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Contemporary Teaching Methods in Mongolian Secondary School Chemistry

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----------**ABSTRACT**----------
New developments in science education can take place due to the use of contemporary teaching strategies in teaching general chemistry. In this paper, the advantages of various teaching methods such as concept map drawing, workshops, problem-based learning, case study, predict-Observe-Explain (POE) methods will be brought into light.
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Current approaches used in teaching chemistry at secondary school level

Student-centered approach

In this approach the teacher gives and explains the most important and basic information regarding the topic to be taught. The students are expected to learn the rest on their own. Despite the fact that students need to learn everything, the teachers are not able to teach everything to them because of limited time and energy. This fact leads to teaching the students the ways of learning on their own instead of giving them the compiled knowledge and information throughout ages. The teachers should enable their students to become active and lifelong learners. This need requires the teachers to focus on characteristics of their students and their learning styles while preparing for their lessons, paying heed to the students' interest and needs for their future.

The students are expected to turn into active learners instead of the passive ones in the traditionally taught lessons. By becoming active they will become independent learners who are able to understand the taught concepts either on their own or by interacting with their peers. In doing so, the teacher becomes a facilitator who guides their learning, not a source of information from which the students are supposed to fill their brains as much as possible. If all the previously mentioned conditions can be achieved, the learning transfers from teacher-centered learning to student-centered learning. Of course, contemporary development of science and technology should be implemented in the teaching process so that the students' attention can be directed to the learning of chemistry. Such innovations in teaching approach can be through multimedia, games and music about the lesson or the Internet. For developing countries building of multiple representations by the students themselves can achieve similar results in learning. These approaches can definitely change the old 'chalk and talk' teaching methods into a much desirable self-sustained teaching approach where learners can become active learners aware of the subject matter's importance in their lives.

Generic science education approaches

A thorough comprehension of education lies in the understanding of its purpose. Similarly, the purpose of science is 'to know'. The most important purpose of chemists is to develop and synthesize new materials to satisfy the needs of human beings. On the other hand, a background of science and technology is needed to understand the whole picture. In other words, the students should be encouraged to develop a science-oriented reasoning for making their future decisions. Not every student in secondary schools is expected to become a chemist since the world needs not only chemists but also other professionals. As a result, what the chemistry teachers teach in their lessons should be based on everyday life and basic items related to real life like soap and baking soda.

Interdisciplinary approaches

Learning is not only active and ever growing, but also integral and connected in nature. Since the beginning of the 21st century chemistry has been one of the most important sciences that mattered in the daily lives of people. That is to say that chemistry is being disseminated into the other sciences in an increasing amount. Nevertheless,

there are the complicated present and future problems which are becoming even more so as the time is passing. An interdisciplinary approach is needed to bring solutions to such problems. More than 1000 scientists from five countries (China, France, Japan, the UK, and the US) participating in the Human Genome Project is a good example for such an approach. Many scientists from various disciplines of science like chemistry, genetics, and so on worked together to create the genome map. Both in theory and practice Chemistry is a unique science which has played a significant role in the realization of this project. With the help of practical chemistry like crystallizing the proteins and determining their structures the theory of cloning the DNA sequences and generating proteins became possible. Similarly, for pharmacists, studying protein structures and functions has become the foundation by which they develop new medicines with resulting ease of much human pain and suffering. Furthermore, in the course of teaching chemistry in secondary schools, the teachers should cultivate a range of interdisciplinary learning methods, teamwork and inter-personal skills in their students.

Proposals for chemistry teaching

Usage of Case Study Method

Usually, medical, business and law schools prefer this method for both learning and teaching because these fields of science have had a long tradition of employing real or simulated stories as cases to teach their perspective disciples about their field. A good case study should make use of many disciplines and relate to the real world. The case study method means learning by doing, cultivating students' analytical and decision making capabilities, and combining their knowledge and skills which will finally lead to their learning how to deal with real life problems. More and more chemistry teachers have been implementing case study teaching method in their classes in the recent years.

Students are expected to study on their own for a certain period of time and learn how to work individually and as a member of his/her group for a case study. As for the teachers, they are supposed to guide and motivate their students in the general direction of the study but not give them direct orders and objectives to accomplish. On the other hand, the traditional lessons made the students to listen and take note of what the teacher said instead of letting them find out information and understand the real meaning and objective behind the learning process. When the lesson is over, the students are left with assignments to hand in at a later date. The final exams in the old sense were the students' reproduction of what they heard from their teachers and read in their textbooks.

All in all, the case study method motivates the students to actively look for and internalize the information required for the case study and lets them learn related concepts to the case study in a much deeper way.

A very good example for the case study method is the discovery of Carboplatin, a component for the cure of cancer.

In 1844, M. Peyrone first produced a compound used in chemotherapy, Carboplatin, and since then it has been coined Peyrone's chloride. Alfred Werner tried to build up its structure for the first time in 1893. For several decades Peyrone's chloride was almost forgotten but in the early 1960s a series of experiments in the laboratories of Barnett Rosenberg at the Michigan State University brought it back into the limelight. These experiments' results were quite interesting. An experiment designed to measure the effect of electrical currents on cell growth yielded Escherichia coli that were 300 times the normal length. This effect was not due to the electrical fields themselves but to a chemical agent that was formed in a reaction between the supposedly inert platinum electrodes and components of the solution. The unexpected compound later on turned out to be Carboplatin which was revealed to have prevented cell division, but not other growth processes in the bacteria and leading to its elongation according to further researches. After learning this fact Barnett's group tested the compound against cancer cells in mice. Carboplatin proved to be very effective in destroying cancer cells. Later on, tests on human subjects bore positive results although there were some toxic side effects which limited them. In 1978, Carboplatin was approved for use in chemotherapies after its side effects were made tolerable with the use of adjuvant therapies.

Possible case study questions should be as the followings:

1. What is Carboplatin?
2. How is Carboplatin produced?
3. What is the chemical structure of Carboplatin?
4. What are some of the side effects of Carboplatin?
5. What is meant by the term 'cell division'?
6. What is the most probable mechanism of action against cancer?

The first three questions are related to basic chemistry so students can visualize the structure and understand the chemical formula of Carboplatin, therefore they are expected to be able to synthesize it. Moreover, coordination compound concepts such as coordination number and geometry are indispensable for them to succeed. The fourth question concerns bioinorganic chemistry with the help of which they learn about the importance of transition metals in the human body. The last two questions demand the students to display their fundamental biological knowledge.

Three focus groups can be formed among the students, and each group will be given the task of researching one of the questions by referring to notebooks, library or Internet resources outside of the lesson period. 2-3 students from each group will be elected to present their perspective groups' findings to the classroom. This method gives an opportunity to the students to lead their peers. This example cultivates students' problem solving skills and interdisciplinary knowledge because it is a fact that students learn from each other well.

Drawing Concept Maps

Since chemistry has a systematic knowledge base it is a unique and fully developed discipline. The students can easily grasp the interrelationships among its concepts with the help of drawn concept maps. A systematic interaction of chemical concepts can be represented through this method which makes all the relationships clear as crystal. This method is adequate for cultivating students' cognitive structures. The meaningful learning which is sought after can greatly benefit from this.

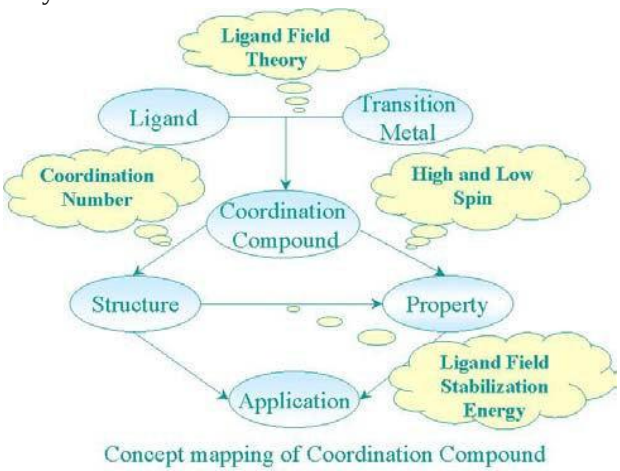

Figure 1: A concept map of coordination compounds

For the teaching of coordination compound Figure 1 can be used.

A ligand and a transition metal can form a coordination compound. During this process, the concept of 'ligand field theory' comes into play. The mechanism of the coordination reaction can be described by this theory. The concept of 'coordination number' connects the compound with its shape. When the central atom has more than one 'coordination number', the compound has numerous shapes. Between a compound and its characteristics, 'high and low spin' results the transition compounds to have different colors. Moreover, 'high and low spin' defines the magnetism property of the compound. The amount of the Ligand Field Stabilization Energy (LFSE) affects the stability of the compound and the velocity of ligand transfer reactions. Coordination compounds have numerous uses in industrial chemistry and medicine. Most catalysts are transition metal complexes: for example, platinum and gold compounds are used in medicine.

Predict-Observe-Explain Method

Chemistry is an experimental science in which the molecular structures of substances can either be broken down or built up. In order to describe an abstract concept, a demonstration experiment or a model is often needed for the method of demonstration preparation. When conducting a demonstration, the teachers should employ the Predict-Observe- Explain method. Students should be asked their perspective results of the demonstration. With the help of this method, the students are given the time and chance to actively ponder on the question which in turn encourages them to study more. After that, students can observe the experiment and see if the result of the experiment turned out the same as their prediction(s) or not. Lastly, the result of the experiment is discussed. The discussion about the experiment cultivates the students' constructive and critical thinking skills.

Workshops and problem-based learning

When it comes to the best way learning there is nothing as good as your own experience of doing things. Workshops and problem-based learning are more adequate for chemists who have the necessary laboratory equipments, in my opinion. However, it is possible for very few because of limited resources such as laboratory assistants, money for equipment and reagents. Only the elite chemistry students whose ultimate goals are directly related to learning chemistry are allowed to have access to these.

In workshops the students are given a chance to conduct specific research on certain areas of chemistry. To do so, the student must choose a chemistry problem of his/her interest and then a teacher to guide and monitor his/her research. The student is expected to do some background research on the problem and discuss his/her findings with the monitor. Under the supervision of the guide, the experiment(s) is conducted, and the conclusive data are gathered and analyzed. The student is expected to report his/her findings in a written form in the end. Through this kind of workshop, the students obtain time management, data-processing and information technology skills.

For problem-based learning, a badly constructed and open-ended question is the incentive of learning. Students become aware of their learning activity's final goal, unlike in the traditional method of teaching where they don`t know the goal of their learning. In order to solve the problem, the students are expected to find out specific knowledge and data. The limelight falls on the information sought after and its usage in certain conditions.

Conclusion

Employing the present teaching methods such as the case study method, enhances the quality of chemistry teaching in secondary schools. Hence, the students will be more interested in studying chemistry. These methods let the students become experienced in problem solving, thinking critically, learning on their own, group collaboration and obtain a lifetime learning skills. As teachers, for a brighter future, the most appropriate route to take is to employ the mentioned methods or at least try to introduce the general idea of it into our teaching practices.

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