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CONCEPT MAPS AS A TOOL FOR MEANINGFUL LEARNING AND TEACHING IN CHEMISTRY EDUCATION

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ABSTRACT

In the present situation, only qualified people can overcome the problems of education system. Today all coutries aims to reach modernized education system. Above all, chemistry education is one of the pioneers of our educational system. Therefore, chemistry concepts must be conveyed to the receiver (student) accurately and well-arranged. For the successful learning, teaching strategies, methods, techniques and tools should transform knowledge from short-term memory to long-term memory. Ausubels' theory of meaningful learning is one of the most important expository theories which explain how to transform information from short-term memory to long-term memory. According to this theory Meaningful learning occurs when complex ideas and information are combined with students' own experiences and prior knowledge to form personal and unique understandings. In this process, it can be said that concept maps are one of the most important teaching and learning tool that promote meaningful learning. This study was designed as the study of the compilation. The purpose of the study is to introduce concept maps as a tool for meaningful learning, student centered, active, new learning and teaching strategy in chemistry education. According to the University of Illinois, there are seven kinds of concept map. The most commonly used five kinds of concept maps in chemistry were mentioned in this study.

Key Words: Concept map, teaching strategy, meaningful learning, chemistry education.

INTRODUCTION

Generally chemistry is introduced first time as a separate subject in IXth class and students study the basics and fundamentals of chemistry, so they feel a lot of difficulties in understanding these things. One of the biggest problem that students are facing in general chemistry classes is their inability to communicate, what they actually know about the concepts, whether with the teacher or in an exam or on a problem set.

The inability to communicate what they know, and receiving a low test score on the material they actually understood, undoubtedly frustrate the students even to the point of given up. The reason for the student's lack of chemistry communication skills is simple, they spend very little time in learning, practicing and speaking the language of chemistry. The problem is very further lengthened when teacher use discussion sections as just another lecture session or review session and spend the majority of time in talking to the students instead of having the students, do the majority of the talk.

Students' response indicates that a majority of them confuse atoms with molecules. They feel difficulty in understanding atomic molecular models, used to explain the properties and chemical phenomenon. They draw their own assumed figure in mind. Some held an addition mode of molecular composition and stated that a water molecule contained a unit of hydrogen gas (H_2). Some student viewed H_20 (*l*) and Cl_2 (g) as representation of one particle without the concept of atoms or a collection. To them, the use of (*l*) or (g) could not trigger any descriptions about multitude of molecule.

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Many students even after studying chemistry do not understand the role of a formula. Some think that formulas are merely abbreviations for names rather than it explains the composition, or structure as well as quantity (mole concept). Some hold the miss conception that a formula is an abbreviation for a mixture.

Most students have difficulties in interpreting chemical equations because their understanding is constrained by the surface feature of representations. When, they see an equation such as.

$$C_{(S)} + O_{2(g)} \rightarrow CO_{2\,(g)}$$

They interpret it as a composition of letters, numbers and lines rather than a process of bond breaking and formation of new bond. The technique of balancing chemical equations makes them picture chemical equations as mathematical puzzles and they can even work algorithmic without having a conceptual understanding of the phenomenon, while they should see symbols and letters as molecules and the arrow as the direction of reaction.

Also a large numbers of students were unable to make translation among formula electronic configuration and ball stick models. Even after a great labour, they lack ability to provide equivalent representation and verbal description for a given representation without appropriate understanding of underlying concepts, most students are not be capable to translate from a given representation to another one. So making conceptual connection between representations and developing understanding of underlying concepts are important for students to learn chemistry.

It is well known, that chemistry is a very difficult subject for students especially the pioneer one but if once they build the better and right understanding of basics and fundamentals, they acquire the skill, to handle the subject very well.

Some of the major reasons for this lack of understanding are.

(1) Students are rote learning (memorizing definitions and statements) instead of learning meaningfully (co-relating new knowledge to previously learned).

(2) Students are unable to recognize the key concepts and concept relationships needed in order to understand the material.

(3) The key concepts or concept relationship may not be clearly presented by the instructor.

(4) Lack of connection between the concept areas. Sometimes laboratory activities enhance this impediment since it lacks conceptual structure associated with text book based instruction since text book provide structure that associate specific facts within an appropriate conceptual frame work. The laboratories are complex information rich environments in which the students may become overwhelmed in their efforts to process the information effectively.

No doubt chemistry laboratories have played an important and effective role in chemical education. However, students frequently lack the ability to associate their laboratory procedures experience with the important chemical concepts.

In order to develop well organized conceptual frameworks students must choose to learn meaningfully rather than by rote learning. In this point, concept mapping is the best teaching strategy that promotes meaningful learning in chemistry.

CONCEPT MAPS

Concept Map is a graphical tool that organizes, connect, and synthesize information. Concept maps show concepts in circles or boxes and one can indicate relationships between concepts by connecting lines or linking words. Figure 1 shows an example of a concept map that describes the structure of atom.

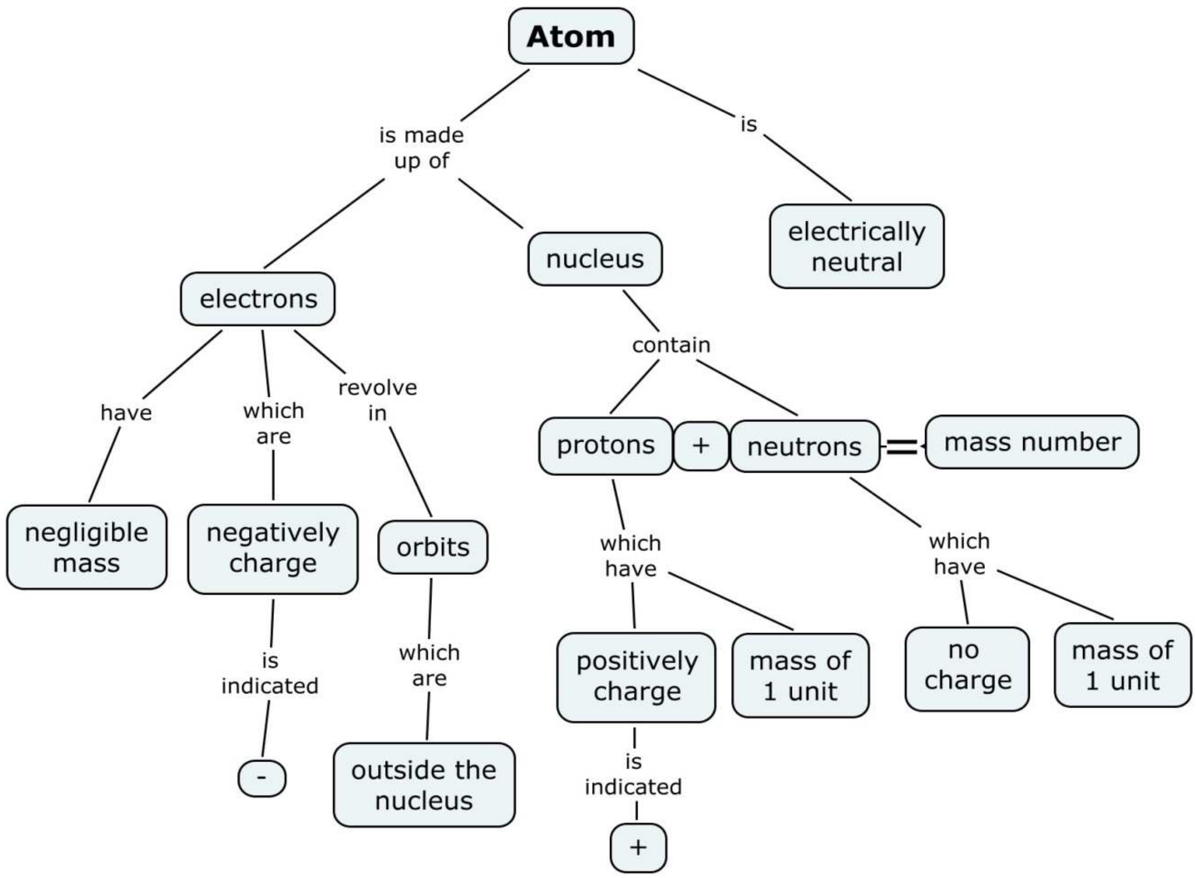


Figure 1: A Concept Map of Structure of Atom

Concept maps were developed on the basis of Asubels' theory of meaningful learning. According to Asubel learning is meaningful when the student comprehends the relationship of what is being learned to other knowledge. When we imbibed the information completely, only then we are able to remember it better. Therefore, meaningful learning is necessary for successful learning.

Comparision Between Meaningful Learning and Rote Learning

As we mentioned above, Ausubel is the founder of the concept of meaningful learning. Ausubel examined the difference between meaningful learning and rote learning in 1981. According to Ausubel:

Rote learning, was the terms encountered for the first time, such as the multiplication table, chemical symbols of the elements, foreign words, the names of the compounds etc. are just taken and stored in mind without any integration or interrilation. All of these items and names are unique and should be kept as they are. Whereas, meaningful learning is the opposite of rote learning where knowledge and concepts which learned is linked to each other.

Rote learning is not object-based. Specially, on the issues where people are unfamiliar with the basic principles or concepts must be memorized before in general. Later, through meaningful learning the same information/subject should be recollected in the memory. So, ultimamately the information grabed through rote learning will become the part of meaningful learning itself. İt will establish a connection to the existing information and become long term memory.

Rote learning is required only for basic concepts to be learn at first impression. Further when the student get taught basic concept, so it will be added to the long term-memory by meaningful learning. İn any case, if student has to learn the whole subject through rote-learning, the subject must be recited by him/her to imbibe and convert into long term memory. İt is because there is no permanance in the human memory. İt is generally forgot by student very soon.

Meaningful learning provides evidence that any individual is able to internalise a new stimulus of any concept and later it is reflected in the ability of one individual to apply the new knowledge in other situations. On the other hand, in rote learning when new knowledge is arbitrarily incorporated into the cognitive structure. Then that individual could recall the learned concept, but is unable to apply it in new emerged problems or situation.

Why Concept Mapping is Superior to Other Methods?

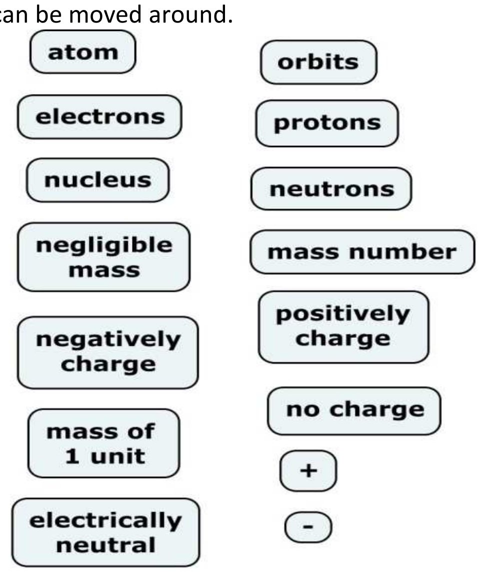
There are several reasons why concept mapping is superior to other methods. These are as follows:

1. The primary benefit of concept mapping is that concept maps can be obtained from the visual presentation of ideas based on the deduction for impairment.
2. It addresses different forms of learning and individual differences between students. It means same subject or same concepts can be drawn differently for the individuals.
3. It can be used easily for the creation and integration of the scope of the assessment.
4. Concept map is student-centered, active teaching method. It can encourage student-teacher interaction when they create a map together by discussing.
5. It is very useful for showing alternative relationships within a system
6. After learning this technique, students get used to establish links between concepts rather than recalling concepts separately.
7. It can be used effectively for revision after a topic. And students are able to rank topics which they learn.
8. It develops the social aspect (confidence level) of students for being able to speak during construction.
9. Provides clarity of the concept.
10. It is a good way to work and prepare for the exams.
11. It is suitable for many different topics, instructional stage and grade level
12. It is easy to use for teaching and learning.

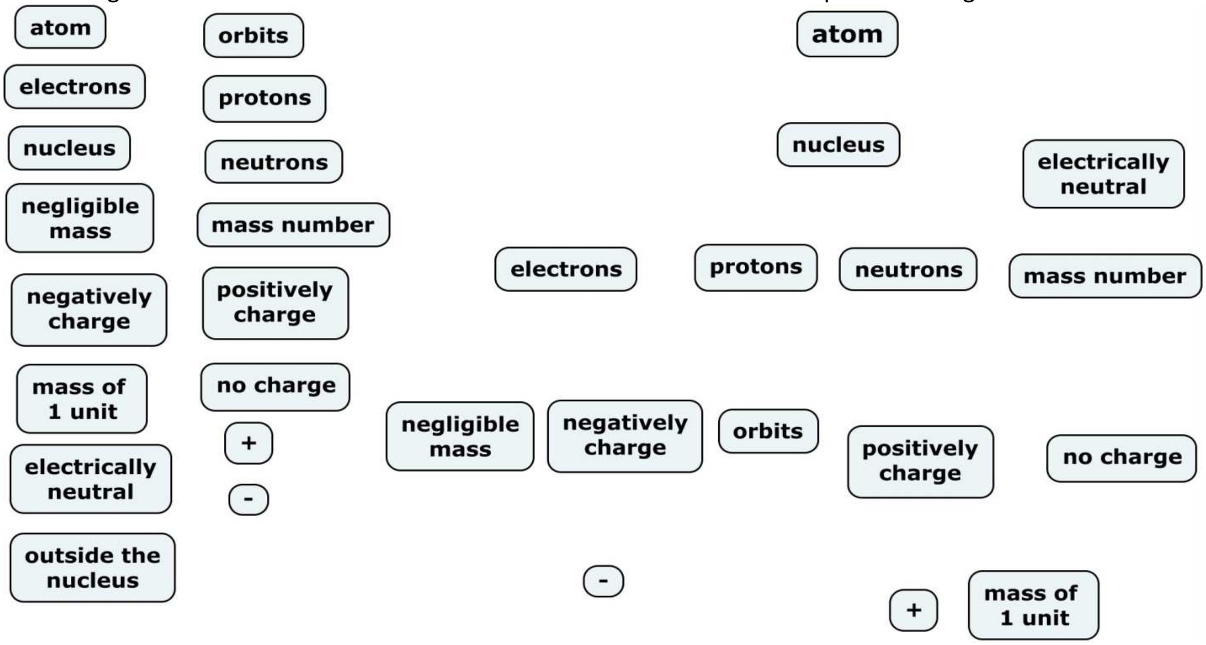
Steps of Constructing a Concept Map

Step 1: To construct a concept map, first, define the context. A good way to define the context for a concept map is to construct a focus question, which means, a question that clearly specifies the problem or issue the concept map should help to resolve. Every concept map responds to a focus question and a good focus question can lead to a much richer concept map. Assume that our focus question is “what is an atom?”

Step 2: Identify the key concepts in a paragraph, laboratory activity or in a chapter; or simply think of the concepts of a subject area and list them. It is better to write the concept labels on separate cards or small pieces of paper, in order that they can be moved around.

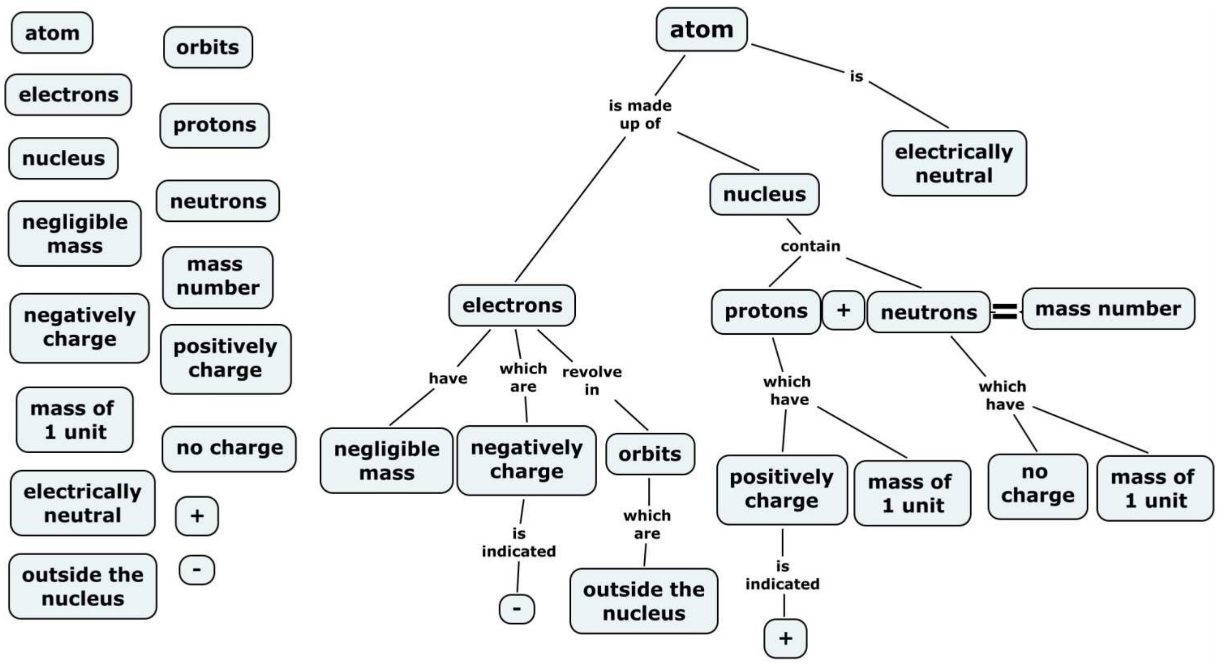


Step3: From the listed concepts, rank the concepts by placing the broadest and the most inclusive idea at the top of the map. It may be difficult to identify the broadest, the most inclusive concept. It should be kept in mind that this rank order may be only approximate. It is helpful to be aware of the context of the concepts we are dealing with or to have some idea of the situation for which these concepts are arranged.



Step 4: Work down the paper and add more specific concepts and do hierarchical arrangement of concepts.

Step 5: Connect the concepts by lines. Label the lines with action or linking words. These links between different domains of knowledge on the concept map can help to illustrate how these domains are related to one another. When you hold together a large number of related ideas, you can see the structure of meaning for a given subject area.



Step 6: Specific examples of concepts can be added below the concept labels. But these are not included in circles or boxes. They are specific events or objects; so they do not represent concepts.

Step 7: A concept map is never finished. After a preliminary map is constructed, it is always necessary to revise this map. Other concepts can be added by student under the guidance of teacher in classroom work. Good maps usually result from several revisions.

Students frequently face problems in adding linking words onto their concept map. This is because they poorly understand the relationship between the concepts which can be specified by linking words. Once students begin to focus in on good linking words, they can see that every concept can be related to every other concept. Some students are facing more difficulty while building concept maps and using it in their experience. This results by primarily from years of rote-mode learning practice in school settings, rather than as a result of brain structure differences. It is not easy to switch students from the former condition to patterns of learning of the later type. While concept maps can help, students also need to be taught something about brain mechanisms and knowledge organization, and this instruction should accompany the use of concept maps.

Benefits and Uses of Concept Maps

There are several benefits and uses of concept mapping for both students and teachers. Concept maps give students an opportunity to:

- ✓ Think about the connections between the chemistry concept being learned at beginning,
- ✓ Organize their thoughts and visualize the relationships between key concepts in a systematic way which can lead students to learn meaningfully
- ✓ Reflect on their understanding.

When an expert creates a concept map, it is typically an elaborate, highly integrated framework of related concepts. Highly sophisticated maps show highly integrated knowledge structures, which are important because they facilitate cognitive activities such as problem solving.

To develop chemistry education, the use of concept maps can be categorized into four.

1) As a method of learning: The use of concept maps has been widely investigated in chemistry by scholars. According to several studies, concept maps help chemistry learning both in classrooms and in laboratories. Concept maps allow learners to think deeply about chemistry by helping them to better understand and organize what they learn, and to store and retrieve information more efficiently. Learners also articulate and challenge their thoughts about chemistry when they discuss their maps with each other.

2) As a Teaching Method: Concept maps are also valuable tools for teachers because they provide information about students' understanding and misconception that student have. Teachers can examine how well a student understands science or chemistry by observing the inclusiveness of their concept map. Concept maps can help us to identify, understand, and organize chemistry concepts we plan to present (teach). At first, students will find concept maps very strange and may even try to memorize them, rather than use them as a thinking tool. It should be noted that it is temporarily, each student has a different capacity to handle this method. Instructors shouldn't give up in such cases.

3) As a Curriculum and Lesson Planning Method: The use of concept maps can also assist the curriculum specialists in developing a curriculum. Concept maps proceed from the more general, more inclusive concepts to the more specific information. It usually leads to encouragement and enhance meaningful learning. Hence it is become obvious that students are required to learn the details of new and unfamiliar disciplines before they have acquired an adequate body of relevant aliments involvement at an appropriate level of inclusiveness.

Concept maps are useful "As a Curriculum and Lesson Planning Method" for teacher and student in following ways:

- ➢ Using concept maps in planning a curriculum on a specific topic helps relating various ideas within a unit format and makes the instruction "conceptually transparent" to students.

- Using concept maps is helpful on revising the existing curriculum in both process and product.
- Concept maps are useful in planning interdisciplinary instructions by developing a conceptually compatible, congruent programme

4) As an Evaluation Method of Students' Understanding: Concept mapping could be a key for developing strong performance assessments that how students are applying concepts and to observe the deep understanding that students are gaining. Student may be provided with a set of unlinked concepts with which they have to construct a map or they may be asked to construct a concept map after the teacher has taught the topic in order to examine their conceptual comprehension. For example, linkages drawn between two unrelated concepts expose students' alternative or negative conceptions in chemistry. Teachers can quickly see the improvements in learning based on knowledge, understanding and problem solving ability, then they modify lesson plans based on received information from students' concept maps.

According to Novak, concept mapping is one of the most powerful evaluation tools, "encouraging students to use meaningful-mode learning patterns."

Scoring of a concept map is based on several criteria such as:

- ✓ Validity of propositions and relationships connecting the concepts.
- ✓ Number of hierarchical levels and correctness of the hierarchical level.
- ✓ Number of cross-links and The validity of cross links
- ✓ Number of links and Extent of latitudinal and longitudinal branching.
- ✓ Number of examples and Appropriateness of general and specific examples.

Kinds of Concept Mapping

According to the University of Illinois, US (2002), there are seven kinds of concept map. The most commonly used five kinds of concept maps in chemistry are mentioned below with examples.

1. A Spider concept map is a kind of map that is used to investigate and enumerate various aspects of a single theme or topic. It helps student to organize their thoughts. Outwardly radiating sub-themes surround the center of the map. It looks a bit like a spider's web, as its name suggests.

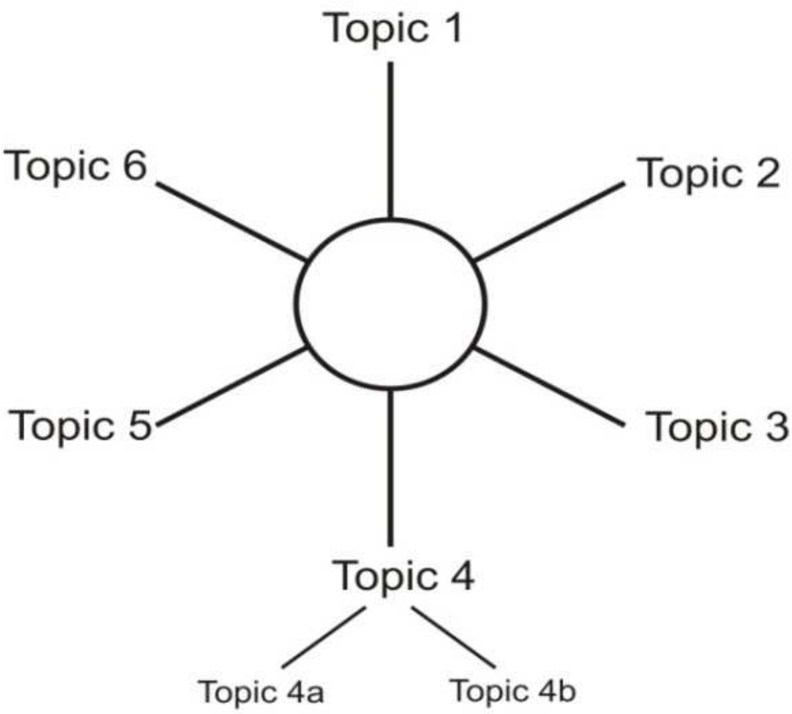


Figure 2a: Spider Concept Map

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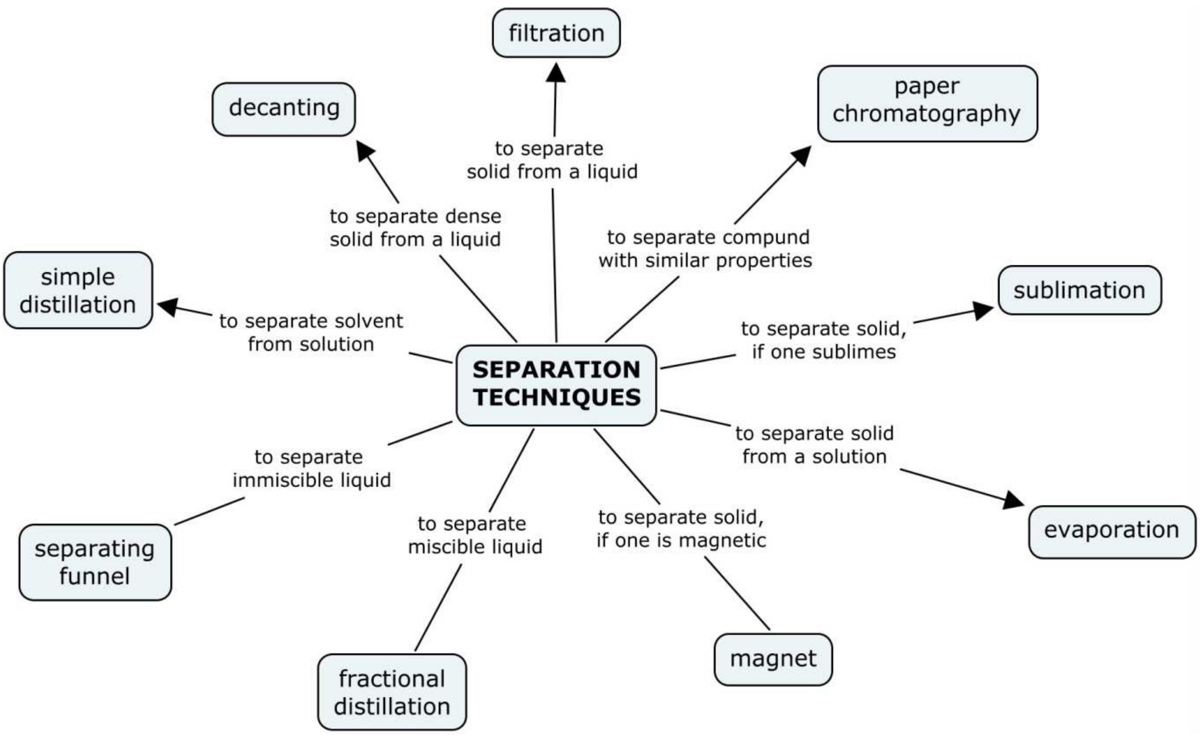

Figure 2b: Separation Techniques

2. The hierarchy concept map, as shown below, presents information in a descending order of importance. Step by step the student noted down the relevant context in the given boxes/circles. It helps to understand and co-relate the subjects. Figure 5 shows an example to the hierarchy concept map.

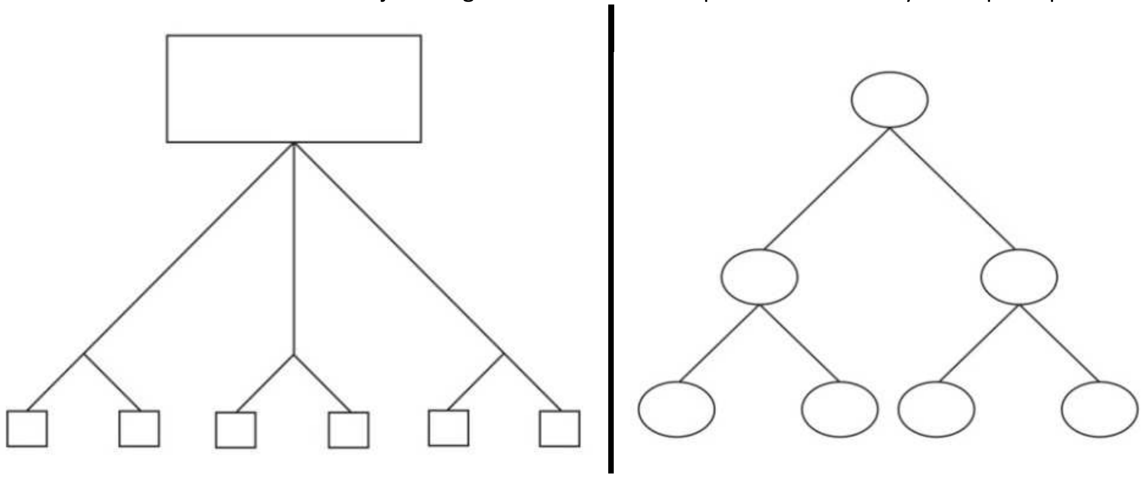

Figure 3a: The hierarchy Concept Map

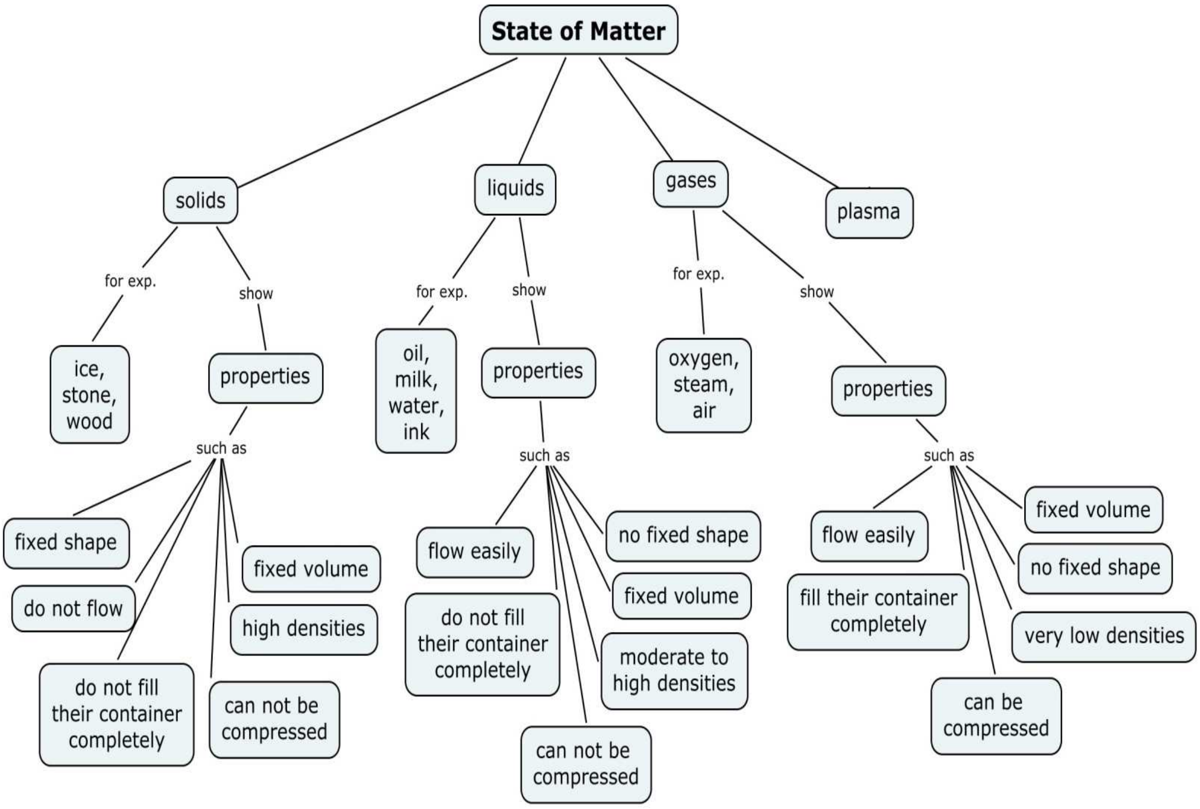

Figure 3b: State of Matter

3. The flowchart concept map organizes information in a linear format.

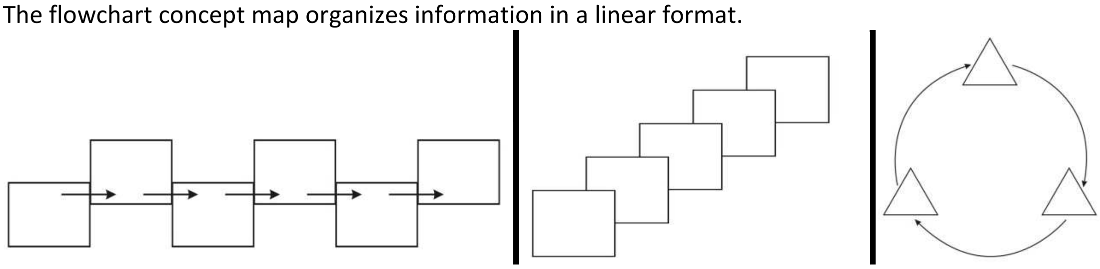

Figure 4a: The flowchart Concept Map

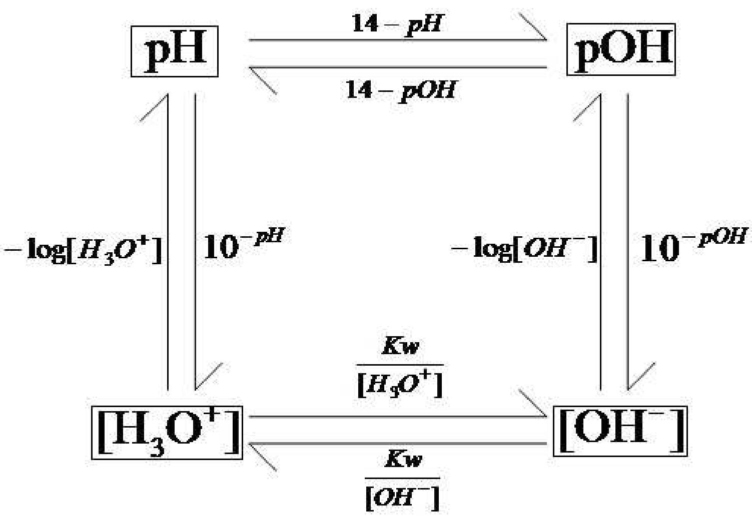

Figure 4b: pH and pOH

4. The systems concept map organizes information in a format. Includes all data on the map and shows many relationships between the data. Uses critical thinking skills along with problem solving skills.

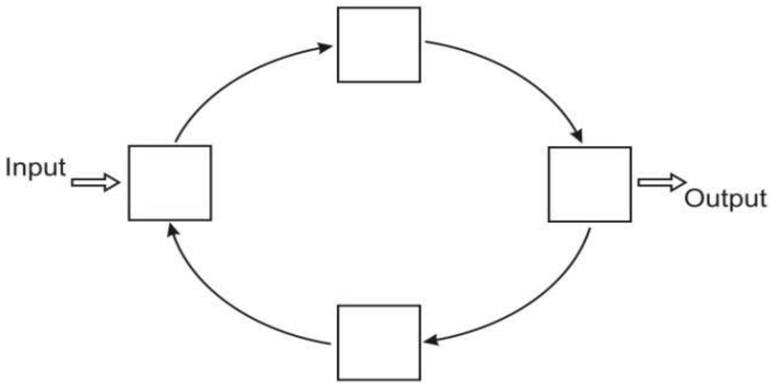

Figure 5a: The systems Concept Map

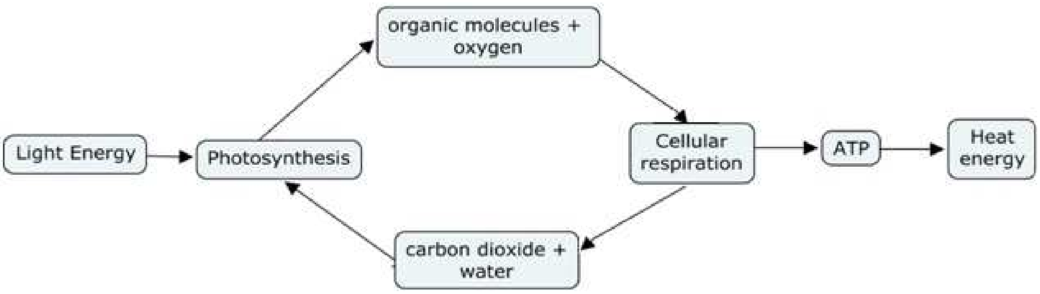

Figure 5b: Photosynthesis and Cellular Respiration

5. Multi dimensional (3D dimensional) concept map describes the flow or state of information or resources which are too complicated for a simple two-dimensional map.

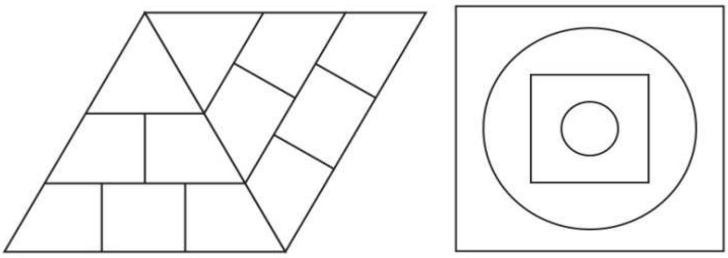

Figure 6a: Multi dimensional (3D dimensional) concept map

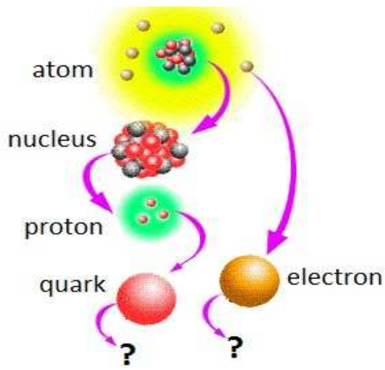

Figure 6b: Atom

Studies Related to Teaching of Chemistry

Chemistry education should be integration of educational knowledge with chemistry knowledge. Chemical education experts provide guidance in the consideration of the choice of appropriate and meaningful chemical content alongside the choice of the most suitable and proven teaching techniques. Some of the related studies mentioned below to highlight the importance of concept mapping in chemistry.

The goal of a study by Nicoll, Francisco & Nakhleh (2001) was to investigate the value of using Concept Mapping in general chemistry and, more particularly, to see if Concept Mapping would produce a more interconnected knowledge base in students, compared to ordinary instruction. The results showed that the Concept Mapping group knew more concepts (49 vs. 38), more linking relationships (69.9 vs. 46.2), more "useful" linking relationships (55 vs. 34.6), and had no more erroneous linking relationships than the non-Concept Mapping students

Sharma (1979), developed a programme in chemistry using Bruner's strategy of conservation focusing. The programme was developed for teaching of concepts to class seventh. The result indicated the programme to be quite effective.

Rosemary Frech Laeary (1993) in her Ph.D thesis considered the effect of concept maps on concept learning and problem solving achievement in high school chemistry. The study investigated chemistry achievement among high school students. A significant relationship between concept learning and numerical problem solving was found in the concept mapping group only, thereby supporting the theory behind the concept mapping strategy.

Keng (1996) conducted a comparative study of note taking, outline and concept mapping learning strategies on National Taipei Teachers College students' understanding at heat and temperature. The result of the analyses permit the following statements in terms of the overall students' performance as measured by the total examination scores, students who used either an outlining or concept mapping learning strategy scored significantly better than students who used only a personalized note-taking strategy.

Pendley et al, (1994), Francisco et al (2002) investigated the effects of concept maps for university student studing chemistry. The result shows that concept maps is beneficial for university students studying chemistry. The reviewed studies clearly revealed that concept mapping enhances students' achievement in chemistry.

CONCLUSION

Since 1990, concept maps have been used in many ways as a research topic in science stream such as, Barenholz and Tamir (1992), Trowbridge and Wandersee (1994), Hegarty-Hazel and Prosser (1991). All of these researches have been proved under the validity, reliability and practicality of concept map as a method of teaching.

The analysis and researches of more than 300 scientific articles about concept mapping shows that in professional education this method is more used in the subject fields which are directly connected to natural or exact sciences. The main idea of using the method is as teaching and learning tool, often combined with assessment tool. In most articles the faculty and students feedback are positive and the authors suggest the method of concept mapping for further use in classroom.

Today instructors and educators are looking for more active and interactive teaching techniques. At this point, concept map will work better in the field of education and will take another step forward to instructional technique. The important thing is our contribution for the usage of effective teaching technique. With each passing day, the effective use and the effective implementation of concept map will be explored and it will make learning easier for learners.

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