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Blending Concept Maps with Online Labs for STEM Learning

Raghu Raman, Mithun Haridas, and Prema Nedungadi

Abstract. In this paper we describe the architecture of an e-learning environment that blends concept maps with Online Labs (OLabs) to enhance student performance in biology. In the Indian context, a secondary school student's conceptual understanding of hard topics in biology is at risk because of a lack of qualified teachers and necessary equipments in labs to conduct experiments. Concept map provides a visual framework which allows students to get an overview of a concept, its various sub concepts and their relationships and linkages. OLabs with its animations, videos and simulations is an interactive, immersive approach for practicing science experiments. The blended e-learning environment was tested by systematically developing a concept map for the concept "Photosynthesis" and by successfully integrating it into the OLabs environment. Our blended approach to concept understanding has interesting implications for the teacher who is engaged in training programs.

Keywords: Concept Map, OLabs, Biology, Photosynthesis, simulations, animations, online labs, virtual labs.

1 Introduction

Concept maps are now popularly used as a tool in K 12 education where they are used as linkages in science standards and concept growth dynamics. It is seen that often students get confused between the relationship of various subjects to each other [1] and one of the major educational challenges of modern times is to provide a framework where subjects can be linked to each other. Educators use concept maps as an assisted tool for providing accurate instructions, learning objectives and evaluator criteria. Because of their multi –usability, concept maps have evolved to become an effective productivity booster and a quick accomplisher [2]. Concept maps are actually founded on the principle that it's

Raghu Raman · Mithun Haridas · Prema Nedungadi
Amrita Vishwa Vidyapeetham, Coimbatore, India

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easier to make sense of new information when it's presented in a visual way. Novak first categorized concept maps in his cutting edge article and gave them a purpose and nomenclature [3]. These maps are great for summarizing information and presenting them as a holistic linked unit. When a student uses concept maps to derive relationships between apparently unlinked subjects, the higher order thinking skills are being utilized. A concept map is an educational tool that follows the idea of meaningful learning. Concept maps are graphical tools for organizing and representing knowledge and they include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts [3]. Blooms taxonomy actually classifies these skills as synthesis and evaluation [5]. Concepts are defined as perceived regularity in events, objects and the sequential flow is represented by symbolic aids like + or % [6]. When multiple concepts are linked together they form a proposition or a semantic map. Stakeholders in education have begun to realize the importance of addressing student difficulties in comprehending the linkages between different subjects [7]. Interestingly concept maps are now integrated into teacher training programs which help incorporate the principles of modern educational culture. Many educational practitioners believe that K 12 education concept maps can be used to strengthen the academic understanding of students and teachers at least in the field of biology [8].

Biology is a core science subject which deals with all the biological process in the biosphere. Considering its fundamental characteristics and importance, biology is today a standard subject of instruction at all levels of our educational systems. From our literature survey we believe that most of the students show poor performance in biological science because of the lack of meaningful learning, and lack of equipment in labs to do experiments. The research done by Tekkaya [9] on high school students found that the students have misconceptions in various areas of biology like osmosis, diffusion etc. The findings of Ajaja [10] suggest that concept mapping when efficiently used as a study skill could enhance post achievement test scores and retention of biology knowledge well over other study skills used by students. In our traditional method we are teaching students in a linguistic way. Research suggests that information is processed and stored in memory in both linguistic and visual forms. Research in both educational theory and cognitive psychology tells us that visual learning is among the very best methods for teaching and learning. If students start learning using visual ways then they are forced to draw the ideas that they have learnt like how the different concepts are connected to each other, relationships between the concepts and organize their knowledge in a graphical way.

We have online labs (OLabs) for science experiments to perform biological lab experiments that are available to students who have no access to physical labs or where equipment is not available. OLabs comes with detailed theory, interactive simulations, animations and lab videos. We enhance OLabs to improve the students learning skills by incorporating tools to create concept maps and the process of designing concept maps to create a more effective virtual learning environment.

2 Online Labs (OLabs) for Science Experiments

With all the advances in communicative technology that came into prominence during the last few decades, there evolved a simulation based eLearning called online labs [11]. Students may conduct virtual experiments that mimic the features of real life experiments. There are several advantages of using virtual environment such as OLabs. There is a relaxation on time constraints as each student has sufficient time in the lab and the geographical constraints are eliminated. There is an increased economy of scale as the cost of setting up a sophisticated learning environment is reduced. Enhanced safety and security is another big advantage of the simulated environment as per [12].

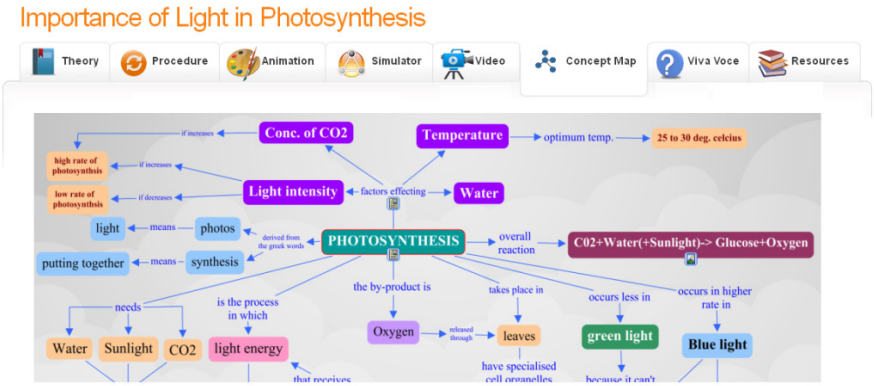

Fig. 1 OLabs Concept Map for Photosynthesis

A concept map typically contains concepts which are represented using circles or boxes. Each related concept can be connected by using lines, and labels on these lines define the relationship between the two concepts. If two or more concepts are connected using linking words and forms a meaningful statement then it known as a preposition. If there is any relationship between concepts in one domain to a concept in another domain then we can connect these concepts using an arrow with linking words. This type of relationship is known as crosslink's. Fig. 2 is an example of a concept map that shows the above characteristics.

In Fig. 2, "Biology", "Animals", "Plants", "living organism" etc. are examples of concepts, and "can be", "made up of", "are capable" etc. are examples of linking words. The relationship between concepts "Plants", "sunlight" and "photosynthesis" is expressed through the linking words "use the energy from" and "to carry out" for forming the **proposition** "Plants use energy from sunlight to carry out photosynthesis". In Fig. 2, the concept "Animals" and "Plants" are two separate domains and are connected to each other to forms a **crosslink**.

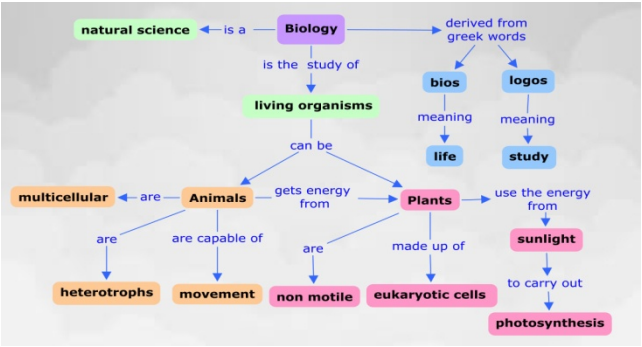

Fig. 2 A concept map about Biology

There are different kinds of concept maps such as hierarchical, linear, circular spider and so on, which helps to facilitate meaningful learning and improve student achievement. The study carried out by Bamidele and Oloyede [13] indicates that "there was no significant difference in the performances of the students with respect to the kind of concept map used and it implies that the concept mapping strategies were not all that different in their superiority". Concept map applications or educational innovation may benefit immensely from proper usage of interactive table top technology [15]. Mostly students in science lab collaborate because there is lack of space and facilities in the laboratory.

3 Making Concept Map for OLabs Biology Experiment

Constructing concept maps is a structured process which is based on a specific topic, revision and re-positioning of the concepts, thus helping to construct a good concept map having a pictorial view of the topic. It helps the students to think efficiently and to reduce complexity of the study. Teachers can take feedback from the students after they finish each step of making the concept map. Concept mapping is also a valuable theory of learning that teachers can use to evaluate a student's level of understanding. This will help to reduce the mistakes of students and to understand each part of the concept map and their reasoning behind the concepts and connections they made.

A. Constructing a good focus question

Novak and Cañas [3] suggested that a helpful way to determine the context of your concept map is to choose a focus question, that is a question that clearly specifies the problem or issue the concept map should help to resolve. Fig. 5 was constructed from the focus question "What is Photosynthesis?" and described all the main concepts related to photosynthesis. Derbenseva et.al [16] found that the structure of the map influences not only the focus question but also the type of relationships that are likely to be constructed in a proposition that links two concepts together. So for constructing good concept map we need specific focus questions and proper concepts.

B. Choose relevant concepts

The next step is to identify the relevant concepts that relate to our main idea or the focus question. Make a list of all the relevant concepts, usually 10 to 25 concepts is sufficient. In Fig. 3(A) it shows that all the main concepts that are related to the topic photosynthesis. From the list, give rank for each concept and place each important concept at the top of the page and arrange all other concepts in a hierarchy underneath that one. Fig. 3(B) shows the ranked list of concepts.

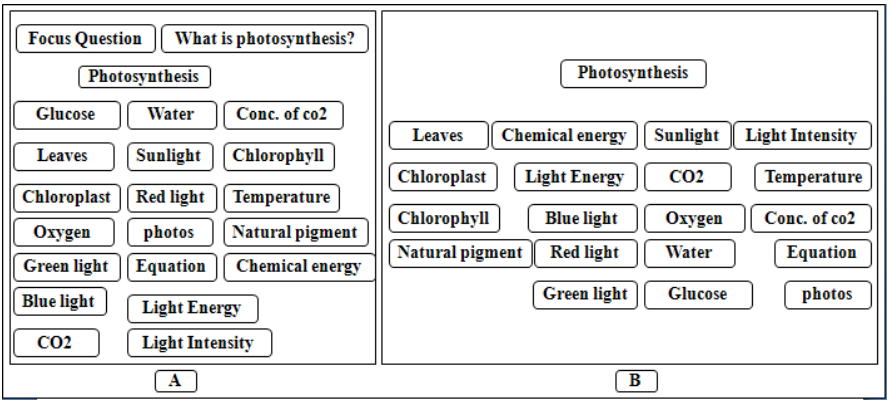

Fig. 3 (A). Focus question and relevant concepts. (B) An example image for arranging important concept at the top and less important below that concept.

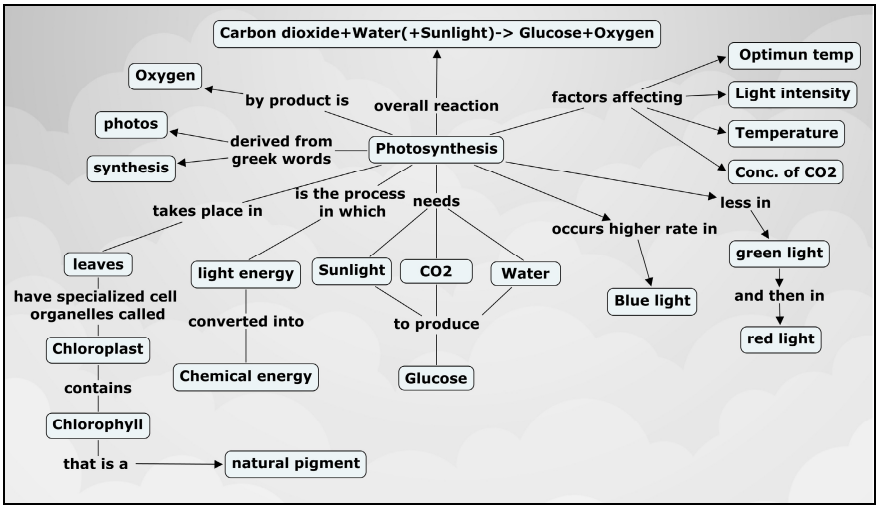

Fig. 4 A preliminary concept map about "Photosynthesis"

C. Construct a preliminary concept map

After choosing relevant concepts we can start making a draft copy of concept map. This will give an overall idea of how the concept map looks. After making a

preliminary concept map, a review is essential to improve the map. We can also add, rearrange or remove the concept from the preliminary concept map. In Fig. 4 we can see a preliminary concept map.

D. Choose linking words to connect concepts

Using the appropriate linking words to clearly express the relationship between two concepts is possibly the most difficult task during the construction of concept maps. Linking words usually contains 1-3 words appropriate for relationship of the two concepts. In Fig. 5 it shows that the linking phrase "takes place in" is used to connect the concept "Photosynthesis" and "Leaves" for making a meaningful relationship.

E. Finding cross-links

One of the important features of concept map is the usage of cross links. Cross links helps students to identify that all concepts are in some way related to one another. According to Novak and Cañas [3] there are two features of concept maps that are important in the facilitation of creative thinking: the hierarchical structure that is represented in a good map and the ability to search for and characterize new cross-links. In Fig. 5 we observe how the concept "Chemical energy" is linked to "Glucose"; both are separate sub domains of the concept map, forming cross-links.

F. Use colors to group concepts

Colors help to structure the concept map by separating groups of concepts thereby helping to recall the content of the map after a long time. The left cerebral hemisphere is specialized for linguistic and cognitive processes, whereas the right cerebral hemisphere is specialized for visuospatial processing [17]. If we are using different colors for each group of concepts, together with text then it will help both cerebral hemispheres to work together and place the information in long term memory. In Fig. 5 we grouped the "factors effecting photosynthesis" using one color and "needs for photosynthesis" using another color. Research shows that color coded concept maps improve the performance of students [18].

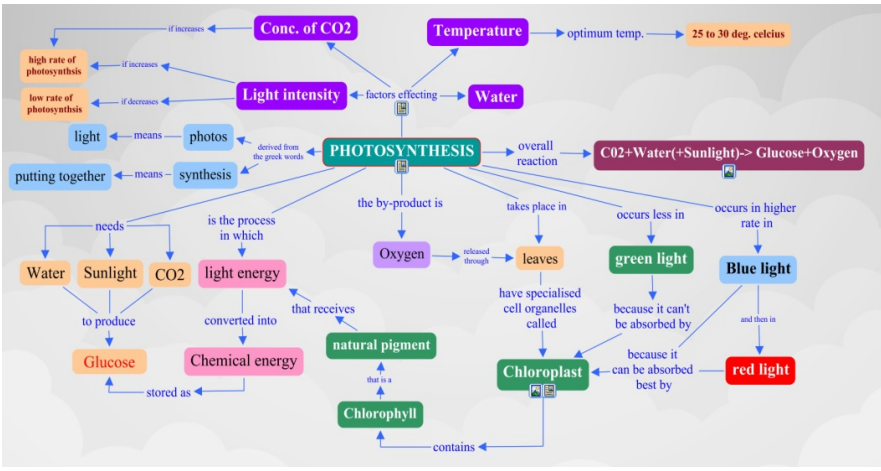

Fig. 5 A Completed concept map about "Photosynthesis"

G. Usage of images, website links, other concept and explanatory notes

Adding images or examples to the map can clarify the meaning of concepts and help to remember the information. We can click on the icon below the concepts to open the images. In Fig. 6 it shows the image of chloroplast inside the concept map. For getting more information about each main concept we also added website links for important concepts. We gave two sample resources from "Amrita" (OLabs) and "Arizona University" for the main concept "Photosynthesis" shown in the Fig. 6.

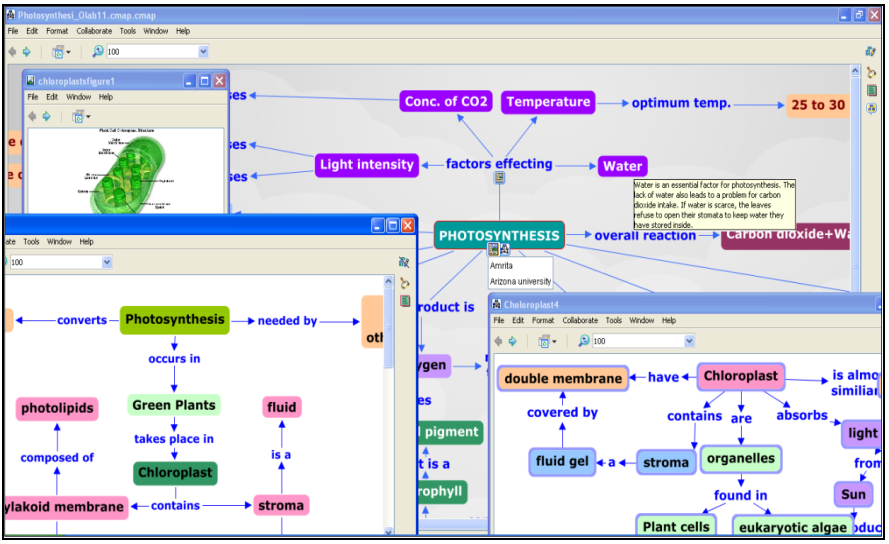

Fig. 6 A Concept map representing "Photosynthesis" with some of the resources

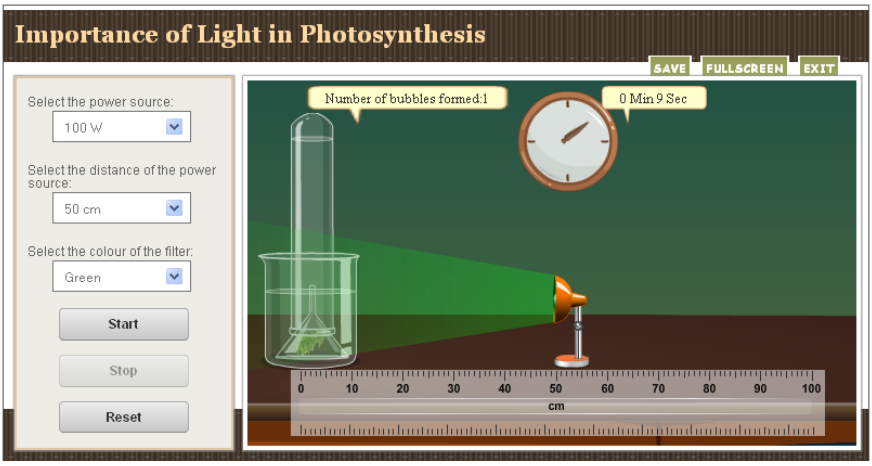

Fig. 7 OLabs simulation for "Importance of Light in Photosynthesis"

We also added sub concept maps for important concepts like “Photosynthesis” and “Chloroplast” as shown in Fig. 6 thus providing further details about the topic. Explanatory notes are used to explain some important concepts in the map. The explanatory notes for the concept “**water**” is shown in Fig. 6. To integrate concept maps and OLabs simulation we have some of the links in concepts that will directly lead to the OLabs simulation environment. Hagemans et.al [18] suggesting that concept map-based learning is relevant for improving student learning in simulation based environments. The completed concept map in Fig. 5 gives overall idea of how different colors like green, blue and red affect the rate of photosynthesis. To experimentally check how different colors are affecting the rate of photosynthesis, students can click on the link below the concept “Green light” to view the OLabs simulation page as shown in the Fig. 7.

4 Conclusion

The paper discusses the theoretical background for concept maps and describes the step by step process in designing a concept map for biology in OLabs. Concept mapping is an effective tool to provide a global picture; as it divides a subject into various branches while showing the connectivity between their subparts, thereby enhancing students’ comprehension. Our framework captures all the necessary elements for the concept map to make it more interactive and integrated with the OLabs simulation environment. Students can use the OLabs concept map as the central element and go to the other resources and get information related to a particular topic. Our framework allows other resources such as videos, simulations, images, website links, and sub concept maps and so on to be elements of the OLabs concept map thus providing a complete reference of the subject. The color coded concept map helps students to remember information about a particular subject for longer terms. We thus provide an easy to use system for educators to design concept maps and publish them using the rich media OLabs resources. We are conducting controlled surveys using the concept enriched OLabs pedagogy in enhancing the understanding of students’ comprehension, ease of learning, and knowledge on subject matter and attitudes.

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