UDC 37.02;371
DOI https://doi.org/10.24919/2308-4863/73-2-53

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THE ROLE OF PROBLEM-BASED LEARNING IN TEACHING CHEMISTRY IN THE DEVELOPMENT OF STUDENTS' CREATIVE SKILLS

The purpose of this article is to investigate the effect of problem-based learning, one of the innovative learning strategies, on students' creative activity in chemistry classes. Problem-based learning represents experiential learning that is organized around the investigation and solution of real-life problems, but also requires the active participation of individuals in terms of both intellect and skill. Since the modern education system determines the individual interests, wishes and expectations of learners and gives special importance to the development of real-world skills, it is preferable to build the training process in this direction. In this regard, problem-based learning is considered to be an effective teaching strategy that helps us best connect with the world we live in. Students are first introduced to the problem statement, and receive assistance regarding the learning situation and goals. Later, they conduct various researches to solve the problem, share their knowledge and discuss solutions. This situation continues until we find solutions to the problem. Learning processes are constantly reviewed based on the explanations students receive from each other and from the teacher. They already accept the problems they solve as a model, and when faced with similar situations, they act according to this model. Within these processes, students' abilities such as problem solving, research, independent learning, creativity, and cooperation develop. A brief explanation of problem-based learning is also given first in the research paper. Then there is information about the application model of this strategy, the stages of learning, its benefits to the student, the possibilities of using it in chemistry classes, the role of the teacher during the process, examples and the problems encountered during the selection of this strategy. In the last part of the article, the results and suggestions related to the research are given.

Key words: *chemistry, problem-based learning, chemical experiment, creativity, activity.*

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РОЛЬ ПРОБЛЕМНОГО НАВЧАННЯ У НАВЧАННІ ХІМІЇ У РОЗВИТКУ ТВОРЧИХ УМІНЬ УЧНІВ

Мета статті – дослідити вплив проблемного навчання, однієї з інноваційних стратегій навчання, на творчу активність учнів на уроках хімії. Навчання, орієнтоване на проблему, являє собою навчання на досвіді, яке організоване навколо дослідження та вирішення проблем реального життя, але також вимагає активної участі окремих людей з точки зору як інтелекту, так і навичок. Оскільки сучасна система освіти визначає індивідуальні інтереси, побажання та очікування тих, хто навчається, і надає особливого значення розвитку навичок реального життя, краще будувати навчальний процес у цьому напрямку. У зв'язку з цим проблемне навчання вважається ефективною стратегією навчання, яка допомагає нам найкраще зв'язатися зі світом, у якому ми живемо. Учні спочатку ознайомлюються з формулюванням проблеми та отримують допомогу щодо навчальної ситуації та цілей. Пізніше вони проводять різні дослідження, щоб вирішити проблему, діляться своїми знаннями та обговорюють рішення. Така ситуація триває до тих пір, поки ми не знайдемо вирішення проблеми. Процеси навчання постійно перевіряються на основі пояснень, які студенти отримують один від одного та від викладача. Вони вже сприймають проблеми, які вирішують, як модель, і, стикаючись з подібними ситуаціями, діють відповідно до цієї моделі. У рамках цих процесів розвиваються такі здібності студентів, як вирішення проблем, дослідження, самостійне навчання, творчість і співпраця. Коротке пояснення проблемного навчання також дається спочатку в дослідницькій статті. Потім є інформація про модель застосування цієї стратегії, етапи навчання, її переваги для учня, можливості її використання на уроках хімії, роль учителя під час процесу, приклади та проблеми, з якими виникли під час вибору ця стратегія. В останній частині статті наведені результати та пропозиції щодо дослідження.

Ключові слова: *хімія, проблемне навчання, хімічний експеримент, творчість, діяльність.*

Introduction to the problem. Problem-based learning requires students to explore together, find different solutions, and delve into real-world problems. In order to successfully implement this process, students must be able to make connections between several subjects and integrate them correctly. Real-world problem solving develops students' creative thinking, critical thinking, research and 4C (creativity, communication, collaboration, critical thinking) skills (Vahabzadə, 2022: 3).

The extent of the problem. Many studies have been conducted in the direction of investigating the impact of the problem-based learning method on students and the development of critical and creative thinking in the context of education. One such study analyzed the joint activity of students in the problem analysis and reporting stages of problem-based learning. Research has also examined how such interactions affect student learning achievement (Visschers-Pleijers, 2004, p. 472). Empirical research conducted in 2015 adds substantial evidence to the effectiveness of the problem-based learning method. The authors assigned groups of students with three methods (problem-based learning, lecture-based or free learning) in teaching the subject and found that students in the problem-based learning group had a higher probability of conceptual change (Loyens, 2015: 36). Problem-based learning applied to the "Inorganic Chemistry Laboratory" class while examining the effects of the strategy, the results of the study were as follows: First, students' self-learning and creative abilities improved significantly. Second, it was found that this strategy allows students to learn freely as well as responsibly, but the problem definition phase is relatively complex. Finally, according to the opinion of students in a survey among students, this method is useful for learning problem-solving skills (Young-Eun Kim, 2016: 778).

The purpose and tasks of the research. The purpose of the research is to investigate the role of the problem-based learning strategy in the development of students' creative abilities, the benefits and drawbacks of the problem-based learning strategy during the teaching of chemistry in secondary schools.

Methods. The main methods are literature analysis and comparative analysis methods used in the article.

The main principles of problem-based learning can be shown as follows:

– Teaching begins with setting a problem;

– The problem situation is organized on the basis of the teaching unit;

– A connection is established between the problem and the student's world;

– Students are empowered to fully formulate the problem and manage the solution process;

– Small groups of students are created for effective learning;

– Guided by asking guiding questions about students' activities (Dahlgren, 1998, p.438).

The structure of the problem-based learning method can be shown in the following scheme:

– What is the problem?

Showing the problem

– What do we know about it?

– What do we need to know to solve the problem?

Guidance

– Collection of resources and information

– Finding and testing solutions

– Presentation of results

Evaluation

– Evaluation

During the selection of a problematic teaching strategy, if the problem is prepared qualitatively, the motivation phase of the lesson is solved by itself. As with other methods, there is no need to build motivation.

One of the most interesting aspects of problem-based learning is how it relates to our everyday lives. This method teaches the student both how to solve the problem and how the learning process takes place (Joan S., 1998: 5). At the same time, it forms students' ability to make independent decisions. As a result of the processes that the student goes through in the decision-making stage, his critical thinking is also improved. In the process of solving the problem within the group, students cooperate with each other, they get a chance to give suggestions, encourage and support their friends who are trying to express their ideas.

What are the limitations of problem-based learning strategy?

1. Identifying the problem – the factors affecting the identification of the problem may later prevent the process from happening correctly during the course of the lesson;

2. Time limitation – using this strategy can last longer than one academic lesson, which causes students to be bored, tired, and not complete the subject (Winning, 2003: 126).

3. Scope – it is difficult to use this method in teaching all subjects. Likewise, it is ineffective to apply social problems in class with students who do not understand the scope of the subject;

4. Class management – when using this strategy, the teacher may not get effective results in class management, because students' cooperation and discussions will create involuntary noise;

5. Evaluation – the presence of different solutions to the problem can create a complicated situation when determining the most correct solution. Non-objective assessment can have a negative effect on student motivation (Winning, 2003: 128).

Among the various problem-based learning teaching-learning models, the IMSA (Illinois Mathematics and Science Academy) model is widely used. The IMSA model mainly consists of three stages:

1. Understanding the problem;
2. Investigate the problem;
3. Solving the problem.

First, in the stage of "understanding the problem", students get acquainted with the problem. In the table about that problem, 'what do I know?' and 'what should I know?' is noted and the investigation of the problem to be solved in this situation is started. In "Problem Research", the information needed to solve the problem is collected through various materials and shared with other members of the group. Discussions and reflection on each student's hypothesis reveal all possible solutions. At the "Problem Solving" stage, the best of these solutions is selected, taking into account various circumstances. Then, on the basis of the chosen solution, the pre-defined problem is solved, the steps are reviewed and the problem is solved in an improved way (Young-Eun Kim, 2016: 773).

Let's take a look at the setting of the problem during the teaching of "Allotropy" in class VII.

It is known that students begin to get acquainted with chemistry in the VII grade. In the topic of the chemistry course, they should first of all understand what the concept of "allotropy" means. However, it is not considered appropriate to directly announce this concept to students. Because the application of the selected strategy should arouse interest and enthusiasm in students to search for new information, learn unknown knowledge, and perform chemical experiments. Therefore, the sequence of activities for defining a new concept can be described as follows:

I. Setting the problem: Is it possible to transform one simple substance into another simple substance?

Students come up with different answers to this question. The teacher asks another auxiliary question: Can the properties of oxygen change due to the influence of external factors?

I. Study of the problem:

Students are provided with textbooks and internet resources to investigate the physical and chemical properties of the given substance – oxygen. Later, the students prepare for the chemical experiment. The experiment is the conduction of an electric current from oxygen.

The equation of the chemical reaction:

$$3O_2 \longrightarrow 2O_3$$

At this time, students say the name, molecular composition, and properties of the obtained substance. When the students cannot find it, the teacher explains it himself.

II. Problem Solving:

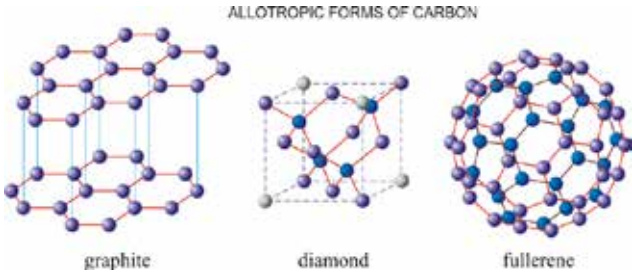
The difference between the properties of these substance molecules is explained based on the comparison of the composition and mass of oxygen and ozone molecules.

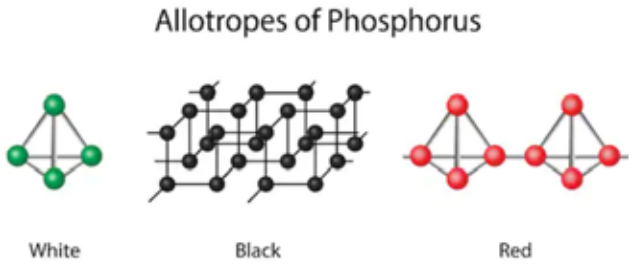
Thus, based on the questions put in front of the class, the children revive their knowledge about oxygen and ozone in their memory, conduct searches, and finally, with the help of the teacher, draw conclusions and define the concept of allotropy. As you can see, solving the problem ends with giving a new understanding. When solving this problem, students rely on the results of a chemical experiment, comparing the composition and mass of oxygen and ozone molecules from theoretical materials (Abbasov, 2018: 201).

In the example of oxygen, after students have a clear idea of this concept, the teacher focuses on other elements with allotropic transformations. These elements are listed in the table below:

Chemical element	The allotropic transformations it produces
O	O_2 , O_3
P	White, black, red
C	Diamond, graphite, carbine, fullerene
S	Crystalline, plastic, etc.
Si	Crystalline, amorphous

After studying the table, students understand that the concept of allotropy applies not only to oxygen, but also to other chemical elements. He notes that sulfur forms several allotropic transitions. The structure, properties, differences between each of these substances, etc. is explained. Thus, students' knowledge of allotropy is strengthened and deepened.





As a result of creating a problem-situation in the teaching of the topic "Allotropy", in addition to the development of creative thinking, research and creative abilities in students, they also develop an interest in learning the lesson, a desire to conduct experiments and draw conclusions (Hüseynov, 2019: 59).

In order to effectively apply the problem-based learning strategy in chemistry classes, the following conditions must be met:

– Students should be provided with a laboratory room and sufficient materials for chemical experiments and activities;

– The use of internet resources and the library should be free to assist research;

– Necessary safety measures should be taken regarding the experiments to be conducted by the students;

– When dividing into groups, not a "weak-strong" group, but an equal grouping should be done (Miflin, 2004: 445).

– At the stage of solving the problem, students should be motivated, directed questions should be asked and group work should be encouraged;

– The results obtained through the problem-based training should be prepared in the form of a report, and these results should be evaluated by the teacher after they are presented to the class.

– During the teaching of the subject through problem-based learning, a number of important qualities and abilities are developed and formed in students:

– Develop high-level cognitive and thinking skills such as analysis, synthesis and evaluation, which are necessary during problem solving;

– Ensures that students are motivated and interested in learning.

– Students' ability to use what they have learned in their social life improves;

– Problem-based learning asks students: "Why are we learning this information?", "How will this benefit us later?", "Can we use it in real life?" answers questions like;

– Students are ensured to use and develop their knowledge, experience and skills independently;

– Supports students' higher-order thinking. In problem-based learning, students try to learn more about a topic or event. Complex problem scenarios encourage students to think critically and creatively. Students provide plausible evidence for a variety of problem situations;

– Increases communication and interaction between students;

– Teach democratic rules such as listening to others' opinions and being open to different opinions;

– Students are taught the ability to use laboratory equipment;

– Increases students' self-confidence and creates a sense of responsibility (Stepien, 1993: 352).

The result

1. The main goal of problem-based learning is for students to apply what they have learned in social life, work life, etc. while solving the problems encountered in the educational process. is to provide the ability to use when solving the difficulties that arise.

2. Based on constructivist learning theory makes learning effective. Because the structuralist approach is based on how the individual learns, not what they learn. Strategy is problem-focused from planning to execution. At the same time, there is an assessment at every stage of this process.

3. Students first encounter a problem that is set not randomly, but in a planned way. The problem is investigated in different stages and a conclusion is drawn. The main point here is that there is no single solution to the problem, the activity is based on active learning and is open to collaboration.

4. Frequent change of the problem situation allows the students to review the novelties again and again, thus their knowledge is updated.

5. In all these stages, the teacher is a cognitive guide who directs the students' learning.

6. The teacher's task of imparting and teaching information has been replaced by "directing the student to obtain information".

7. It is an approach that can be effective in creating active learning environments, which has become especially popular in our country in recent years. Since the development of students' creative thinking

skills is identified as an important goal in reformed education, it can be said that using this approach will facilitate the achievement of the goal.

Offers

1. Despite its many benefits, problem-based learning has some limitations as mentioned above. Knowing these shortcomings before organizing chemistry lessons will strengthen the effectiveness of the teaching process.

2. Necessary tools and textbooks should be prepared for problem-based training.

3. It is considered that it would be more appropriate to apply the problematic learning strategy in classes with a small number of students, since it takes a lot of time to monitor the students' activities and give feedback in the trainings carried out with this strategy. Because it is necessary to allocate time to each group and all members of the group, to follow the stages of solving the problem. This situation is considered as limiting the ability of the teacher to provide the required support in classes with many children.

4. "Technical service teams" consisting of teachers can be created. These teams can inform students about libraries, computers, laboratories and their efficient use on certain days and hours.

5. Reports prepared by students on the progress and results of the conducted chemical experiments can be published on the school's website. Presenting the "work" prepared by the students with their own efforts in this way will increase their motivation and also serve as an example for other students in their future work.

6. In order to ensure success in problem-based learning, the teacher must know the student, be fair, be open to scientific developments, be able to draw the student's attention to the topic, listen to the student's comments on each topic, draw conclusions and guide them.

7. One of the reasons why traditional teaching methods are always preferred is that they are easy to apply or the instructor is not aware of new methods. For this reason, teacher candidates studying in universities for the teaching profession should be given training on problem learning during their undergraduate studies, and the university library should be enriched.

8. The subject and age groups of students to which the problem-based learning method will be applied are very important. In particular, the level of knowledge, experience, available resources and opportunities of students in lower grades should be taken into account.

9. It is known that the majority of chemistry teachers working in secondary schools today prefer traditional methods when teaching this subject. Although this situation happens for certain reasons (weak material and technical base, lack of laboratory rooms, lack of materials, etc.), as a result, favorable conditions for the development of students' creativity and research abilities are not created. Correcting this situation is the responsibility of the school management and education departments appointed by the Ministry of Education.

BIBLIOGRAPHY

1. G. Vahabzadə. Problem əsaslı öyrənmə, Aran ictimai-siyasi qəzeti, 11 oktyabr 2022, səh. 13–15.
2. Young-Eun Kim, Effect of "Inorganic Chemistry Experiment" class applying problem-based learning (PBL), Journal of the Korean Chemical Society Vol. 54, No: 6 pages.771–780. DOI https://doi.org/10.5012/jkcs.2010.54.6.771
3. M.N.Hüseynov, G.N.İsmayılova, D.N. Əhmədova., Kimyanin tədrisində problemlilik şagirdlərin idrak fəaliyyətini aktivləşdirən vasitə kimi, Kimya məktəbdə jurnalı 4(68) 2019, pages. 58–59.
4. M. Abbasov,V. Abbasov,V. Əliyev, G.Quliyeva, N.Abışov. Kimya 7, dərslik 2018, page. 30.
5. Winning T. and et. all. Developing pbl packeges internationally: an evaluation of outcomes. İnnovations İn Education And Teaching İnternational. 2003, Vol. 41. No:2, pages 125–134. DOI https://doi.org/10.1080/1470329042000208666
6. Seng tan O. Student experiences in problem-based learning: three blind mice episode or educational innovation? İnnovations İn Education And Teaching İnteraction. 2003, Vol. 41., No 2., pages 169–184. DOI https://doi.org/10.1080/147 0329042000208693
7. Miflin B. Small groups and pbl: are we singing from the same hymn sheet?. Medical Teacher. 2004, Vol. 26. No 5, pages 444–450. DOI: https://doi.org/10.1080/01421590410001696425
8. Joan S. ve A. Huges Problem-Based Learning as classroom solution. Educational leadership. U.S.A: Association for Supervision & Curriculum Dev., 1994, pages. 1–6.
9. Stepien, W.J., Gallagher, S.A. ve D. Workman Problem-based learning for traditional and interdisciplinary classrooms, Journal for the Education of the Gifted, 1993, 16, pages. 338–357. DOI: http://dx.doi.org/10.1177/016235329301600402
10. Dahlgren M.A., Castensson, R. ve L.O. Dahlgren. PBL from the teachers' perspective, Conceptions of the tutor's role within problem based learning, Higher Education, 1998, 36, pages. 437–444.
11. A.J. Visschers-Pleijers, D. Dolmans, I.H. Wolfhagen, C.P. Van der Vleuten Exploration of a method to analyze group interactions in problem-based learning, Med Teach, 26 (5) (2004), pages. 471–478. DOI: http://dx.doi.org/10.1080/0142159 0410001679064
12. S.M.M. Loyens, S.H. Jones, J. Mikkers, T. van Gog. Problem-based learning as a facilitator of conceptual change, Learn Instr, 38 (2015), pages. 34–42. DOI: https://doi.org/10.1016/j.learninstruc.2015.03.002

REFERENCES

1. Vahabzadə G. Problem əsaslı öyrənmə [Problem-based learning]. Aran ictimai-siyasi qəzeti, 11 oktyabr 2022, səh. 13–15 [in Azerbaijani].

2. Young-Eun Kim, Effect of "Inorganic Chemistry Experiment" class applying problem-based learning (PBL), Journal of the Korean Chemical Society Vol. 54, No 6, pages.771–780. DOI https://doi.org/10.5012/jkcs.2010.54.6.771

3. Hüseynov M.N., İsmayılova G.N., Əhmədova D.N.. Kimyanin tədrisində problemlilik şagirdlərin idrak fəaliyyətini aktivləşdirən vasitə kimi [Difficulty in teaching chemistry as a means of activating students' cognitive activity]. Kimya məktəbdə jurnalı 4(68) 2019, pages 58–59 [in Azerbaijani].

4. Abbasov M., Abbasov V., Əliyev V., Quliyeva G., Abışov N. Kimya 7 [Chemistry 7]. dərslik 2018, page 30 [in Azerbaijani].

5. Winning T. and et. all. (2003). Developing pbl packeges internationally: an evaluation of outcomes. İnnovations İn Education And Teaching İnternational. Vol. 41. No 2, pages 125–134. DOI https://doi.org/10.1080/1470329042000208666

6. Seng tan O. (2003) Student experiences in problem-based learning: three blind mice episode or educational innovation? İnnovations İn Education And Teaching İnteraction. Vol. 41., No 2., pages 169-184. DOI https://doi.org/10.1080/14703290 42000208693

7. Miflin B. (2004). Small groups and pbl: are we singing from the same hymn sheet?. Medical Teacher. Vol. 26. No 5, pages 444–450. DOI: https://doi.org/10.1080/01421590410001696425

8. Joan S. ve A. Huges (1994). Problem-Based Learning as classroom solution. Educational leadership. U.S.A: Association for Supervision & Curriculum Dev., pages. 1–6.

9. Stepien, W.J., Gallagher, S.A. ve D. Workman (1993). Problem-based learning for traditional and interdisciplinary classrooms, Journal for the Education of the Gifted, 16, pages. 338–357. DOI http://dx.doi.org/10.1177/016235329301600402

10. Dahlgren M.A., Castensson, R. ve L.O. Dahlgren. (1998). PBL from the teachers' perspective, Conceptions of the tutor's role within problem based learning, Higher Education, 36, pages. 437–444.

11. A.J. Visschers-Pleijers, D. Dolmans, I.H. Wolfhagen, C.P. Van der Vleuten Exploration of a method to analyze group interactions in problem-based learning, Med Teach, 26 (5) (2004), pages. 471–478. DOI http://dx.doi.org/10.1080/0142159 0410001679064

12. S.M.M. Loyens, S.H. Jones, J. Mikkers, T. van Gog. Problem-based learning as a facilitator of conceptual change, Learn Instr, 38 (2015), pages. 34–42. DOI: https://doi.org/10.1016/j.learninstruc.2015.03.002