The Process of Learning Chemistry

A Review of the Studies

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According to present trends in education, the student–not the teacher—is the main object of the teaching process. The teacher's task is to augment the student's cognitive activity. To do it constructively and properly, the teacher should possess knowledge about the course and conditions of the learning process. Information in this field is provided by the studies in cognitive psychology. Recently the interest in this subject has developed rapidly, leading to possibilities of better understanding and interpretation of cognitive learning processes. At the same time among different research trends on chemistry education the most intense studies have developed on learning chemistry lately.

Studies on learning process include various problems of a broad range. They cover—among others—concept formation, knowledge structure, short-term memory capacity, development of cognitive abilities, and solution of problems.

Chemical Concepts

Concepts are basic elements in the knowledge structure. Taking into account the reasoning level the student must learn some concepts. One view is to divide them into two groups: concrete-operational, whose meaning can be developed from first-hand experience with objects or events, and formal operational concepts, whose meaning is derived through position within a postulatory–deductive system (*1*). The first group includes such concepts as beaker, flame, metal, and sulfur. The second one includes atom, mole, chemical equilibrium, oxidation, and reduction.

Studies on a way of learning the chemical concepts by students refer first of all to the second group. It is due to the greater importance of formal-operational concepts in the whole chemical knowledge and the fact that the process of learning them is more complex and difficult. The aim of these studies is to determine conditions and to find optimal methods for learning formal-operational concepts as well as to determine students understanding of chemistry concepts and reasons of forming incorrect ones; i.e., misconceptions. As an example there are the studies on the concepts "mole" (*2*) "chemical equilibrium" (*3, 4*) "molecular orbital" (*5*).

Organization and Connection

The optimum learning process depends on the fact that we are concerned with the ordering and connection of individual elements of knowledge. There can be distinguished a few trends in recent studies of these problems.

The first trend is based on the fact that, at the outset, each student already possesses some knowledge. Its source may be a common influence of social and natural environment or previous schooling. It is important that this knowledge making a compact system can stray from that regarded to be correct scientifically, to a smaller or greater extent making it difficult or even impossible to acquire new knowledge. The aim of recent studies is to determine the amount of knowledge the students start with, its effect on learning and definition of the initial knowledge of students so that the process of learning will be optimal and to choose the best ways of reasoning so that students will progress from their initial knowledge to that sought by the educational aims (*6, 7*).

Knowledge Structure

The structure of the knowledge acquired by the student is an indicator of how well it is being understood. This affects its reproducibility and application in problem solving. Therefore, another important trend in this group of studies centers on determination of extent and ways of structuring the knowledge acquired by students as well as factors influencing the formation of these structures (*8–10*).

The knowledge structure can be considered in a broader context–not only as mutual connections of its elements but also as a hierarchy using methodological procedures for transforming knowledge. Such studies are useful for helping students to create more complex structures of knowledge consisting of facts, concepts, and theories (*11*).

Information Processing

The amount of information used by the student from the learning setting and the coding of this into his/her memory or using it in problem solving is limited and covers 5–10 "units". There are some studies on the problem of amount of information presented for simultaneous performing and its influence on new chemical knowledge acquisition or using already possessed knowledge in problem solving (*12–14*).

Cognitive Abilities

The studies that seek to determine the effect of students cognitive abilities on chemistry learning have been largely based on Piaget's theory. The aim of recent research is to determine the extent of formal operational thinking necessary in the process of learning chemistry and the way formal operation develops, as well as teaching aids and methods that make it easier for the students missing this kind of thinking to acquire a certain amount of chemical knowledge (*15–17*).

Another group of investigations, dealing with the effect of students' cognitive abilities on the process of learning chemistry is based on spatial visualization (*18, 19*), or generally on abilities of operating on creative representations. These abilities are important in learning, especially when the object of learning are concepts whose examples and critical attributes are not available in direct study.

Problem Solving

Problem-solving ability is an important but difficult aim of the chemistry learning process. Its acquisition depends not only on the knowledge possessed by the student but also on other relevant intellectual abilities. Studies on problem solving include: determination of the knowledge extent necessary to solve a problem or a type of problems, search for strategies (algorithms, heuristics, etc.) the most suitable to reach the aim (*20*); and finding out difficulties and errors made by students (*21*). This research is useful

to create models presenting a course of problem solving in a comprehensive form (*22*).

Theoretical Assumptions

A brief survey of the most important trends of studies on the process of learning chemistry points to a wide range of problems covered by the studies, some of which are formulated on different theoretical assumptions. The methods and techniques employed in them are various, in many cases quite original and prepared especially for these studies.

Common Research Methods

The most common research methods used are based on the measurement of achievement. Their aim is not only to find out if the student mastered a piece of knowledge, or acquired given skills, but also to determine reasons of failure in solving correctly suitable tasks. Eylon, Ben-Zvi, and Silberstein (*23*) presented theoretical assumptions on the basis of a test and analysis of its results. The test would contain a set of tasks that one would check abilities of performing a more complex activity, but the other tests would check abilities of performing simpler activities which together would be necessary to perform the activity studied by the first task. Specific examples of the test as construction and its application in the study of learning processes can be found in the papers by Gabel, and Sherwood, (*2*), Gabel, and Samuel (*24*) as well as Gorodetsky, and Gussarsky (*3*).

Individual Interview

The individual interview is used to get to know particular aspects of the learning process. The most important in this method is careful consideration and preparation of an interview sheet including a set of questions that ought to be answered by the student. This method was among others employed by Hackling, and Garnett (*4*) and Yarroch (*25*). For some time some efforts have been made to use computer technology in this method (*26*).

Psychological Examination

Another group of research tools used more often are psychological tests to determine particular features of the students. One of such ability according to Piaget's theory, is students level of reasoning. To determine this in the case, of a large group of students a "paper and pencil" test briefly called IPDT ("An Inventory of Piaget's Developmental Tasks") can be used (*27*). Other examples of such tests investigating the intellectual operations that should influence chemistry learning are TIPS II (The Test of Integrated Process Skills) (*28*), and the test used by Garnett, Tobin, and Swingler (*29*).

A quite different group of methods has been used to determine the structure of students' knowledge. These were described by Sutton (*30*).

Conclusion

It can be stated that studies on the process of learning chemistry are in the early stage of development. Their results are of great importance both for the theory of teaching chemistry and teachers' approaches and implications for learning. Knowing the results of such studies helps teachers to organize instructional teaching content dependent on students intellectual possibilities, and this must consider factors that influence educational processes that can cause successes or failures, and justifies choice of methods and teaching devices.

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