Blending Concept Maps with Online Labs (OLabs): Case Study with Biological Science

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ABSTRACT
Experimental learning combined with theoretical learning enhances the conceptual understanding of a subject. Therefore, the Online Labs (OLabs) that hosts science experiments was developed. OLabs uses interactive simulations with theory, procedure, animations, videos, assessments and reference material. Our study blended OLabs with concept maps to examine if it enhances students' learning in Biology. Concept mapping is a framework that provides a deeper knowledge of a subject by understanding the relationships among concepts. The study was quasi-experimental; pre-test, post-test and a satisfaction survey was used as measurement instruments. The study sample was 54 students from a school in Haripad, Kerala, India. The students were randomly grouped into a control and an experimental group. The experimental group that used concept maps as a learning aid scored slightly higher, suggesting blending concept maps can lead to a deeper understanding of the subject. Gender difference did not significantly affect the scores.

Keywords
Concept Maps, Online Labs, Biology, Photosynthesis.

1. INTRODUCTION
The efforts to understand the complexities of human learning and memory were started more than 125 years ago. Scientists have conducted a great many experiments during this period [1]. It was in the 1970s that Novak and his team of researchers in Cornell University developed the technique of Concept Mapping, a powerful tool employed in schools and colleges for learning[2] [3].

Concept mapping provides a framework that allows students to get an overview of the subject matter through its various sub-divisions and connections to each other.

In concept maps, the concepts are displayed as two-dimensional graphics [4], usually as boxes, and they are interlinked using connecting lines to show the relationships among them [5]. Furthermore, creating concept maps require students to actively explore their understanding of the relationships among concepts [6]. David Ausubel's Assimilation Learning theory lays the foundation for concept mapping, which differentiates between meaningful and rote learning [7]. Meaningful learning transfers the information learnt from the working memory into long-term memory, and helps the working memory process information efficiently. Rote memory, on the other hand, uses the technique of memorization for retention of information. Similar to meaningful learning, the information retention under rote learning too takes place in long-term memory. But, in the process, the integration between new knowledge with existing knowledge does not occur [5]. This results in two consequences. One, the knowledge learnt by rote learning technique tends to be quickly forgotten, unless repeatedly rehearsed [5]. Two, the knowledge structure or cognitive structure of the learner is not enhanced or modified in rote learning and hence, the existing faulty ideas in the minds of learners do not get resolved. Thus, misconceptions in learning will persist, and knowledge gained has little or no potential for use in further learning and/or problem-solving [5] ability.

The main idea in all fields of concept mapping is to reflect the way the brain works and educators, in general, are interested in the connections between the working and long-term memory [8].

1.1 OLabs
Since the introduction of computer and modern communication technology, researchers started using computer technology to improve the online and collaborative learning. Virtual Laboratories have the potential to perform lab exercises the way physical labs conduct them using tools like simulation environment lab, remote control of instruments online and automated data acquisition [9], [10].

Combining experimental learning with theoretical learning enhances the conceptual understanding of the subject being learnt. Physical labs in schools play a vital role in this area as it aids in experimental learning.

However, not all schools in India have access to physical labs. Most schools face limitations in providing full access to physical labs. Some of the issues are non-availability of equipment, the cost of equipment, limited number of equipment, and as in the case of rural schools in India, the absence of physical labs. In case the physical labs with full facilities exist, the students may not access them due to time constraint.

These issues inhibit the learning cycle of a student, resulting in poor skills in research and scientific enquiries, and the inability to gain a deeper knowledge or understanding of a subject.

Such factors led to the development of the Online Labs (OLabs), a research initiative developed for science experiments. OLabs is

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used by students as a supplementary learning system to perform science lab experiments and is also used in rural schools where equipment are not available [11], thus overcoming the constraints students face in having no or limited access to physical labs.

The OLabs hosts experiments in physical sciences and mathematics. It provides a complete learning environment for developing practical skills using interactive simulations with supporting theory, procedure, animations, videos tutorials, assessments and reference material for each topic under a subject.

The assessment module follows a comprehensive assessment strategy that includes the assessment of the conceptual, experimental, procedural and reporting skills of the student.

Using the Online Labs, a student can explore, construct and experiment before arriving at a solution. The labs provide implicit feedback, in which the students can see the results of their actions. Also, access to OLabs is free.

Considering the multiple benefits of Olabs for the students and teachers, especially the assistance it can provide for schools in rural India, the Central Board of Secondary Education (CBSE) has recommended it as a teaching and learning aid to 15, 000 schools following CBSE curriculum. CBSE is a Government of India board of education for public and private schools.

Figure 1 demonstrates few sections like the detailed theory, interactive simulations, animations and lab videos in the OLabs.

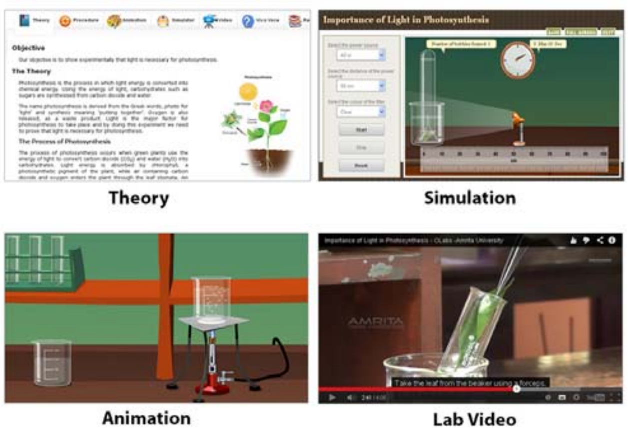

Figure 1. Theory, interactive simulation, animation and lab video sections in OLabs

There are researches which suggest that concept map-based learning is relevant for improving student learning in simulation-based environments [12].

In a previous work, we enhanced OLabs to improve the students learning skills, by incorporating tools to create concept maps and develop the process of designing concept maps, so as to create a more effective virtual learning environment [13].

1.2 Integrating Concept Maps for Photosynthesis in OLabs

Only very few studies have attempted to analyze the usefulness of concept maps in a blended learning environment, like blending it with Online Labs. This study is one such and it tries to evaluate if concept mapping as a study skill will improve students' achievement, and their attitude towards concept mapping, by blending it with the Online Labs.

A concept map was developed for the experiment using a topic 'Importance of Light in Photosynthesis', a topic in the biological science syllabus for Class 10. The concept map that was developed for the experiment allows the student to browse the interface for the topic (concept) selected.

Figure 2 shows the concept map that was developed for the experiment on topic 'Importance of Light in Photosynthesis' for Class 10, in OLabs.

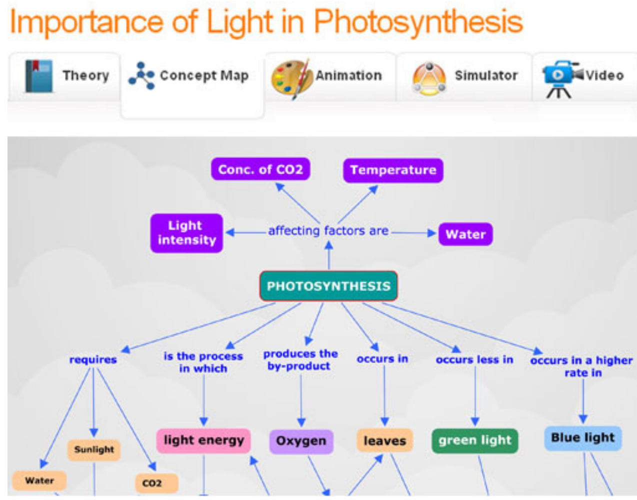

Figure 2. Concept Map for Photosynthesis in OLabs

The student can click on the concept to get a brief explanation of the topic. It uses images, website links, other concept maps, explanatory notes and so on to explain the topic. To integrate concept map with the simulation and animation of the particular experiment, we have provided links along with the concepts that directly leads the student to the OLabs simulation or animation environment.

2. CASE STUDY

A pilot study was undertaken to explore students' use of concept maps with OLabs. The results revealed the benefits of concept maps, student's attitude towards concept mapping and also the effectiveness of concept mapping as a study skill.

The below were the three main queries addressed in the study:

Research Questions:

- Is there any significant improvement in students who used concept mapping as a study skill from those who did not?
- Is gender a significant factor in determining performance?
- Is the concept mapping tool useful for students?

2.1 The Sample

The sample chosen for the study was 54 students from Class 10 of a school in Haripad, a place in the state of Kerala in India. This study was conducted as a part of an IEEE student symposium that was held at Amrita University [15].

According to the gender variable, 23 (43%) male and 31 (57%) female students participated in this study. The students were randomly assigned as control group and the experimental group.

27 students were enrolled in the control group and the other 27 in the experimental group. The study ensured that these students did not have prior experience in constructing concept maps.

2.2 Procedure

Before the experiment was conducted, the students were pre-assessed using a questionnaire as a tool to ensure that the two groups were at the same knowledge level. The questionnaire tested the basic knowledge of the students in photosynthesis, on their understanding of basic concepts of the topic.

The experimental group was then trained on how to construct a concept map. During the training session, we explained the basics of concept maps, such as what a concept map is, and, how the concepts are interrelated. We also explained the importance of concept mapping in enhancing the learning and showed some examples of concept maps to the students.

After the training session, the experimental group used the concept map section that we developed in OLabs, to study the experimental topic 'Importance of Light in Photosynthesis', while the control group used the theory section in the OLabs to study the same experiment (as seen in Figure 1, the Theory).

After the hands-on session, a post-assessment questionnaire was administered to both the groups to ascertain the students' learning achievement.

Unlike the pre-assessment, post assessment questionnaire is framed on the basis of a clear understanding of the content in the concept map or the theory part.

After the post assessment session, training was also given to the control group on how to construct concept maps.

As a last procedure, the students from both the experimental and control groups filled a satisfaction survey to rate their attitude towards their experiences of using the concept map and the OLabs.

The survey was a five point Likert scale study to determine the degree of the students' agreement with statements about the Online Labs and concept mapping. On Likert scale, 5 implied 'strongly agree', 4 implied 'Agree', 3 implied 'Neutral', 2 implied 'Disagree', 1 indicated 'Strongly Disagree'.

Responses received were statistically analyzed using the SPSS software and R. The study also used parametric techniques such as t-test and ANCOVA, based on the significance level of α=0.5. These were used to test the significance of the differences.

3. RESULT

The results obtained from study show that the group that used the concept map as study skill has an advantage to the group that used theory section as a study skill.

Detailed analyses of the results are shown below:

3.1 Pre-test and Post-test Analysis

Table 1 shows the mean pre-test scores of students in the experimental group (M=7.96) and the control group (M=8.00). They fall within a close range.

The independent t-test results do not show any significant difference between both the groups (t=-0.1432, p=0.886). The non-significant differences in the pre-assessment scores demonstrate an equivalence of the groups before the treatment.

Table 1. Independent T-Test Result for Pre-Test Scores

Groups	Mean	sd	t	p
Experimental group	7.96	0.98	-0.1432	0.886
Control Group	8.00	0.92		

Table 2 shows the independent t-test results of the post-test scores. The results showed a significant difference between the group that used the concept maps as a study skill and the group that used the theory as a study skill (t=1.836, $p<0.05$).

Table 2. Independent T-Test Result for Post-Test Scores

Groups	Mean	sd	t	p
Experimental group	12.41	2.12	1.836	0.036
Control Group	11.00	3.37		

The one-tailed independent t-test suggests an advantage in the group that used the concept maps section as a study skill (M=12.41, SD=2.12) over the group that used the theory section as a study skill (M=11.00, SD=3.37).

To determine the gender differences in the post-scores performance among students, an independent-samples t-test was conducted. Table 3 shows its scores. The results revealed that there is no major difference seen in the performance level between the male and female students who used concept maps as study skill (t=-0.585, $p>0.05$).

Table 3. Independent T-Test Result based on Gender

Gender	n	Mean	sd	t	p
Male	10	12.10	2.025	-0.585	0.565
Female	17	12.59	2.210		

ANCOVA analysis was conducted in the study using the post-test score as a dependent variable, pre-test score as a covariate, and the mode of study and the gender as a fixed factor. Table 4 shows the ANCOVA analysis result.

After adjusting for pre-test scores, there were significant effects between subjects-factor: mode of study, $F(1, 49) = 4.032$, $p \leq .05$, partial $\eta^2 = .076$. Adjusted mean post-test scores suggest an advantage to the study using concept maps section (M=12.39, SE=0.49) over the study using the theory section, (M=10.86, SE=0.48). However, the interaction between the mode of study and the gender was insignificant.

Table 4. Tests of Between-Subject Effects

Source	Type I Sum of Squares	Mean Square	F	Sig.	Partial η^2
Corrected Model	134.47	33.61	5.405	0.001	0.306
Intercept	7396.7	7396.7	1189.16	0.000	0.960
Pretest	81.039	81.03	13.03	0.001	0.210
Gender	17.826	17.82	2.866	0.097	0.055
Mode	25.078	25.078	4.032	0.050	0.076
Gender* Mode	10.528	10.528	1.693	0.199	0.033
Error	304.78	6.220			
Total	7836.0				
Corrected Total	439.25				
R Squared = .306 (Adjusted R Squared = 0.249)					

3.2 Perception of Students on Concept Mapping

From the satisfaction survey taken by the students, the below explained results were derived, giving an insight into their attitude towards concept maps and OLabs.

The Cronbach's alpha value estimated the reliability of the whole scale. The resulted Cronbach's alpha value of the test, 0.7325 indicated an acceptable reliability [14], which implies an internal consistency of the items in the scale.

Table 5 presents the participants' mean scores with the standard deviations of each latent variable.

The participants scored the highest on 'Perceived Usefulness' (mean = 17.74), which was followed by 'Attitude towards using online labs and concept maps' (mean = 17.46).

Table 5. The Mean and Standard Deviation based on Student's responses

Category	Mean(out of 20)	sd
Compatibility	16.19	2.30
Ease-of-use	16.30	2.46
Perceived usefulness	17.74	1.40
Attitude	17.46	2.41
Behavioral intention	16.13	2.07

Figure 3 shows the percentage of responses of some of the selected questions. From the chart, we can infer a strong agreement of most of the students that concept maps would help them study better.

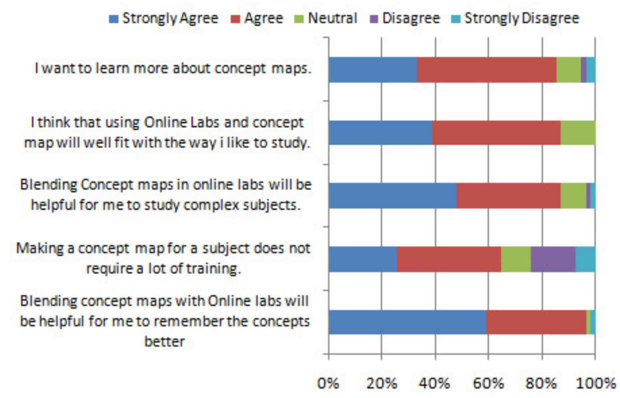

Figure 3. Percentage of responses of few sections of the questionnaire.

The survey questionnaire had a section for written feedback, where the students could write their experience in few words about using the Online Labs and the concept map. Some of their responses are shown below:

- Well, it was a nice experience coming to this computer lab and going through the concept maps and online labs! The concept maps, I think, will assist me a lot in the weak subjects like Social Sciences. Linking each concept with each other using simple linking words is a good idea. I thank Amrita University for developing this website, which will helpful for future students.
- It is very useful for my studies. Henceforth, I will use Online Labs for my studies. Concept maps are also very helpful for my studies. So, I would like to use concept maps for all the subjects.
- It is a very good idea to learn the concept maps. I would prefer to learn this way.
- The Online Labs and concept maps are helpful for me in improving my knowledge. The concept map and Online Labs have given a new technique for improving my studies.
- In my opinion both approaches are good, but through concept map, I feel it would be easier for me to study complex topics.

4. DISCUSSION AND CONCLUSION

The aim of this case study was to examine the efficacy of blending concept mapping with Online Labs that would enable students to see the interconnection of various dimensions of the topic they learn. This would, in turn, makes their learning meaningful and helps transfer the newly acquired knowledge to the long-term memory for easy recall.

The findings of this study indicated that the experimental group who used the concept maps as learning tool showed significant improvement on student achievement. Before commencing the experiment, we ensured that the students in both groups have the same level of knowledge using a pre-assessment questionnaire. The study suggested that the concept mapping would help students to master their learning in a meaningful way. The ANCOVA result clearly showed that (after adjusting pre-test scores) there was significant effect between subjects-factor and mode of study.

The study also showed that there is no significant gender difference in the performance of students who used concept map as a study skill. Both the male and female students performed equally well in their topic using concept maps and the Online Labs.

Most students gave a positive feedback in the satisfaction questionnaire, stating concept mapping would help them to learn new concept in Biology. A few students made encouraging comments which said; "I think it (Online Labs and concept maps) makes studying complex subjects easier." or "It makes me understand even a complex subject very easily, and also it makes easier to think about a topic".

From these opinions expressed by the students, we can conclude that the concept map can be used, not only in Biology, but also in those other subjects that students find difficult to understand.

From the data given in table 5, we conclude that 'perceived usefulness' received the highest mean score, suggesting the usefulness of concept maps for students. These findings suggest that students should use concept map as a leaning strategy.

The future scope of study includes the assessment of students for the time period of about six months or so on. We are also planning to extend the blending of concept map with subjects like Physics and Chemistry and to assess its effectiveness.

5. ACKNOWLEDGEMENTS

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