approach to use the recommender system is the use of Collaborative Filtering algorithms. In this approach, instead of using the items’ contents, the ideas and rankings provided by the users are used for recommendations. In other words, recommendations are produced by calculating the similarities between the interests and the choices of the target user and the ones of the other users.

Content-based method: In the content-based method, the items are recommended based on the similarities they have with the target user’s interests. In this method, the main focus is on finding similarities between items.

User-based method: This method is one of the first and most known recommending methods. Here the users’ interests are modeled based on the users’ scoring of the items and these scorings are used to estimate the similarities between the users’ interests.

Item-based method: In this method, instead of using the correlations between the users and similar users’ ideas as in user-based method, item-item correlations are utilized. This means that in this method, the recommended items are similar to the user’s previous items of interest.

Knowledge-based method: In this method, the recommendations are proposed based on the knowledge of customer’s needs and the items’ specifications. In this type of recommender systems, the system’s knowledge of the customer and the items provide the basis for the lists of suggestions. These systems utilize various methods suitable for knowledge analysis such as genetic and fuzzy algorithms, neural networks, etc [11].

Hybrid method: The fourth type of recommender systems are the Hybrid ones. The designers of these systems combine two or more of the previously mentioned three types to achieve two main goals: 1-increasing the system’s performance and 2-reducing the effects of the weak points of each individual type. In this paper, a system is designed using the CF algorithm to suggest educational resources to the learners [2,12-13].

B. Concept Map

Concept maps were first introduced by Novak in 1970 in a research where he designed and used them as tools of illustrating knowledge. In fact, a concept map is a way of showing knowledge and it consists of a graph-like network to illustrate concepts and the relations between them [1]. The main components of a concept map are:

Node (Concept): Predefined events or items as conceptual words which appear in a square.

Link: The related concepts are connected using labeled lines. The concept labels are usually words. However, in some cases symbols like + and % are also used.

Proposition: The related concepts and the kind of relation between them are shown through a meaningful proposition. A proposition is created when two concepts

The International Conference on E-Learning in the Workplace 2019,  www.icelw.org  2
are connected using a connector line and some words to give meaning to the proposition.

In Figure 1, a sample of a concept map is shown. In this example, the concepts of “concept map” and “illustration of knowledge” are connected to each other with the word “visual tool for” to create the meaning “concept map, a visual tool for illustration of knowledge” [3, 14-17].

C. Fuzzy logic and Fuzzy systems

In the conventional methods for extracting people’s knowledge, the learner’s overall level is shown by accept or fail and the percentage of knowledge is not clarified. Using the fuzzy logic, the extraction of knowledge takes place in a more accurate manner and it is possible to know to what extent has each learner understood which concepts or to what extent has he/she had problems learning them. As a result, considering the extent of a person’s knowledge helps us make corrections and enhancements in the upcoming steps [18-20].

Fuzzy logic was first introduced by Professor Lotfalizadeh based on Set theory [4]. The traditional Set theory can be considered as a black and white case where the member “m” belongs to the set A or it simply doesn’t. However, the Fuzzy logic presents a gray case where the member “m” may belong to set A with a specific membership function and may belong to set B with another membership function. In the Fuzzy logic, we deal with linguistic variables, linguistic values and membership functions (which is a number between 0 and 1).

D. Fuzzy system

Related to its type of design, a fuzzy system receives some inputs and then it performs inference operations on them using the fuzzy logic concepts and finally creates the corresponding outputs [3].

Figure 2 shows the existing components of a Fuzzy system.

Fuzzy constructor: Conversion of deterministic input values to Fuzzy values happens in this section. Fuzzy rules base: A fuzzy system consists of a set of rules in the form of IF-THEN which are expressed by the system designers. They have the general form of:

If $X1=A1, X2=A2, ..., Xn=An$, then $Y=B$.

Inference Engine: The fuzzy system starts inference using the Rules base and Fuzzy logic. This inference engine can function either by combining the rules or by using separate rules. For a fuzzy system, different inference engines have been designed. “Mamdani”, “Product”, “Lotfalizadeh” and “Łukasiewicz” are most known among the engines [21]. Non-fuzzy constructor: It is used to convert the fuzzy values to deterministic values.

III. PREVIOUS WORK

The studies related to the subject of the present paper are considered in two sections: recommender system and construction of concept map. Section (1) will focus on the studies related to the recommender system and section (2) will discuss the research studies of concept map and then we will compare our work with pervious works.

1. Algorithms in Recommender Systems

Collaborative Filtering algorithm is one of the important methods of producing suggestions. Although these algorithms have generally proven to be effective, they have some problems which make them unusable for a specific group or people [5,25-30]. Some problems which occur in this case are Cold start and Sparseness problem. These relate to the condition when the system has no information regarding the interests of the user and consequently can give him no information [6]. In [7], the OWL (Organization-Wide Learning) recommender system is utilized for the purpose of learning IT capabilities in the organizational level. In this case, when the users ask the OWL which soft wares they need to learn, OWL gives them suggestions based on the activities of their similar co-workers [8].

[9] presents the various limitations of the current generation of recommendation techniques and possible extensions with model for tagging activities and tag-based recommender systems, which can apply to e-learning environments in order to provide better recommendation capabilities. In [10], cosine similarity method is used to express the resemblances between the items. In [11] and [12], a recommendation is created using the concept extracted from the user’s profile. Too
many resources are used to reach this goal. Therefore, the website of Wikipedia is selected due to its related topics and being up to date. The average quality of the information on the web is too weak.

In [13], the educational system of Adaptive Hypermedia Systems (AHS) is used to personalize a virtual character for interaction with the user through a special recommender system. In [14], a working frame is proposed for EPERS (Expert Personalized E-learning recommender System). An EPERS helps users find educational content and it is the best choice for them based on their needs. To this end, a special rule-based system is considered for finding the suitable educational content.

In [15], a recommender system is proposed that uses tagging to suggest a user’s references of interest to him by considering the tagging properties and its resemblance with the user’s model. In [16], a new algorithm for estimating tag connector and tag orientation is investigated and the role of tag in improving the performance of tags plantation is studied by a user study.

A. Construction Concept Maps

[17] presents the investigated outcomes for students when support for the development of SRL was embedded in a PBL medical curriculum. This investigation involved design, delivery and testing of SRL support, embedded into the first phase of a four-year, graduate-entry MBBS degree. [18] presents a method for automated constructing of the concept map based on the fuzzy rules and users’ test records. In this method, Fuzzy rules and fuzzy inference techniques are used to draw the concept maps. He also used the data mining techniques to construct concept map. In another work by Paulo R. M. Correia, concept maps have been used to educate beginners. In this project, the learners had to extract the main concepts of the lesson and then complete the half-constructed map together. After the completion of the map, they received a feedback from the teacher. This method caused the learners to draw the concept map of the lesson in a short time and it improved the education time [5].

In [19], the Apriori algorithm for concept map is utilized to develop a smart concept identification system. This method made the teachers to quickly find out the learning limitations and the learners’ mistakes. [30] presents a method for concept maps which leads to a better visualization and finding all the connections between the concepts in the field of computer engineering. The proposed map helps present an overview of the related field. Fuzzy rules have also been used to assess the learners. In [31], a method for automated construction of grade Membership Functions base on fuzzy rules is presented.

In [1], an attempt has been made to construct concept map for e-learning from academic papers. In [23], fuzzy rules and fuzzy inference techniques have been used to construct concept maps in an automated way and assessment of the degree of relation between concepts. In the research work of [24], TP-CMC (two-phase algorithms) used to draw the learner’s concept maps, where in this algorithm the learner’s test records and fuzzy rules are used to construct concept maps. In the resource [25], fuzzy rules have been used to draw concept maps. To draw concept maps in an automated manner, student’s test records were used and the following phases were considered: a) Using the theory of fuzzy sets to convert numerical test records to symbolic data and using data mining to obtain grade fuzzy association rules: b) Analysis of the obtained rules to create the essential connections between the groups of concepts of test items based on our observations of real learning situations. Some of the criteria considered in the maps’ evaluation are as follows: considering the volume of the map, number of the correct expressions with respect to the map volume, concepts with high value in the maps, scoring the expressions and scoring the cross references.

Ben E. Cline et al. proposed a method for assessing concept maps automatically. In this method, the assessment of concept maps is executed by logical and structural evaluation using expert map based on the structure of the expressions and their hierarchy compared to the expert map [24].

Hwang discussed the Concept Effect Graphs in which the educational concepts are placed together in tree diagrams. In this work, he used the concept effects table to show the relations between the concepts. In this table, the number “one” shows the relation between two concepts and the number “zero” means that there is no relation between them, Ci represents the possible prerequisite concept of Cj [27]. In table 1, for example, the concept C2 is prerequisite for C3 and consequently number “one” is put in the table which shows the relation between these two concepts.

<table>
<thead>
<tr>
<th>Prerequisite</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8</th>
<th>C9</th>
<th>C10</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>C9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NP</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

NP: Number of prerequisite concepts for Cj
Ci: Indicator of prerequisite concepts of Cj

Measurement of educational performance is usually expressed numerically, based on examination results. Classical evaluation therefore consists of a judgment based on the comparison of student results against established performance-criteria.

IV. OUR ACHIEVEMENTS IN THIS WORK

In the interactive educational environments, it is necessary to have human-computer interaction. This
interaction exists in the proposed method because of the recommendations that are given to the users of the second group for studying. In this way, the user receives more suitable resources in shorter time by getting recommendations from the system.

The advantages of this proposed system are:
- Other than the known concepts, the troublesome concepts for the learner are also found.
- Learning level in each concept is assessed and also the assessment results are not in numerical form, but in the form of suggestions to the learners and the main goal is to increase the learning level of the learners.
- In each of the concepts, the amount of the learner’s knowledge is determined.
- The learner is allowed to present resources similar to his own and as a result it is possible to access some of the resources which were not considered before.
- Understanding key points is faster and more accurately and the best recourses will be introduced to learner

The innovation of the present study is to recommend resources to users and construction and completion of Concept map in a semi-automated way and also have the cooperation of the learner in each step for the completion of the map. Also, the results of people’s tests are taken into account in the recommendations given to the learner and this leads to utilization of this method in partially smart environments.

V. RESEARCH METHODOLOGY

In this project, two user groups of 30 people login to the website in determined time intervals. In the mentioned website, there are 30 resources related to 10 concepts in the field of paper writing. If the user chooses 10 suitable resources out of 30, it will cause confusion. But the problem can be solved to a great extent if the system recommends the suitable resources in an automated manner.

The users of the first group after the registration, entered the resources section and study the 10 resources. This group of users had access to the resources in the system and after selecting the resources and entering the “comments” section could score the selected resource and leave comments (The scorings of the users of the first group are used to give suggestions to the users of the second group). Considering the fact that each resource includes several concepts, the resources related to each concept must be separated from each other in a table and the user must be able to choose a resource from each concept. After choosing 10 resources and commenting on them, the users enter the test section and take part in it. After the test, the learning status of each concept is shown to the learner in the form of a concept map. If there is a need for another test, the system will identify the concepts related to the questions with wrong answers and will recommend one resource from the resources related to each concept. The user will continue the process of studying the recommended resources and taking the test and repeating this step until complete learning of the concepts (maximum of 3 times).

It must be noted that the scores of the resources will be defined by three experts. If the user scores a resource more than the one score range of the defined score, the system will not accept it and will consider the average of the three experts’ scores instead of the wrong score. One score range includes half a score higher and half a score lower than the given score to the related resource by the three experts. This is done to avoid recommendation of wrong resources from the system due to the users’ wrong scoring.

VI. RESOURCE SELECTION CALCULATION

The resources similar to the resource selected by the target user are calculated by the system using the correlation similarity formula:

\[
\text{sim} (i, j) = \frac{\sum_{u \in U} (R_{ui}^2 - \overline{R_i}) (R_{uj}^2 - \overline{R_j})}{\sqrt{\sum_{u \in U} (R_{ui}^2 - \overline{R_i})^2} \sqrt{\sum_{u \in U} (R_{uj}^2 - \overline{R_j})^2}}
\]

(1)

\text{sim} (i, j) shows the resemblance between resource i and resource j. It shows how much resemblance there is between the resources i and other resources like j.

\(R_{ui}\) shows the score that the user u has given to resource i. \(\overline{R_j}\) shows the average of the scores that the user u has given to the resources available in the system. Therefore, the resource that obtains a higher value in this formula is more similar to the resource i [2,14].

VII. CONSTRUCTION OF THE INITIAL CONCEPT MAP

In the first step of this research, some main concepts related to the presented lesson are chosen. The relation between the concepts is determined in the concept effect table, as depicted in table 1. The reference Concept map is created by an expert based on the extracted concepts and the relations between them. This map is drawn in the Cmap.
tools software. CmapTools is a tool that allows the user and the program to interactively construct concept maps. CmapTools allows integration of other multimedia resources into the concept maps [30-32].

Figure (3) shows an example of concept map that one of learners achieved, as shown, learner should study recourses about C7, C8, C9, C10 and C11.

![Sample of learner concept map](image)

We used 4 colors in concept maps to show the level of learning in each concept. Descriptions are attached as table 2. These percentages are calculated according to the formula (2).

<table>
<thead>
<tr>
<th>Color of the node related to Cj</th>
<th>P(Cj)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>0.75&lt; P(Cj)&lt;1</td>
</tr>
<tr>
<td>Orange</td>
<td>P(Cj)=0.75</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.25&lt; P(Cj)&lt;0.75</td>
</tr>
<tr>
<td>Green</td>
<td>0&lt; P(Cj)=0.25</td>
</tr>
</tbody>
</table>

System presents learning guidance to users in Table 3

<table>
<thead>
<tr>
<th>Color of Cj</th>
<th>Learning Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>It seems that you misunderstood the concept Cj</td>
</tr>
<tr>
<td>Orange</td>
<td>It seems that you partially misunderstood concept Cj</td>
</tr>
<tr>
<td>Yellow</td>
<td>You have learned the concept well</td>
</tr>
<tr>
<td>Green</td>
<td>You have learned the concept very well</td>
</tr>
</tbody>
</table>

VIII. TEST DESIGN

In this research, the questions of the test are of multiple-choice type or true-false type and they are designed by an expert (which here is taken to be the instructor of the lesson) based on the lesson contents and the users’ answers are received in a pre-defined form. The questions are designed in a way that each question includes one or more than one of the educational concepts. Using the TIRT (Test Item Relationship Table) table, the relation between each of the questions and the educational concepts are determined.

The relation between each question and the lesson concepts needs to be clarified. Each value of TIRT(Qi,Cj) is a number between 0 and 5 which shows the extent of relation between the question Qi and the concept Cj. The number zero shows no relation and the numbers from one to five present the intensity of the relation. Sum(Cj) is the sum of the Cj concept in the tests [30].

If the student fails to answer only one question, the probability is calculated from the ratio of TIRT(Qi,Cj) to ΣCj. If the learner fails to answer more than one question, then formula (2) can be used to calculate failing rate for each concept. P(Cj) shows the probability of the learner’s failure in answering the concept Cj[23].

\[
P(C_j) = \frac{\sum_{i=1}^{m} (1-A_j) \times TIRT(Q_i,C_j)}{\sum_{i=1}^{m} TIRT(Q_i,C_j)} \times 100,
\]

\[j = 1,2,...,n\]

Let A show the answers of the learner to each of the questions and m be the number of test questions. If A=1, it means that the learner’s answer to the question Qi is correct. Otherwise we have A=0 [2,4].

If A is shown as A={1,1,...,1,1,...} and m=10 and we consider the TIRT table (Table 4), it shows that the learner has failed in answering questions related to C1, C2 and C3 by 50%, 28.5% and 58.33%.

Respectively. Also, it shows that the learner has not understood the concept Cn, because P(Cn)=1. Figure (4) shows a complete concept map after learner could answer all questions correctly and understand all concepts and shows the final concept map that learners should achieve.

<table>
<thead>
<tr>
<th>Color of Cj</th>
<th>Learning Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>It seems that you misunderstood the concept Cj</td>
</tr>
<tr>
<td>Orange</td>
<td>It seems that you partially misunderstood concept Cj</td>
</tr>
<tr>
<td>Yellow</td>
<td>You have learned the concept well</td>
</tr>
<tr>
<td>Green</td>
<td>You have learned the concept very well</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COLOR</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Orange</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>...</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Yellow</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>...</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>...</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Red</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>...</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Orange</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Yellow</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>...</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Green</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>...</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Red</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>...</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Orange</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>...</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

\[\sum_{i=1}^{n} C_i = 16, 14, 12, 12, 10\]
To convert the numerical data of values of $ER(C_j)$ to symbolic data, three membership functions are defined for each of the concepts. In the Fuzzy results, “Low”, “High” and “Medium” show the learning statuses “weak”, “good” and “average”, respectively. (Figure 5)

For the Fuzzification of the values of variable $ER$, first for a given value of $ER$, for example $ER(C_j)$ that belongs to one or more membership functions, we calculate the value of $y$ for each membership function to which $ER(C_j)$ belongs. The value of $y$ must be between 0 and 1 (Here $x1$, $x2$ and $x3$ show the values of each membership function in Figure 5 2.[24]. In Figure 5, the horizontal axis shows the learner’s mistake ratio in percent and the vertical axis shows the membership degree of each of these values in the membership functions.

The learning status in each of the concepts is equal to:

$$\text{Learning Status} = \text{Max}(y_{low}, y_{medium}, y_{high}) \quad (3)$$

- If the learning status of concept $C_j$ for the learner $i$ is High, then this learner has learned this concept very well.
- If the learning status of concept $C_j$ for the learner $i$ is Medium, then this learner has had some trouble learning this concept.
- If the learning status of concept $C_j$ for the learner $i$ is Low, then this learner has not learned this concept.

A. The system architecture and its operating algorithm

In order to test the proposed method, an e-learning base is needed which can support the suggested method. To this end, a web-based teaching system using Asp.net and the SQL-server database was provided for the learners. This system was designed to instruct a portion of concepts related to paper writing. In this system, a personal page was assigned to each user once they logged in and permitted educational activities were provided for the user and he/she was guided through the required steps to do the activities by numerous guiding messages. The components of the system are shown in Figure 6.

Learner’s profile database: It includes general information and the learning status of each of the learners. This database provides the required data for the test and diagnosis section following which the expert Fuzzy system creates the status of each learner after analysing the tests.

Recommender system: used to collect the student’s usage and interaction information, then stores student’s interests about the resources in database, it shows the learner the suitable resources in accordance with his/her choice based on the system’s input data.

User interface under Java: It controls the registration and login process and lets the user’s access the system using web browser.

Test and diagnosis unit: After a successful login, the user can study the lesson and then take the test. Then, based on the test results and the answers, the concept map that the user needs to complete is shown to him/her.

Fuzzy interface: It translates the user’s test parameters to fuzzy parameters. These Fuzzy parameters along with some fuzzy rules are sent to an expert system for starting the inference process.

Concept map builder: Using this interface, the learner’s concept map is created and it is possible to add concepts and links and edit the concept map. When the learners submit their answers, the server gathers all the answers from the clients and saves them in 5 text files:

- Question-id file, users’ answers file, correct answers file, related concepts file and the file related to each of the concepts in the test questions.

After the inference process, 2 text files are created:

One file for the concepts that have been fully learned and the other for the problematic concepts. Based on these files, the server provides the required guidance for the learners. Once the learners answer the test questions,
their status in each of the concepts is determined and by considering the learning status table, some recommendations for increasing the learning level of the learners are presented to them. Also the related Concept map is shown to them. Fig. 5 illustrates a fuzzy membership function related to learning status of concepts and ER(Cj).

IX. ASSESSMENT OF RESULTS AND ANALYSIS OF DATA

The SPSS10 software is used in order to analyse the data. T-test is used to study if the averages of the two groups have meaningful statistical differences. In this case zero assumption means that the two groups have similar averages. If the results of the test do not verify this assumption, it can be concluded that a meaningful result is obtained.

Since the used tests were of multiple-choice type, for each question, a correct answer received 2 scores and zero score was assigned to the other answers and based on this scoring system, the final score of the learners was calculated. Considering the normal distribution of the data, parametric tests are used to analyze the obtained scores.

TABLE V. LEARNING STATUS OF EACH CONCEPT

<table>
<thead>
<tr>
<th>Learner</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8</th>
<th>C9</th>
<th>C10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>2</td>
<td>H</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>3</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>4</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>5</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>6</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>7</td>
<td>H</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>9</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>10</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

Table 5 shows the level of learning for 10 learners in each concept. In order to investigate the learners’ scores in the pre-test and the third in the groups, even T-test and in order to compare the scores of the two groups, the independent T-test is used. A total of 60 students in two groups (each group includes 30 students) take part in the tests, including 33 females and 27 males in the range of 21 to 23 years old.

A. Comparison of the two groups ‘pre test

As it is shown in the tables 6, the average scores of the groups are almost the same and there is no meaningful difference between the averages of the two groups based on Independent T-test. (p>0.05)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Average</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test 1</td>
<td>30</td>
<td>5.70</td>
<td>2.191</td>
</tr>
<tr>
<td>Pre-Test 2</td>
<td>30</td>
<td>5.60</td>
<td>2.313</td>
</tr>
</tbody>
</table>

After the test was finished, we did ANOVA test on 3rd exam scored between two groups, as shown in table 7 and table7.

The variance is homogeneous based on table 6 (Sig.>0.05), there is a meaningful difference between the averages of the two groups, because the Sig. is larger than 0.05, as depicted in table8.

<table>
<thead>
<tr>
<th>Levene Statistic</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.774</td>
<td>1</td>
<td>58</td>
<td>.382</td>
</tr>
</tbody>
</table>

In this section, we study the results of the third test of the groups with the pre-test. Table 9 indicates the results of this test. The results show that, there is a meaningful difference between the results of the first and third tests in groups test results.
TABLE VIII. ANOVA TEST

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>MeanSquare</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>504.600</td>
<td>1</td>
<td>504.600</td>
<td>22.341</td>
<td>.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>1310.000</td>
<td>58</td>
<td>22.586</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1814.600</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The scores of the second group (which used the method of resource recommendation and concept map for learning) in the probability level of 0.05, are higher in a meaningful way. This leads to the conclusion that both of the educational methods are useful for improving the students’ learning and knowledge. Other findings show that the scores of the first group (in which the recommender system for resources was not used) were lower compared to the ones of the second group.

TABLE IX. DESCRIPTIVE STATISTICS BETWEEN 3rd AND PRE-TEST

<table>
<thead>
<tr>
<th>Group</th>
<th>Test</th>
<th>N</th>
<th>Average</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3rd Test</td>
<td>30</td>
<td>15.60</td>
<td>4.215</td>
</tr>
<tr>
<td></td>
<td>Pre-test</td>
<td>30</td>
<td>5.70</td>
<td>2.313</td>
</tr>
<tr>
<td>2</td>
<td>3rd Test</td>
<td>30</td>
<td>9.80</td>
<td>5.235</td>
</tr>
<tr>
<td></td>
<td>Pre-test</td>
<td>30</td>
<td>5.60</td>
<td>2.191</td>
</tr>
</tbody>
</table>

The difference between the test averages in the two groups shows that the test results averages in the second group (which used recommender system) are higher than the first group. In Figure 7, the learning statuses of the learners in the three tests are compared with the pre-test. As it can be seen, the second group’s improvement (that was trained with the proposed method) is more considerable compared to the first group.

Figure 7. Comparison of scores average in the two groups with the pre-test

X. CONCLUSION

With the growing advances of technology in e-learning, using educational recommender systems have become inevitable. It seems very likely that in the near future, these systems will be an inseparable part of the educational system. The recommender systems show a great capacity for further improvement and so far, different technologies have been used to develop such systems. Providing recommendations for the learner and the teacher and scoring each activity of the learner are among the benefits of such systems.

Drawing concept maps sometimes seems a complicated task and it is really difficult for the learners to construct concept maps and draw the concepts and the relations between them. Also, the process of constructing these maps must be in a way that their updating and assessments should be possible. In addition, in most educational systems, assessment of learners’ knowledge level is done through their scores.

This means that numerical scores are given to the learners as feedbacks and this kind of feedback does not improve the learning process and the learner is not encouraged to improve his knowledge level. So, it would be much better if a learner’s assessment results are presented in the form of some statements showing his/her learning level and some recommendations for improving his/her learning in the concepts which have not been learned well.

In this research, architecture for using concept maps in e-learning is proposed which is capable of reducing the difficulties in constructing the concept maps to a great extent and it also provides the possibility of the maps updating. In this method, the feedback is not presented in the form of numerical scores, but they appear as recommendations for improving the knowledge level of the learner. After studying the lesson and taking the test, the learners are taken to the concept map page related to them. In this map, the learners can see the concepts they have fully learned and to view the other concepts, they are recommended to re-study the useful concepts for their improvement and their concept map is completed once they manage to give correct answers to questions regarding these concepts.

In this way, since the learner is eager to see the completed concept map, he/she has to study the lesson again and take the test. This process causes an improvement in the learning process. Another advantage presented by this method is: Reaching a deeper learning for the learner and understanding the problematic concepts as well as the learned concepts.

XI. SUGGESTION FOR FUTURE STUDY

- Combining this method with Moodle system to make it practical in educational environments and providing the basis for developing similar algorithms
- Checking this method for other subjects and learners to verify the initial results
- Future research could be conducted on the use of concept maps in educational environments to help students develop propositional statements when constructing concept maps and represent their technical knowledge.
• Using graphical images to make the presented feedbacks more attractive
• Using face detection algorithms to know about the users’ moods for education and taking the test
• Using scheduling method for each activity to increase the user’s concentration and efficiency
• Scoring each activity of the learner in order to encourage him/her and to increase the interaction in the system

REFERENCES


AUTHORS

Golsa Mirbagheri is Ph.D. student at computer and Electrical Engineering Department of Clarkson University in NY/USA (e-mail: mirbaggg@clarkson.edu).

Mojdeh Hakimian is graduated student at Department of Computer Engineering and Information Technology at Amirkabir University of Technology in Tehran/Iran (e-mail: mjhakimian@yahoo.com).

Ahmad Agha Kardan is Assistant Professor at Department of Computer Engineering and Information Technology at Amirkabir University of Technology in Tehran/Iran (e-mail: aakardan@aut.ac.ir).

Manuscript received 25 March 2019. Published as submitted by the author(s).