Effectiveness of Concept Mapping Strategy on Student's Achievement and Concept Retention in Organic Chemistry

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Abstract

The present study aims to investigate the effectiveness of Concept mapping strategy on the achievement and concept retention in Organic Chemistry of Class XII science students belonging to higher Intelligence and lower Intelligence groups. For this purpose a sample of 80 science students was drawn from Class XII science students from a school at Varanasi (U.P.) affiliated to CBSE.

The Pretest – Post test Non-equivalent Groups Design was used for this study. Two intact sections that is 'A' and 'B' of Class XII were chosen as the sample of the study. Out of these two sections, section 'A' was randomly assigned as the experimental group and other section 'B' as the control group. Both the groups were equated on intelligence using Mixed Group Test of Intelligence (Hindi Version) by Dr. P.N. Mehrotra, Verbal and Non-verbal Test. In both groups students of two levels of intelligence based on median split were given treatment. The control group was taught through Lecture method and the experimental group was taught through Concept mapping strategy. The students were tested with investigator constructed Pre and Post-test containing 25 multiple-choice questions. t-test was applied to arrive at the following conclusions:

(i) Experimental group was found to attain significantly higher achievement scores and retained more in both higher and lower intelligence groups as compared to the control group.

(ii) Higher intelligence experimental group was found to attain significantly higher achievement scores and retained more as compared to the lower intelligence experimental group.

Introduction

Planning the science education of young people is all about selection of content to be included, selection of processes and skills

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to be practiced, and selection of appropriate activities to familiarise the students. The selection is normally carried out at the syllabus formulation stage or course production level. However, at the classroom level it is rarely so. Keeping in mind the immense course content of the science curriculum at the intermediate level some new teaching methods must be adopted by the teachers. Organic Chemistry as a main branch of Chemistry has lot of applications in other branches of science (Chen, 2004).

In our schools, conventional Chemistry classes at 10+2 level are conducted to achieve mastery of the textbook content and practice the problems given in the end of the chapter, textbook assignments and examinations. Many students who are considered successful in conventional classes are not successful when it comes to solving problems in a new context. At times students who have mastered solving end of chapter problems have a weak grasp of basic concepts and are unable to apply what they know to new situations.

At present time, to teach Organic Chemistry, traditional methods are being used in our classrooms which does not meet the learning needs of the students of 21st century. Hence there is a need of improvement in Chemistry teaching methods which can help students to learn more effectively.

One way to fulfill this is to use Concept Mapping as a teaching strategy. Concept mapping which is based on Ausubel's theory of meaningful verbal learning is currently a favourite subject of research in the western world. For correcting misconceptions one can use Concept mapping method as misconception correction tool.

Concept maps are similar to flow chart in which concepts are linked through lines and on these lines we write appropriate word or phrases which represent meaningful relationship between these concepts. In Concept maps the key Concept is arranged at the top of the map and less inclusive concepts at the bottom of the map.

Since the subject of Organic Chemistry occupies an important place in the school curriculum there is a need to probe the effectiveness of Concept mapping strategy. Hence, the investigator has selected Concept mapping strategy to find out its relative effectiveness on student's achievement and concept retention in Organic Chemistry.

Objectives

This study was designed to realise the following objectives:

- To develop Concept maps of 2 concepts from selected one unit of Organic Chemistry syllabus prescribed by the C.B.S.E. Board for Class XII science students.
- To compare the achievement and concept retention in Organic Chemistry of students belonging to higher intelligence groups (using median split of intelligence test scores) being taught through Concept Mapping Strategy and through Lecture method.
- To compare the achievement and concept retention in Organic Chemistry of students belonging to lower intelligence groups (using median split of intelligence test scores) being taught through Concept Mapping strategy and through Lecture method.
- To study differential effect of Concept Mapping Strategy on achievement and concept retention in Organic Chemistry of students belonging to higher and lower intelligence groups (using median split of intelligence test scores).

Hypotheses

$H_0$1.1: There is no significant difference between gain in achievement and concept retention in Organic Chemistry of higher intelligence experimental group and higher intelligence control group at the 0.01 level of significance.

$H_0$1.2: There is no significant difference between gain in achievement and concept retention in Organic Chemistry of lower intelligence experimental group and lower intelligence control group at the 0.01 level of significance.

$H_0$1.3: There is no significant difference between gain in achievement and concept retention in Organic Chemistry of higher intelligence experimental group and lower intelligence experimental group at the 0.01 level of significance.

Design and Sample of the Study

The study was quasi-experimental in nature where Pretest—Post-test Non-Equivalent Groups Design was used. The sample of the present study comprised of 80 science students studying in two intact sections that is 'A' and 'B' of Class XII of an English Medium School at Varanasi. The average age of the students was 17 years. Out of these two sections, section 'A' was randomly assigned as the experimental group (n_1=40) and other section 'B' as the control

group (n_2=40) for the study. Since the sample was small and it was difficult to get extreme sub-groups in each group. So by median split of all the students in each group, each group was divided into two halves that are higher intelligence group and lower intelligence group. Table 1 shows the division of each of the two groups into two sub-groups by median split.

Table 1
Division of the two Groups into two Sub-groups by Median Split

Groups	Experimental Group	Control Group	Total
Higher Intelligence Group	20	20	40
Lower Intelligence Group	20	20	40
Total	40	40	80

Mixed Group Test of Intelligence by Mehrotra (1975), Verbal and Non-verbal Test was used to measure general mental ability and t-test was applied to find out the difference between intelligence test scores of the both groups. Results have been given below in Table 2.

Table 2
Mean, S.D. and 't' values obtained on Intelligence test by Experimental Group and Control Group

Group	N	Mean	S.D.	df	't'
Experimental Group	40	59.34	11.34	78	0.258
Control Group	40	60.02	12.22		

Table 2 reveals that "t" value of 0.258 for intelligence scores was not significant at the 0.05 level of significance. It meant that significant difference does not exist between the intelligence of the both groups.

Tools Used

12 Concept maps of 2 concepts from selected one unit of Organic Chemistry syllabus prescribed by the C.B.S.E. Board.

Mixed Group Test of Intelligence (Hindi Version) by Mehrotra (1975), Verbal and Non-verbal Test was used for equating the both groups i.e., experimental and control groups on the basis of their intelligence scores and was also used to divide the students of both groups into two levels of intelligence based on median split.

An Achievement test consisting of 25 multiple-choice questions based on 2 concepts from selected one unit of Organic Chemistry syllabus prescribed by the C.B.S.E. Board for Class XII science

students was developed by the investigator to measure the students' achievement and concept retention in Organic Chemistry. In this test each question carries one mark. The achievement test served as both Pre-test and Post-test (Post-test I and Post-test II).

Experimental Procedure

The experiment was conducted in four phases:
(i) Pre-testing (ii) Experimental treatment (iii) Post-testing and (iv) Delayed Post-testing

Phase I: Pre-testing

In the Pre-test stage, intelligence test and achievement test were administered to the students of both groups i.e. experimental group and control group.

Phase II: Experimental Treatment

Both the groups viz. experimental group and control group were taught by the investigator herself so as to avoid teacher variable. The experimental group was taught through Concept Mapping strategy, while the control group was taught through Lecture method. Same concepts were taught to the both groups.

Teaching of Experimental Group

The group was exposed through Concept Mapping strategy. The investigator introduced two concepts of selected one unit namely Phenol and Ether through 12 concept maps regarding various aspects such as preparation, properties, reactions and inter-conversions, which were developed with the help of students by the investigator on the blackboard.

Development of Concept Maps

It has been previously stated that present study compares the effectiveness of Concept Mapping strategy with Lecture method. Concept Mapping was chosen since it aims at fostering meaningful learning of concepts. This not only adds objectivity to Concept Mapping but also helps the teacher in planning the lesson scientifically.

In this study, for developing Concept Maps the following steps were followed by the researcher –

(a) The topics selected to be taught to the experimental and control groups were enlisted.

(b) The key concepts were identified and listed.
(c) The concepts underlying the key concepts were identified and listed.
(d) The various concepts were hierarchically arranged.
(e) The concepts were mapped out, with the key concepts at the centre or at the top and the concepts hierarchically spread out.
(f) The various concepts were inter-linked by using suitable links.
(g) These linking lines were defined by using suitable words/ phrases to elicit meaningful relationships between the concepts.

Even while implementing lessons in the class, on the basis of the above concrete steps a teacher can effectively proceed and ensure that objectives of meaningful learning are sequentially met. Thus developing the Concept Mapping strategy ensures fulfilling the objectives or goals while keeping the interest of the students in mind.

Stages of the Concept Mapping Strategy

After in-depth review of the research work done on Concept Mapping strategy and by carefully analysing the above listed sequential steps for developing concept maps, the various stages of Concept Mapping strategy were developed by the investigator. The Concept Mapping strategy developed in this study consists of well defined stages. This makes the strategy more flexible and gives freedom to the teacher to mould the various stages (though within the prescribed framework) if the circumstances prevailing in the classroom so demand. Keeping all these points in mind following stages of the Concept Mapping strategy were developed by the investigator:

Stage I: Presentation of Abstraction

(a) The students were presented with a definition or generalisation, which was linked to the learner's existing cognitive structure.
(b) The students were asked to identify various concepts and sub-concepts and enlist them.
(c) The students' understanding of these concepts was assessed by asking them to provide new and unique examples.

Stage II: Propositional Stage

(a) The teacher used prompts and cues to guide the learners to arrange the concepts hierarchically with the broader/general

concept at the top and the less inclusive concepts at the bottom, giving the whole structure the look of a pyramid.

(b) The various concepts were inter-linked logically by using (arrowhead) lines.

(c) These lines were supplemented by word/words/phrases, which defined them and elicited meaningful relationships between the various concepts.

(d) The whole Concept map was viewed as a network of concepts.

Stage III: Application

The students applied their knowledge to generate new examples and reflected on the existing ones.

Stage IV: Closure

The students summarised the major ideas developed during discussion.

A Sample Lesson Plan indicative of the procedure adopted while teaching through Concept Mapping strategy has been given below:

Lesson Plan For Concept Mapping

Topic : Phenols

The teacher started the lesson by probing the previous knowledge of the students.

Teacher : 

What is the name of this compound?

Student : Benzene.

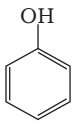
Teacher : The structure of Benzene is also called by some other name, what is it?

Student : Benzene ring or Aromatic ring.

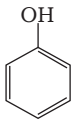
Teacher : What is the simplest hydroxy derivative of Benzene?

Student : Phenol

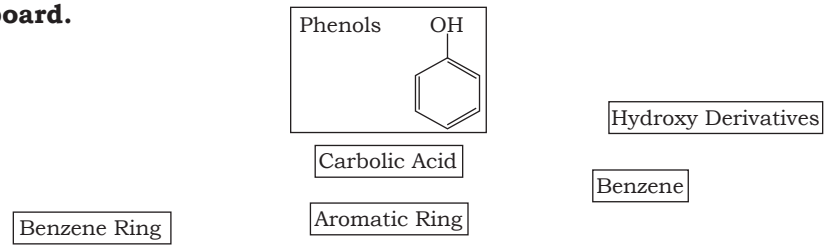
Teacher : What is the structure of Phenol?

Student : 

Teacher : Phenol is also known by other name what is it?

Student : Carbolic acid. 

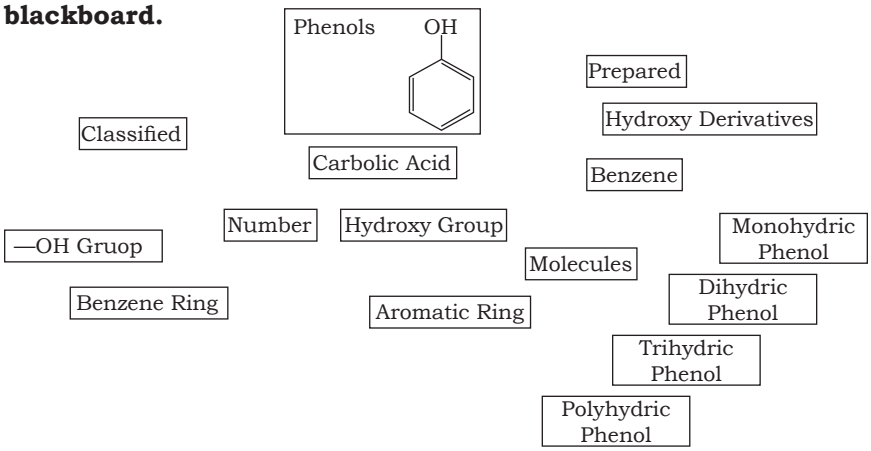
The teacher writes 'Phenols' , 'Benzene', 'Hydroxy Derivatives' 'Benzene Ring' 'Aromatic Ring','Carbolic Acid', on the black board.



Teacher : In the structure of Phenol the symbol —OH represents to which group?
Student : Hydroxyl group (—OH Group).
Teacher : What are the synonyms of make and divide?
Student : Prepare and Classified.
Teacher : On the basis of number of hydroxyl group present in the molecule of Phenol, it can be classified into how many types?
Student : .....
Teacher : On the basis of number of hydroxyl group present in the molecule of Phenol, it can be classified into four types:

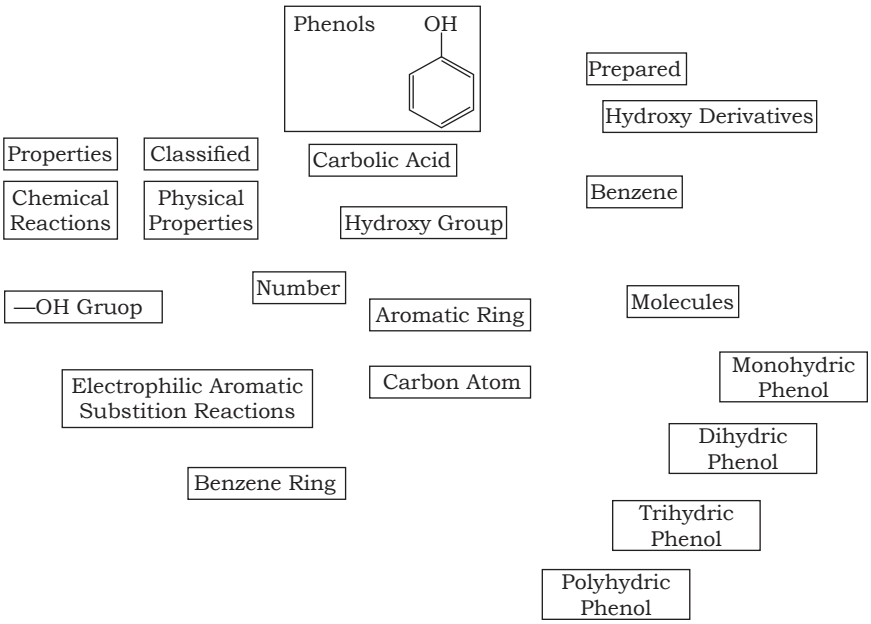
(i) Monohydric Phenol
(ii) Dihydric Phenol
(iii) Trihydric Phenol
(iv) Polyhydric Phenol

The teacher adds 'Hydroxyl group', '—OH Group', 'Prepared', 'Number', 'Classified', 'Molecules', Monohydric Phenol', 'Dihydric Phenol', 'Trihydric Phenol', 'Polyhydric Phenol', on the blackboard.

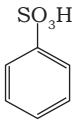


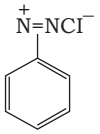
Teacher : What is the General formula of Alcohol?
Student : R—OH
Teacher : What is the structural difference between Alcohol and Phenol?
Student : . . . . . .
Teacher : Alcohol contains hydroxyl group directly attached to carbon atom of an aliphatic system (CH3OH) while a phenol contains hydroxyl group directly attached to carbon atom of an aromatic system (C6H5OH).
Teacher : Water is found in three states solid, liquid and gas. What does this statement represents about water?
Student : Properties of water.
Teacher : Which type of properties a chemical compound possess?
Student : Chemical reactions and Physical properties.
Teacher : Due to benzene ring Phenol shows which type of chemical reactions?
Student : . . . . . .
Teacher : Electrophilic Aromatic Substitution reactions.

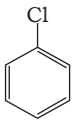
The teacher adds 'Carbon Atom', 'Properties', 'Chemical Reactions', 'Physical Properties', 'Electrophilic Aromatic Substitution Reactions', on the black board.



Teacher : What happens when Benzene reacts with propene at 523K with Phosphoric acid?
Student : Cumene is produced.
Teacher : Give the name of these compounds –

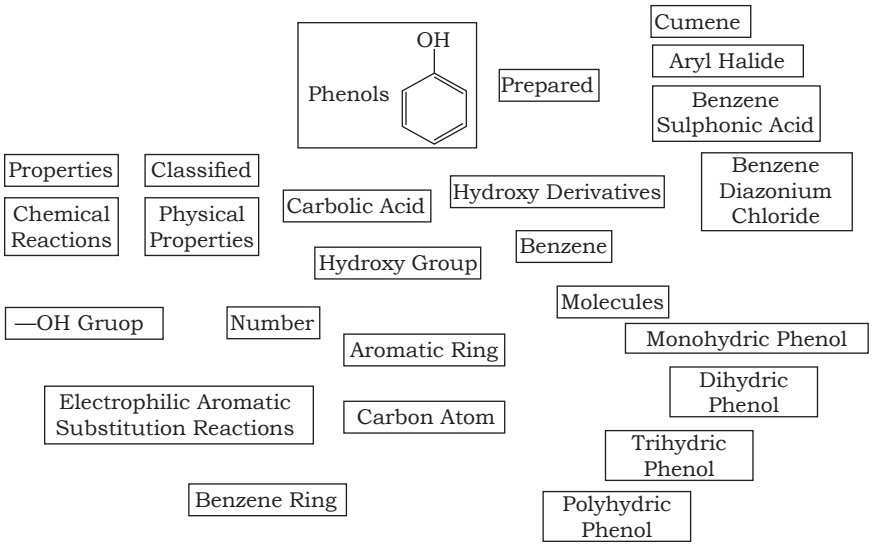
(a) 

(b) 

(c) 

Student : (a) Benzene Sulphonic acid
(b) Benzene diazonium chloride
(c) Chlorobenzene
Teacher : Chlorobenzene is alkyl halide or Aryl halide?
Student : Aryl halide.

The teacher adds 'Cumene', 'Aryl Halide', 'Benzene Sulphonic Acid' and 'Benzene Diazonium Chloride', on the black board.



The teacher points at the list of concepts and sub-concepts written on the black board.

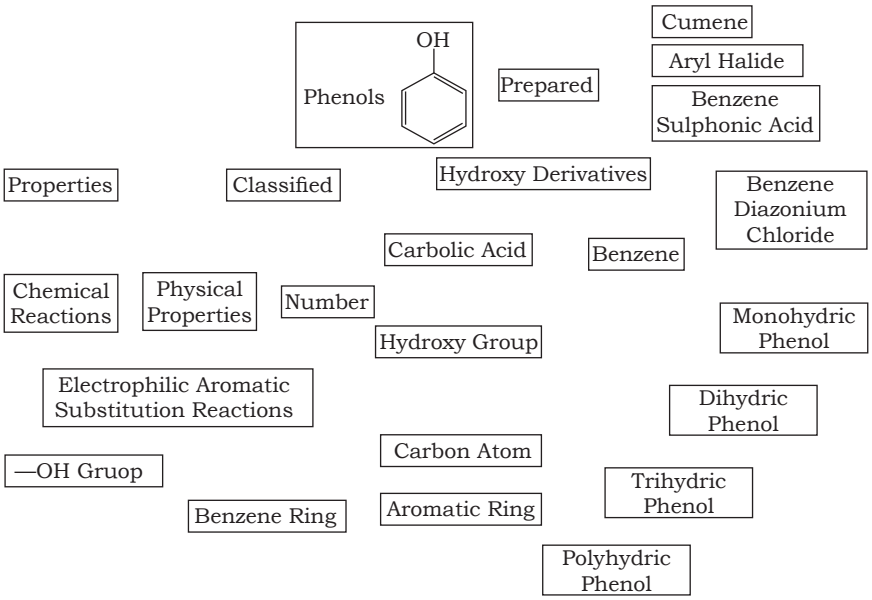
Teacher : Of the various concepts you have noted down, identify the most inclusive i.e. broader concept.

Student : Phenols.

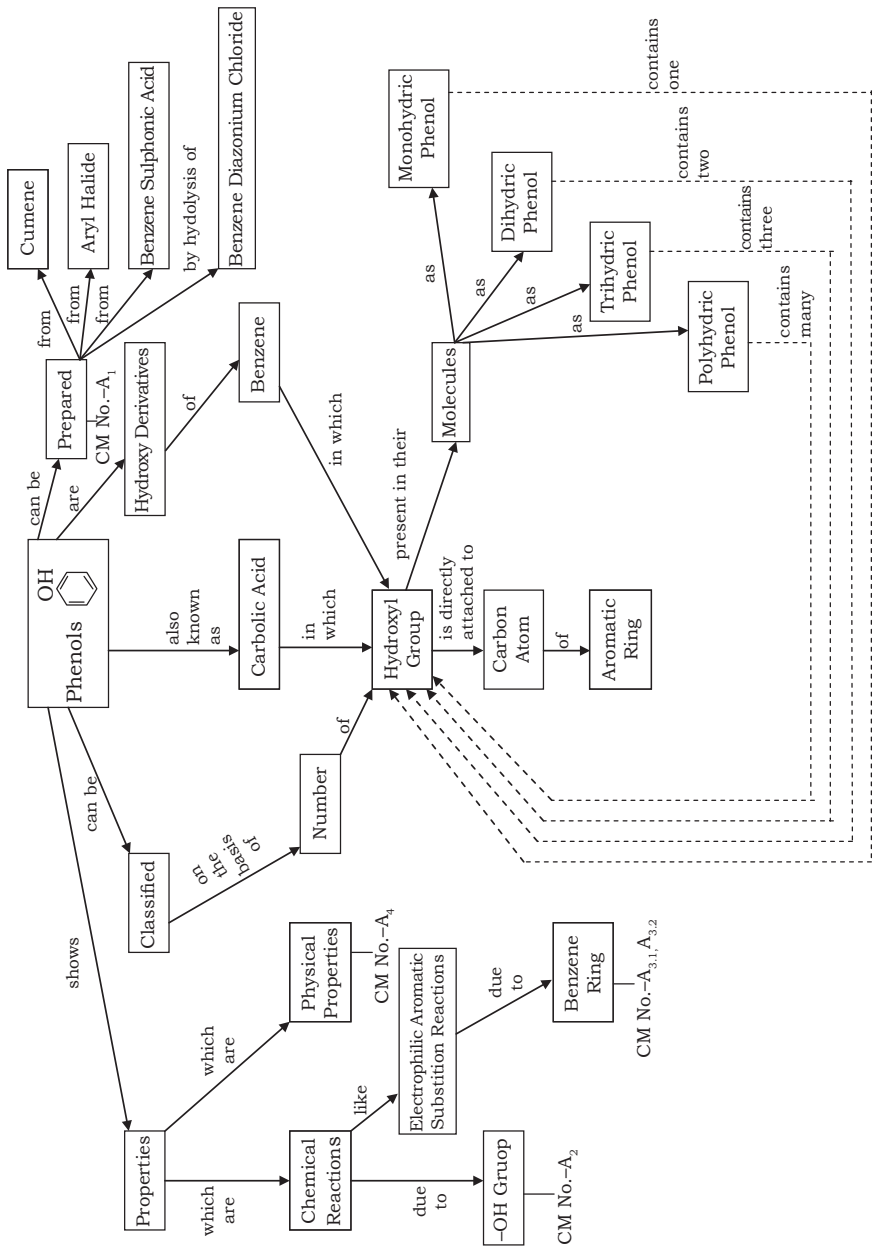
Teacher : Right, **Teacher shifts this concept label on the top and asks the students to identify the next less inclusive concept, which should occupy the hierarchy.**

Student : Properties and Prepared.

The teacher shifts these concept labels in the next hierarchical place on the black board and continues probing the students till all the concept labels are arranged in the hierarchical order, thus a pyramid is developed on the black board. She asks the students to copy the list in their note books.



Now the teacher calls one of the students on the board and asks her to connect the various labels using arrowhead lines. The rest of the students were directed to do so in their notebooks. After appreciating the students' efforts the teacher guides the students to define the connecting lines with appropriate words so that the relation between concepts could be highlighted using minimum words. The final structure developed through


OH
Phenols
can be
are
Prepared
CM No.–A1
from
Cumene
from
Aryl Halide
from
Benzene Sulphonic Acid
by hydolysis of
Benzene Diazonium Chloride
Hydroxy Derivatives
of
Benzene
in which
also known as
Carbolic Acid
in which
Hydroxyl Group
is directly attached to
Carbon Atom
of
Aromatic Ring
present in their
Molecules
as
Monohydric Phenol
as
Dihydric Phenol
as
Trihydric Phenol
as
Polyhydric Phenol
contains one
contains two
contains three
contains many
can be
Classified
on the basis of
Number
of
shows
Properties
which are
Physical Properties
CM No.–A4
which are
Chemical Reactions
like
Electrophilic Aromatic Substition Reactions
due to
Benzene Ring
CM No.–A3.1, A3.2
due to
–OH Gruop
CM No.–A2

mutual discussion, which was displayed on the black board, looked like:

The teacher completes the lesson by giving a few questions involving reflective thinking, to the pupils to work upon.

The above Lesson Plan at a glance present, how 2 concepts namely Phenol and Ether were introduced to the experimental group through 12 concept maps in an effective manner.

Phase III: Post-testing

After completion of the instructional treatment achievement test was administered as Post-test I to students of experimental group and control group for measuring their achievement.

Phase IV: Delayed Post-testing

After a gap of six weeks from the treatment achievement test was administered again as Post-test II to students of experimental group and control group for measuring their concept retention.

Analysis and Interpretation of Data

Table 3
MeanGain' MeanGain (Retention), S.D. and "t" values obtained on Pre-test and Post-test I , Pre-test and Post-test-II (Delayed Post-test) in Organic Chemistry by Higher Intelligence experimental group and Higher Intelligence control group

Group	N	df	MeanGain (Post -test I – Pre-test)	S.D. (combi-ned)	"t"	MeanGain (Retention) (Post-test II– Pre-test)	S.D. (combined)	"t"
Higher Intelligence Experimental Group	20	38	9.05	2.06	9.98	6.5	2.47	6.78
Higher Intelligence Control Group	20		2.55			1.2		

It is apparent from the result in Table 3 that the mean gain achievement scores and mean concept retention gain scores of students of higher intelligence experimental group is significantly higher than that of the higher intelligence control group and 't' value is significant at the 0.01 level of significance. On the

basis of this result we can say that Concept Mapping Strategy is significantly more effective than the Lecture Method in the improvement of achievement and concept retention in Organic Chemistry of students belonging to higher intelligence group. Thus the hypothesis H01.1, there is no significant difference between gain in achievement and concept retention in Organic Chemistry of higher intelligence experimental group and higher intelligence control group at the 0.01 level of significance is rejected.

Table 4

MeanGain' MeanGain (Retention), S.D. and "t" values obtained on Pre-test and Post-test I , Pre-test and Post-test-II (Delayed Post-test) in Organic Chemistry by Lower Intelligence experimental group and Lower Intelligence control group

Group	N	df	MeanGain (Post -test I – Pre-test)	S.D. (combined)	"t"	MeanGain (Retention) (Post-test II – Pre-test)	S.D. (combi-ned)	"t"
Lower Intelligence Experimental Group	20	38	5.75	1.92	5.93	2.05	1.21	3.38
Lower Intelligence Control Group	20		2.15			0.75		

It is clear from the Table 4 that the mean gain achievement scores and mean concept retention gain scores of students of lower intelligence experimental group is significantly higher than that of the lower intelligence control group and 't' value is significant at the 0.01 level of significance. On the basis of this result we can say that Concept Mapping Strategy is significantly more effective than the Lecture method in the improvement of achievement and concept retention in Organic Chemistry of students belonging to lower intelligence group. Thus the hypothesis H01.2, there is no significant difference between gain in achievement and concept retention in Organic Chemistry of lower intelligence experimental group and lower intelligence control group at the 0.01 level of significance is rejected.

Table 5
MeanGain' MeanGain (Retention), S.D. and "t" values obtained on Pre-test and Post-test I , Pre-test and Post-test-II (Delayed Post-test) in Organic Chemistry by Higher Intelligence experimental group and Lower Intelligence Experimental group

Group	N	df	MeanGain (Post-test I – Pre-test)	S.D. (combi-ned)	"t"	MeanGain (Retention) (Post-test II – Pre-test)	S.D. (combi-ned)	"t"
Higher Intelligence Experimental Group	20	38	9.05	2.50	4.17	6.5	2.57	5.47
Lower Intelligence Experimental Group	20		5.75			2.57		

Table 5 shows that the mean gain achievement scores and mean concept retention gain scores of students of higher intelligence experimental group is significantly higher than that of the lower intelligence experimental group and 't' value is significant at the 0.01 level of significance. On the basis of this result it can be concluded that Concept Mapping Strategy is significantly more effective in the improvement of achievement and concept retention in Organic Chemistry of students belonging to higher intelligence group than students belonging to lower intelligence group. It can also be concluded that more intelligent students are benefited more and retained more by the use of Concept Mapping Strategy. Thus the hypothesis $H_0$1.3, there is no significant difference between gain in achievement and concept retention in Organic Chemistry of higher intelligence experimental group and lower intelligence experimental group at the 0.01 level of significance is rejected.

Discussion of Results

The results of the present study indicates that Concept Mapping Strategy is significantly more effective than the Lecture Method in the improvement of achievement and concept retention in Organic Chemistry of students of both levels of intelligence. The results also indicate that this strategy is more effective for students of higher intelligence group than the lower intelligence group for improvement of achievement and concept retention in Organic Chemistry. The result of this study is also supported by findings of other studies conducted by Gupta (1999), Yekta Z. et. al. (2004), Rao(2004) and

Ahuja(2006).Whereas Snead and Snead (2004) found that effect of Concept Mapping on science achievement of lower ability students have higher success rate and has reported results contrary to the results of the present study. Okebukola (1990), Bantanur (2007), Chiou (2008) and Aparna (2002) have also found this strategy to be superior to Lecture method.

Conclusion

Based on the result of this study, it can be concluded that the Concept Mapping Strategy is more effective for improving the achievement of students in Organic Chemistry and also more effective for concept retention in Organic Chemistry of Class XII science students when compared to the Lecture method. Hence there is a need to include Concept Mapping Strategy with the constructivist basis as one of the major approaches to teach Organic Chemistry in our schools. Use of Concept Mapping Strategy as a main route of teaching or as a complementary strategy for traditional teaching method may improve the students' achievement in Organic Chemistry and knowledge retention capability.

Implications of the Study

The study has significant implications for students as well as teachers:

Implications for Students

Concept Mapping Strategy as an instructional method would be helpful to raise the achievement levels of students. Besides adding to the clarity of concepts, concept maps will lead to the formation of strong linkages with related concepts. Thus Concept Mapping Strategy would be helpful to the students for enhancing retention of concepts in their cognitive structure. During the preparation of Board exams and other competitive exams Concept maps can also be used by the students as revision tools. Concept maps can also be used by the students for identifying gaps in their knowledge, if any, and hence convincing them about the continuity of subject matter.

Implications for Teachers

Concept maps would also be helpful for the subject teachers to identify the causes of under-achievement among students and to remedy them. It would also be helpful for the teachers to organise

their curriculum systematically and present it effectively. Teacher can also use concept maps as misconception correction tools. From students' constructed concept maps, teachers can diagnose students' understanding of concepts and can identify the existing misconceptions. Once misconception in students' cognitive structure are diagnosed, remedial teaching in this direction can also be done by using Concept Maps.

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