ICMAP: An interactive tool for concept map generation to facilitate learning process

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Abstract

Human-computer interaction could play an essential role in learning. In distance learning, interactive tools can facilitate the learning process for teachers and students. In this article, the design and implementation of software will be introduced which helps users to learn more with the help of interactive instructions and concept map (Cmap) generation. Cmaps are graphical visualisations of knowledge about a topic, in which the concepts of a subject are meaningfully related to each other. Cmaps are widely used in E-learning and proved to be helpful to learners and informative to teachers. The step-by-step process of making a Cmap by means of specific tools with specific interfaces will result in a better learning process. Therefore, with this tool, a learner can make Cmaps stage by stage with necessary textual or graphical instructions. Other interactive features such as colours and message boxes are utilised to instruct, assure or warn the user when making a Cmap. Some other attributes of the tool help teachers receive a report about students’ frequent mistakes in order to understand which part of the course should be developed.

Keywords: Human computer interaction; Interactive tool; Distance learning; Concept map; Learning process

1. Introduction

The constructivist model of learning contains the idea that students should participate in the formation of information gained or taught [1]. Based on Ausubel’s work developing a constructivist learning model, Marshall et al. mention: “people learn through active exploration when exploration uncovers inconsistency between experience and current understanding [2] Based on the constructivist model of learning, concept mapping has been identified as an effective learning tool” [2]. The use of Cmap is believed to facilitate meaningful learning [3].

Cmap is a knowledge representation tool which is one of the learning tool categories. These tools help the learner capture or review knowledge through visualisation. Cmap can keep a learner engaged in an active learning process by helping a learner construct their knowledge about a topic and relate the concepts meaningfully [2]. In short, Cmaps are graphical visualisations of knowledge about a topic and are widely used in different levels of education. They are helpful in education, research, creating new knowledge, writing, managing organisations and so on [4]. There are many tools to help users construct a Cmap with the aid of computers [1, 2, 4, 5, 6]. Some are web-based

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and some are not. Some of them utilise features to help the user construct a map better, use resources for it, search the web for new concepts, search others’ Cmaps or use experts’ Cmaps [4]. Some of the concept-mapping tools are designed for instructors and are meant to be used in classrooms or as an evaluation tool.

Regarding the constructivist model of learning, in concept-mapping tools with the purpose of learning, interaction can play an important role in the learning process and knowledge acquisition by the student. Interaction through a computer interface with representations such as Cmaps could be summarised in what the user does and the response to the user’s action. Sedig points out that a system’s response increases interactivity and has some benefits. For example, “making mental manipulation of ideas easier; providing opportunities for discovery; and, serving as a coordinator between the internal mental models of users and an external representation” [7]. But in many tools, interaction is only used in features like changing the colour of the Cmap, modifying the Cmap or suggesting words [6]. The second interactivity part – systems’ response to users – is ignored for the step-by-step construction of Cmaps.

In this research, we considered the interactive generation of concept-mapping and our purpose was to facilitate the learning process. We used simple interactive features with a scenario for this interaction to help learners construct a Cmap. In step-by-step Cmap generation, our system makes users’ actions easier and communicates with users for all actions, in the form of assurances or warnings. This system can be used in E-learning environments, where teacher and students are not in touch with each other directly. It has some benefits for use as an educational tool in virtual environments; these benefits are discussed in other sections. In addition to features for students, some attributes of the software can help teachers in course design to find which parts of courses are misunderstood by students.

1.1. Concept map (Cmap)

The origins of Cmaps in education can be found in Novak et al.’s work [8]. They used Cmaps as a learning tool to help meaningful learning. Cmaps show the relationship between concepts within a particular topic, with the help of nodes and links. Nodes or boxes contain the concepts and are linked together with lines. A word or phrase is usually written on the connections, which shows meaningful relationship between the concepts. The phrase on the link is called a linking phrase [5, 8]. It is considerable that each pair of concepts and the linking phrase between them can make a proposition [3] and hence can help students to gain knowledge. Cmaps are a good tool for experts’ knowledge representation and sharing [3] and this can achieve one of the aims of ICMAP: help the students learn more.

![Fig. 1. (a) ICMAP client side architecture; (b) ICMAP server side architecture](image-url)
2. System design and implementation

In this section the design considerations to achieve ICMAP goals and design system architecture will be discussed.

2.1. System Architecture

ICMAP is a web-based Cmap generation system, which helps instructors to facilitate the learning process. It can be used by teachers and students for many different courses. The system administrator can add or delete administrator, teacher and student users, along with Cmaps themselves. Everyone has a user name and password for logging into the system and each category has particular privileges. The system architecture is shown in Fig 1. Teachers can generate a Cmap for each part of the course and save the map. Teachers’ Cmaps are considered reference maps, which are complete, correct Cmaps about a topic. The reference map is used to show students later, to help them complete a Cmap about a topic, and also to evaluate students’ Cmaps and actions. Other features of ICMAP related to students and teachers are discussed in the sections below.

2.2. Features related to the student

To improve learning processes in non-educational environments, we considered user-friendly interfaces which have two design points for implementing ICMAP. First, the interface should be designed such that students could be sure about their actions or receive some reward in the form of a game. In this way, the process of Cmap construction could become satisfactory for them and result in learning.

As stated before, Cmaps for each part are drawn and saved by the teacher, and shown in the form of blank or disabled Cmaps, in which the nodes (the circles around the concepts) are displayed without showing the links between them or including any label or colour. The blank Cmaps are shown to students with the concepts and linking phrase lists, and students must complete the Cmap and relate the nodes by using these lists through drag and drop action. A sample of a reference Cmap is shown in Fig 2 (a), and the blank Cmap in Fig 2 (b).

System usability has many features for designing and evaluation, but as Shackel concludes, a good interface design is necessary for usability, so that the system can interact with the user and serve her/him [9]. For this reason, the considered features for the ICMAP interface are: when the student logs into the system, he/she can choose the Cmap of any part of the course from a list with chapter and sub-sessions. After selecting one, a blank Cmap is shown in which the nodes become bold and colourful after completion. The chapter or sub-chapter title is known, so the student is familiar with the main concepts of the topic. In order to facilitate the work and avoid confusing the students, the concepts list and linking phrases are shown in different boxes at the right-hand side of the working area window. The student then may choose a concept and find the right place for it with a drag and drop action. The ease of this process will prevent exhaustion while filling a Cmap with a long list of concepts. It is important that a node’s correct place is not the exact spatial place and that it relates to the hierarchical features of Cmap – the level of a concept (distance from the root or the highest node of the Cmap) and its relation with other nodes.

The interaction features are used in the next part. In the drop action, if the concept is dropped in the right place, the node becomes enabled, the colour changes to green and the concept is omitted from the list in the right-hand box. In this way, the system assures the student that her/his action was correct and persuades him/her to continue making the map. If the concept is not dropped in the right place, the node becomes red and one wrong action will be submitted for the student.

After placing all the concepts, the learner should find the relationship between the concepts from the linking phrases listed in a separate box at the right-hand side of the Cmap construction window. The user can relate each pair of concepts by selecting one node and drawing a link to another one. If there is no relationship between the concepts, one mistake is added to the user’s mistakes, and the link becomes red and disappears. Once the links are drawn, the linking phrases can then be dragged to the links.
There are several reasons for using this model for concept-mapping in ICMAP:
- Facilitating the user’s work in constructing Cmaps
- Helping the student make a Cmap step-by-step
- Facilitating the learning process by step-by-step Cmap construction
- Making the process of constructing similar to a game
- Making the process easier by giving the list of concepts and linking phrases
- Making evaluation of a student’s Cmap easier by comparing it to the reference (teacher’s) Cmap
- Facilitating evaluation of a Cmap at the time of construction
- Assuring the student about every action in the Cmap construction process, which allows students and teachers to identify which parts of a chapter is not understood well.

This latter element relates to the hierarchy feature of Cmaps which is discussed in detail below.

2.3. Features related to the teacher

In addition to benefits for students, ICMAP also has benefits for teachers, who can log into the system and make Cmaps for different chapters of a course. These Cmaps, in addition to their use as reference Cmaps and for evaluation, can help the students to capture knowledge because they are representations of expert knowledge which is shared with students [3]. In addition to Cmap generation features, ICMAP has a reporting feature for teachers, where all the mistakes of all students in Cmap generation are listed. For each chapter, the mistakes are categorised so the teacher can find which parts of the course are not well-learned. Utilisation of this feature can help the instructor to re-design the misunderstood parts of the course.

3. Discussion on effects of ICMAP on learning process

The concept-mapping technique uses the constructivist model of learning, in which the learner is not only passive, but also active in the learning process by constructing learned ideas and information, and meaningfully relating the concepts learned about a topic. Concept-mapping is said to be an effective learning tool and to support meaningful learning [1, 2, 3, 7].

When students interact with a representation of knowledge (Cmap), they outline their understanding about concepts and the relationship between them in the representation; Sedig et al. mention [7]. Two aspects of the interactive features of Cmaps can be mentioned: the user’s action on the Cmap is represented in the software’s user interface window, and the system generates a response to what the user has done. The second point increases the level of interactivity and as Sedig mentions, has some benefits, such as supporting emergent understanding of encoded ideas; making mental manipulation of ideas easier; providing opportunities for experimentation, discovery,
and hypothetical reasoning; facilitating acquisition of qualitative insight into the nature of representations; and, serving as a coordinator between the internal mental models of users and an external representation. [7]

Interaction with visual representations has different types relating to factors such as continuous or discrete flow and direct or indirect focus. Additionally, there are multiple modes for interaction, such as manipulation and navigation. In a flow interaction, “the user’s perception of the effects of relationship between cause and effect in time space” is considered [7]. The main difference between manipulation and navigation modes, as is obvious from their name, is the ability to modify the representation [7].

In our work, we considered these types of factors, and especially the system response to the user. We used the interaction flow in which the system responds to user interactions simultaneously. As mentioned before, the learner receives acknowledgment of an action immediately. If the learner places a concept or linking phrase in the right node or link, the system assures the learner by enabling the node and changing the colour to green, or warns her/him by changing the colour to red and adding a mistake to her/his mistake counts in the text shown at the right-hand side of the Cmap generation window. In this way, the student manipulates the concepts, retrieves information or updates the concepts and has the opportunity to discover and acquire knowledge.

Another effect of interactive features of ICMAP on learning processes relates to the Cmap hierarchy. In a Cmap, concepts are categorised into common and detailed areas. This hierarchy is well-defined in a Cmap, with more general concepts at the top and more specific concepts in the lower levels [4]. Therefore, the correct positions of concepts shows this hierarchy, and the assurance of actions helps the student to learn the hierarchy of concepts in a visual representation. Additionally, when this hierarchy is made by the user interactively, their positions would be remembered or, in the case of an incorrect action, would make the user reconsider the wrong ones.

4. Summary and future works

In this paper we designed a tool with interactive features for the step-by-step generation of a Cmap in order to help students learn better in E-learning environments. ICMAP is educational software and can support a total course assignment for the teachers. We believe that the interactive features have learning effects for the students as discussed in part 3.

In future work, we suggest that course contents be used as resources for the Cmaps. They can be useful resources for education and students can use course contents and Cmaps simultaneously. Additionally, if other interactive features such as sound and animation are used, it can be a good game-like tool for use in learning.

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