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Concept Maps in Organic Chemistry Practicals

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Abstract Chemistry laboratories have played an important and effective role in chemistry education. However, students frequently lack the ability to associate their laboratory experience with the important chemical concepts. The objective of practical work and experimentation in science curriculum is universally accepted. Students can appreciate various concepts of chemistry through laboratory experiments. The main goal of this study was to investigate into students' understanding of organic chemistry practicals through the use of concept maps in pre-lab and post-lab sessions. The study was conducted during field work in senior secondary school, using 40 chemistry students in class XII. The experimental group was given treatment based on pre-lab and post-lab sessions using concept maps, while the control group followed a traditional method in which instructions as to what to do were given and students performed the practical as per instructions. Concept mapping was developed to help students make conceptual connections while doing laboratory work. Both groups took 20-item achievement tests one week after each experiment. The students' performance was evaluated after each experiment. Students were interviewed to get their perceptions regarding usefulness of pre-lab, post- lab sessions in chemistry practicals. Significant differences were found between experiment and control group with respect to students' understanding as determined by achievement tests. Students responded very positively towards the use of pre-lab and post-lab sessions in the laboratory, and they felt strongly that using concept maps in pre-lab and post-lab sessions helped them understand the theory reasoning involved in organic chemistry experiments. Students' perceptions concerning the usefulness of concepts maps in chemistry practicals were also explored. The use of concept maps in practicals are intended to stimulate the students' interest in conducting organic chemistry practicals.

***Keywords**: laboratory work, practicals, organic chemistry, concept map, pre-lab and post- lab sessions*

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1. Introduction

As we know, concept maps are visual and spatial representations of ideas and concepts as well as their interrelationships. They are "tools intended for organizing what the learner knows" and for "engaging learners in relating new ideas to what they already know" [1]. The concept map is a graphic metacognitive tool [2] which provides an external representation of structural knowledge – a visual image – in the form of a two-dimensional semantic network [3]. Concept maps were created as a device of meaningful learning, which can be regarded as the opposite of rote learning. Concept maps are graphical teaching, learning, evaluation and presentation tools [4,5]. Chemistry is often full of abstract concepts, resulting from the complex nature of this science. It may lead to extensive misconceptions among students [6]. It is also a common problem in chemistry that even if students do well in examinations they still may fail in solving basic textbook problems, which is a sign of rote learning [7]. It is important to find various interesting ways that can lead toward meaningful chemistry learning. One way to accomplish this is to apply Ausubel's theory of meaningful learning [8]. Laboratory is a diverse learning environment and therefore a challenging space to teach and learn. One solution to promote teaching and student's meaningful learning in laboratory is concept mapping, which is a modeling technique where conceptual frameworks are illustrated with concepts and linking words in order to create concept maps [9,10,11,12]. This paper describes and illustrates the use of concept maps in understanding organic chemistry practicals at the senior secondary stage. At elaboration and systematization sessions, concept maps are combined with demonstration experiments to help students to apply their knowledge of concepts and their interrelations. This approach is illustrated by two examples: (i) an introductory chemistry session at senior secondary classes of a rural government senior secondary school, Phulera, and (ii) the systematization sessions of the topic "Functional group identification". Also, this paper shows how concept maps can be used to determine whether students, by themselves, connect the concepts taught in the practical classes.

1.1. Purpose of the Study

This study was conducted to investigate whether the concept mapping at senior secondary level enhances the students' understanding of organic chemistry practicals and motivation. Specially, this study was aimed to compare the performance and attitudes of students towards chemistry practicals using concept mapping via pre-lab and post-lab sessions. In particular, the following research questions were posed.

- Is there any significant difference in performance of senior secondary school chemistry students doing experiments in the lab via using traditional method and using concept mapping, pre-lab and post-lab discussions?
- Is there any significant difference in understanding of theory of experiments via pre-lab and post-lab sessions?

2. Methodology

2.1. Research Design

The sample consisted of 80 students of a school: 40 in the experimental group and 40 in the control group. The school is a rural day school and the average age of the students involved in this study was 17 years old. The school was co-educational and located in a rural area. There was only one section of class XII in the school, the section consists of both physical science (group of students with optional subject physics, chemistry and mathematics) and biological science (group of students with physics, chemistry and biology) group. The practical classes were taught by the same teacher. The teacher has a Master's degree in chemistry and about 20 years of teaching chemistry at senior secondary level. Both groups of students were assigned similar organic chemistry experiments. Both the groups were assigned to do the experiment through traditional glasswares. Students from the experimental group were instructed through pre-lab and post-lab sessions using concept mapping while the control group students were asked to perform the experiments after the usual routine instructions. Pre- and post-tests were administered before and after the treatment for both the groups. A chemistry concept test and a questionnaire on attitude and motivation towards chemistry laboratory and chemistry learning were administered to evaluate the effectiveness of concept mapping in understanding the basic principles and their implementation in conducting the experiments.

2.2. Implementation of the Study

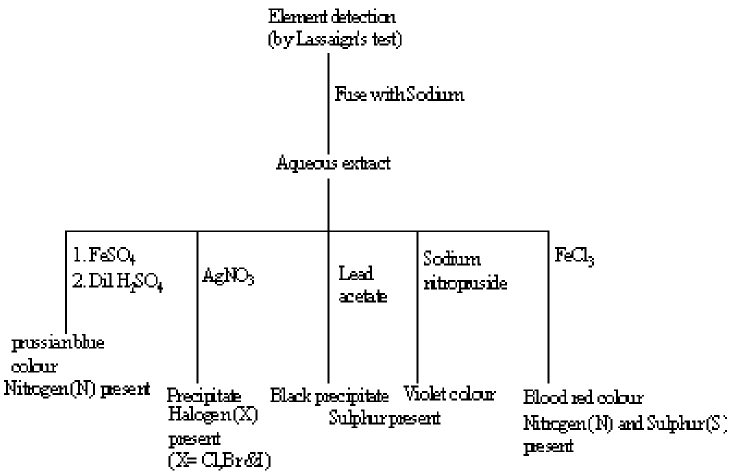

Figure 1. Concept map for detection of element present in organic compound

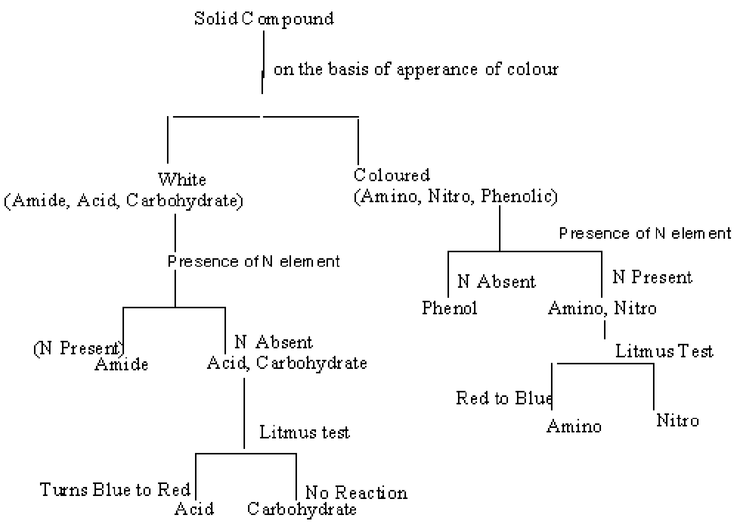

Figure 2. Concept map for identification of nature of solid compound

The topic chosen for the study was organic chemistry practical which is normally considered to be difficult by the students. The experimental group was required to do the experiments using the concept map (see Figure 1) followed by pre-and post-lab discussions. The concept maps (see Figure 2-Figure 4) prepared and discussed to students in pre-lab and post lab sessions. The students carried out all the functional group identification tests prescribed by Board (Rajasthan State Board adopted the NCERT syllabi and textbooks at secondary and senior secondary level). The control group was also required to do the same experiments, but with the traditional way of instructions. The study was conducted over two and half months. In the curriculum, chemistry is given four class periods per week. The teachers for both the groups used two periods for teaching the concepts related to the topics and another two periods (alternatively for control and experiment group) for conducing the chemistry practical.

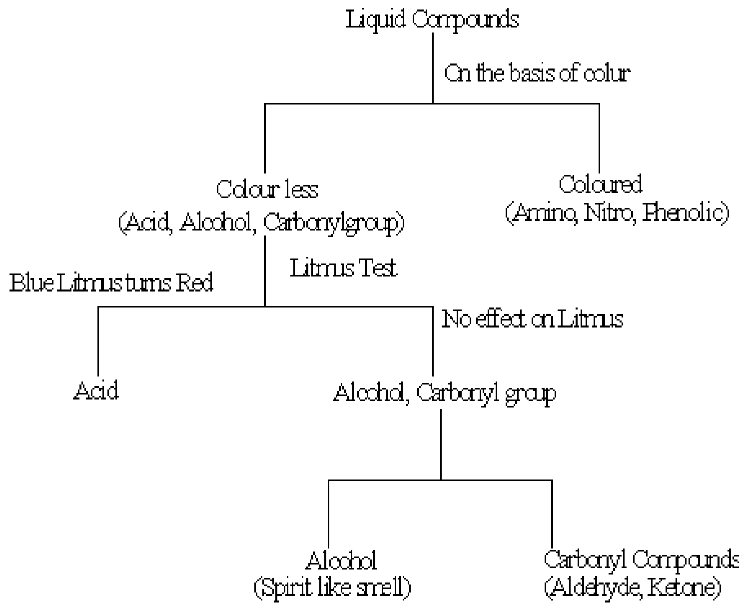

Figure 3. Concept map for identification of nature of liquid Compound

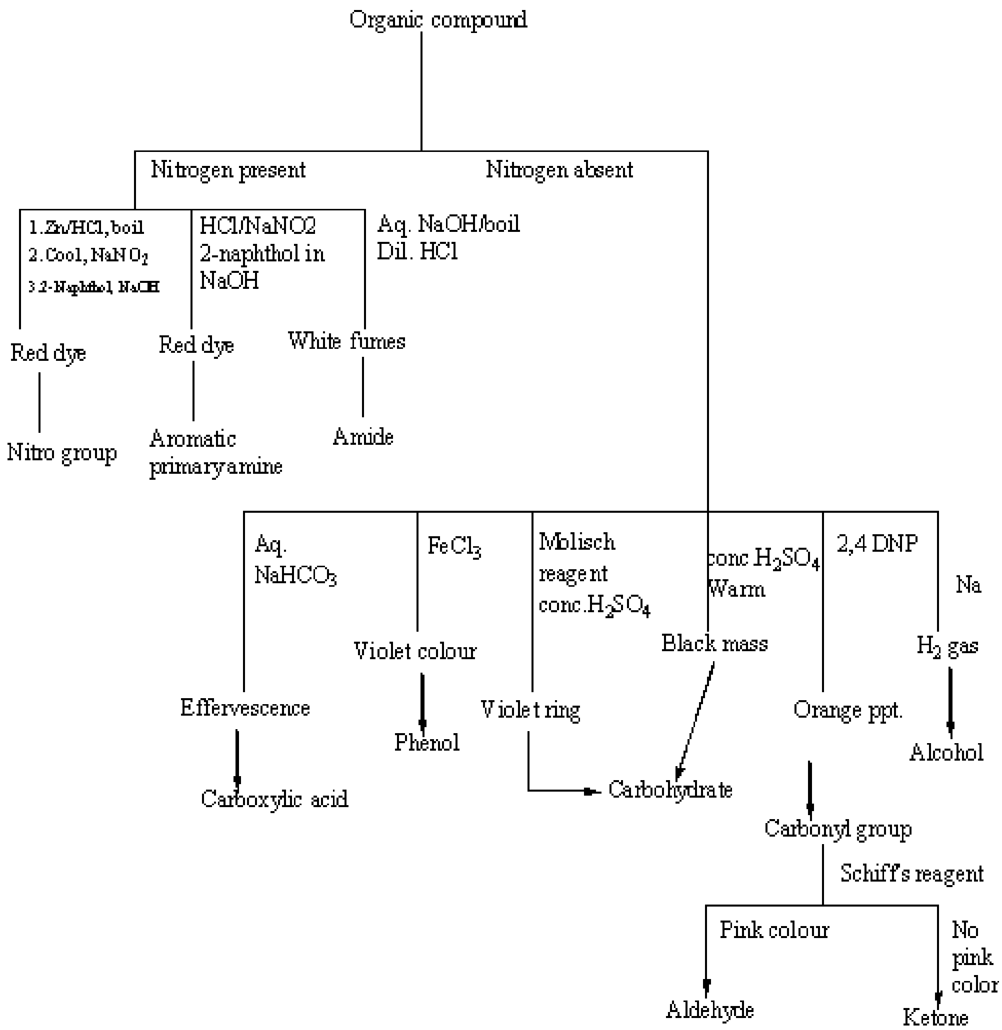

Figure 4. Concept Map for Identification of functional group

2.3. Data Collection

Data were collected through questionnaires on chemistry concept, attitude towards chemistry, laboratory practical work and interviews. The pre-test was administered to both groups for the purpose of gauging their prior knowledge on the topics. Post-test concentrated on the topics related to the practical work along with chemical reactions related to the practical. Both the tests consisted of 20 multiple choice items. The content of both the tests was validated by experts consisting of chemistry faculty from the Institute. The questionnaire for attitude [13] towards chemistry was prepared by considering the interest of students towards chemistry practical, enjoyment of performing chemistry practical, general aspect of laboratory work and enhancement of learning. The practical work was evaluated by asking students to demonstrate certain activities and experiments in a practical containing functional group identification and for each correct activity 5 marks were assigned. Individual semi-structured interviews were conducted after the administration of the post-test. Twenty five students of the experimental group were interviewed for the purpose of getting their views of understanding the organic chemistry practicals questions asked included:

- Understanding of practical concepts using concept maps
- Benefits of pre-and post-lab sessions.
- Do you think that this approach can increase
- Understanding of chemistry practicals?

3. Results and Discussion

This study investigated students' understanding of chemistry concepts for two different groups (control group and experimental group). Comparison of pre-test as mentioned in Table 1 for two groups by an independent t-test revealed no significant differences in academic performance between the groups.

Table 1. Comparison of the pre-test scores for experimental and control groups

Group	N	Mean	Std. Deviation	t-test
Experimental	40	13.425	2.086	0.786
Control	40	13.05	2.13	
t-test not significant at p<0.05.				

Table 2 shows the comparison of the post-test scores for experimental and control groups in the chemistry concept test. The overall mean and standard deviation values indicate that there was a significant difference between groups in the post-test.

Table 2. Comparison of the post-test scores for experimental and control groups

Group	N	Mean	Std. Deviation	t-test
Experimental	40	16.275	1.62	8.59*
Control	40	13.075	1.75	
**p<0.05.*				

The mean score of the experimental group was significantly higher than that of the control group. The findings show that introduction of concept maps in pre lab post sessions contributes to increase in students' understanding of the organic chemistry practical.

Table 3. Students' Achievement in demonstration activities

Group	N	Mean	Std. Deviation	t-test
Experimental	40	13.25	2.66	8.97*
Control	40	8.13	2.44	
**p<0.05.*				

Table 3 shows the comparison between the post-test scores for the demonstration activities performed by experimental and control groups with regard to certain activities related to colour identification, detection of Nitrogen as an extra element, acidic property, and identification of functional group in given Organic compounds.

In general, we can suggest that introducing of the concept map via pre-lab and post-lab discussion motivates students in their learning of chemistry practicals and student's viewed positively in the practical laboratory experience.

4. Teacher and Student Feedback

Feedback on the use of concept maps via pre-lab and post-lab discussions was collected through interviews with randomly selected 25 students in the experimental group and also with the teacher.

4.1. Teacher's Feedback

Usage of concept maps in practical classes gives enormous information to the students in a short period of time and enables students to feel more comfortable handling the glassware and chemicals appropriately in the laboratory. This also creates a good environment in the class due to enhancement of interest of students in performing practicals in a logical and systematic way.

4.2. Students' Feedback

The students' perceptions were also taken through semi- structured interviews. The questions asked during the interview focused on student perceptions in terms of their understanding of organic chemistry practicals. Most of the students expressed the view that use of the concept map approach in pre-lab and post-lab discussions facilitated a better understanding of chemistry practicals. The students also felt that they had gained a deeper insight into the basic principles underlying the chemistry practical. These views are amply supported by the results obtained in the post-test, and in demonstration activities assigned to the students.

5. Conclusion

The implication of this study is that both the teachers and the students involved in this study viewed the concept map approach positively. The concept mapping strategies are powerful in terms of improving students' performance in chemistry practicals. Students taught using the concept mapping approach during pre-lab and post-lab sessions are likely to retain the information better than those taught traditionally. It is therefore recommended that the concept map approach be used to conduct the chemistry practical for senior secondary classes.

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