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THE FEATURES OF THE APPLICATION OF THE CASE STUDY METHOD IN CHEMISTRY AND BIOLOGY LESSONS

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Abstract. In recent years, the relevance of the case study method has increased dramatically in Kazakhstan, as it fosters critical thinking, problem-solving skills and prepares specialists for real-life challenges. The case study is a contextual learning method that uses real-life examples to actively engage learners in the learning process. It not only encourages them to discover suitable solutions to practical scenarios but also fosters their active participation through collaborative discussions and debates. The method involves a case that explains a specific practical scenario, a problem statement, references and extra information (audio, video, and other resources). The purpose of this study is to investigate the effectiveness of the case study method in the teaching of biology and chemistry in secondary schools. The experiment was conducted based on a specialised boarding school “Information Technologies” from January to April 2024. Students of the 9th grade took part in the approbation of the developed case-study chemistry and biology tasks. The topics included in the experiment: “Halogens”, “Group 16 (A) elements”, “Group 15 (A) elements”, “Group 14 (A) elements”. Cell cycle”, “Patterns of heredity and variability”, “Microbiology, and biotechnology”. The significant improvements in the increase in the quality of knowledge of the experimental group in chemistry and biology highlight the effectiveness of the case study method. Furthermore, the

analysis of the results of the survey to determine the level of motivation before and after the experiment showed that most of the students in the experimental classes increased their level of motivation, which improved their perception and attitude towards learning chemistry and biology.

Keywords: case-study, problem-solving, science literacy, chemistry, lower-secondary school, biology, questionnaire, 9th grade

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ХИМИЯ ЖӘНЕ БИОЛОГИЯ САБАҚТАРЫНДА CASE-STUDY ӘДІСІН ҚОЛДАНУ ЕРЕКШЕЛІКТЕРІ

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Аннотация. Соңғы жылдары Қазақстанда Case-study әдісін қолдану өзектілігі күрт артып келеді, себебі бұл әдіс сыни ойлауды дамытуға, практикалық мәселелерді шешуге және мамандарды нақты өмірлік қиындықтарға дайындауға ықпал етеді. Case-study – оқушыларды оқу процесіне белсенді түрде тарту үшін нақты мысалдарды қолданатын контекстік оқыту әдісі. Бұл әдіс оларды практикалық жағдайлар үшін қолайлы шешімдер табуға ғана емес, сонымен бірге олардың бірлескен талқылаулар мен пікірталастарға белсенді қатысуына ықпал етеді. Әдіс нақты практикалық сценарийді, мәселені тұжырымдауды, сілтемелерді және қосымша ақпаратты (аудио, бейне және басқа ресурстар) түсіндіретін жағдайды қамтиды. Бұл зерттеудің мақсаты жалпы білім беретін мектептерде биология мен химияны оқытуда case-study әдісінің тиімділігін зерттеу болып табылады. Эксперимент 2024 жылдың қаңтар-сәуір айлары аралығында "Ақпараттық технологиялар" мамандандырылған мектеп-интернатының базасында жүргізілді. 9-сынып оқушылары химия және биология бойынша әзірленген тақырыптық (кейс) тапсырмаларды сынақтан өткізуге қатысты. Тәжірибеге енгізілген тақырыптар: «Галогендер», «16 (A) топ элементтері», «15 (A) топ элементтері», «14 (A)

топ элементтері», «Жасушалық цикл», «Тұқым қуалаушылық пен өзгергіштік заңдылықтары», «Микробиология және биотехнология». Химия және биология бойынша эксперименттік топтың білім сапасы айтарлықтай жақсарғаны case-study әдісінің тиімділігін көрсетеді. Сондай-ақ, зерттеу әдістемесі бойынша экспериментке дейін және одан кейін қолданылған мотивация деңгейін анықтау әдістерін пайдалана отырып, сауалнама нәтижелерін талдай келе, сыртқы және ішкі мотивация студенттің оқу қабілетіне айтарлықтай әсер ететініне көз жеткіздік. Студенттердің кейс әдісін қолданбас бұрын орташа мотивациялары төмен болды. Процесті қолданғаннан кейін эксперименттік сыныптағы көптеген оқушылардың мотивация деңгейі жоғарылады, бұл олардың химия мен биологияны оқуға деген көзқарасы мен қабылдауын жақсартты.

Түйін сөздер: Case-study, есептерді шешу, жаратылыстану сауаттылығы, химия, орта мектеп, биология, сауалнама, 9-сынып

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ОСОБЕННОСТИ ПРИМЕНЕНИЯ МЕТОДА CASE-STUDY НА УРОКАХ ХИМИИ И БИОЛОГИИ

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Аннотация. Актуальность применения метода Case-study в последние годы в Казахстане резко возрастает, так как он способствует развитию критического мышления, решению практических задач и подготовке специалистов к реальным жизненным вызовам. Case-study — это метод контекстного обучения, который использует реальные примеры для активного вовлечения обучающихся. Данный метод не только побуждает их находить подходящие решения для практических ситуаций, но и способствует их активному участию в совместных обсуждениях и дебатах. Метод включает в себя кейс, который объясняет конкретный практический сценарий, формулировку проблемы, ссылки и дополнительную информацию (аудио, видео и другие ресурсы). Целью данного исследования является изучение эффективности метода case-study при

преподавании биологии и химии в общеобразовательных школах. Эксперимент проводился на базе специализированной школы-интерната “Информационных технологий” с января по апрель 2024 года. Учащиеся 9-х классов приняли участие в апробации разработанных тематических (кейс) заданий по химии и биологии. Темы, включенные в эксперимент: “Галогены”, “Элементы группы 16 (A)”, “Элементы группы 15 (A)”, “Элементы группы 14 (A)”. “Клеточный цикл”, “Закономерности наследственности и изменчивости”, “Микробиология и биотехнология”. Значительные улучшения в повышении качества знаний экспериментальной группы по химии и биологии подчеркивают эффективность метода case-study. На основе анкетирования уровень мотивации до и после эксперимента по методике исследования, мы убедились, что внешняя и внутренняя мотивация оказывают существенное влияние на способность обучающихся к обучению. У студентов была низкая средняя мотивация, прежде чем они использовали метод кейса. После применения этого процесса уровень мотивации многих учащихся экспериментального класса повысился, что улучшило их отношение и восприятие изучения химии и биологии.

Ключевые слова: Case-study, решение задач, естественнонаучная грамотность, химия, средняя школа, биология, анкетирование, 9 класс

Introduction. The Republic of Kazakhstan's modern view of education focuses on the definition of new values to improve educational quality, the development of the student's individuality, and the production of abilities shown in specific life circumstances. For this reason, the student's potential and creative abilities in all sectors of life are given the utmost attention (Sadykov, et al, 2023: 1). The educational standards in the country have been developed to bring about changes in the primary school curriculum. The aim is to create a school environment that is adapted to the needs of students. The main goal is to reduce the workload by creatively applying knowledge, promoting critical thinking, and utilizing various communication methods based on research. This will involve individual and group work, as well as the application of practical knowledge and skills.

Case studies (method of unique scenarios) are currently among the popular active methods of teaching. It is extensively used in various academic fields, including psychology, sociology, pedagogy, and other social and humanitarian fields. The case-study approach is a contextual learning methodology that uses real-world examples to challenge students. It not only encourages them to discover suitable solutions to practical scenarios but also fosters their active participation through collaborative discussions and debates. This technique involves a case that explains a specific practical scenario, a problem statement (identifying the aim of the study), references and extra information (including audio, video, and digital media), and methodological resources (Belessova, et al., 2023: 63). The case study method, a powerful tool for enhancing learning, is yet to be widely embraced in the education system. Despite its proven effectiveness, its integration has been hindered by several challenges (Hua, 2020: 82):

- Many teachers find that gaining knowledge of case technology methodology is worthwhile, although it can be very tough initially. This approach, which emphasizes problem-solving and critical thinking, has been shown to enhance student engagement and learning outcomes significantly.

- Some teachers prefer traditional teaching methods over interactive ones.

- The integration of case technology into a standardized educational process is a complex task, posing significant challenges, primarily due to the extensive study time required.

- No methodical guidelines provide situational activities for both topic and integrative material. Preparing cases is a complicated procedure that demands significant personal work from teachers (Yin, 2017: 75).

There is little experience in writing cases in Kazakhstan, and the bank of cases has yet to be formed. However, it is evident that solving cases significantly expands the possibilities of forming cognitive skills and creative thinking, effectively improving the learning process. The desire to raise educational standards and modify the educational process to meet modern requirements also contributes to the importance of the research (Akhitova, 2023: 9).

The research (Sadykov, 2015: 449) demonstrates the beneficial effects of the case-study method on students' cognitive development and the effectiveness of learning the course material. Therefore, incorporating the case method in resolving various situational tasks is essential for training future professionals in the natural sciences field.

The use of the case-study method not only stimulated students' learning activities and increased basic professional competencies, but it also reduced the gap between their theoretical understanding of environmental issues and the application of environmentally friendly behaviour principles in the lives of both groups of students (Abdykerimova, et al, 2023; Sadykov, et al, 2024: 188).

The one of the main conditions for the formation of students' reflection is the introduction of case technology into the educational process. When working with cases, the learner acts as a full participant in the process, and the feelings and reflections obtained through experience are intertwined with learning cognition (Sarimbayeva, et al, 2023: 224).

Due to the rapid advancement of science and technology, and the large amount of information available to students, it is important to create innovative teaching methods that not only impart knowledge, but also develop the necessary skills to apply it. The case study method meets these needs by helping students to develop analytical, critical thinking and problem-solving skills - all of which are essential in subjects such as biology and chemistry. It will demonstrate its potential as a tool for improving the effectiveness of teaching chemistry and biology, and allow reasonable conclusions to be drawn about its use in the educational process. In addition, the use of cases in chemistry and biology classes helps students to understand the practical application of the concepts covered, which increases their motivation and interest in studying. In addition, the technique helps students prepare for real-life scenarios by

improving their critical thinking, independent decision-making and adaptability to rapidly changing situations (Marfu'ah, et al, 2024: 193).

Types of “case-study” method

Practical examples from the real world. At the same time, their educational purpose can be simplified to teaching students and consolidating information, skills and behaviours (decision-making) in any setting.

Training cases represent common scenarios that occur frequently in life.

Research cases are models for learning new information about situations and their behaviour (Jesionkowska, et al, 2020: 204).

The case typically includes a situation (a problem), context (chronological, actions, participants), author's comment on the situation, assignments for collaborating with the case, and applications. The stages of case development begin with determining the place of the case in the structure of the educational process and the discipline being studied. Then it is necessary to form a model of the situation around which the case will be formed (Khandakar et al., 2020: 480).

The work aims to examine the effectiveness of the case study method in teaching biology and chemistry in secondary schools.

Materials and methods of research. The experiment was conducted based on a specialised boarding school “Information Technologies” (Karaganda), from 30.01.2024 to 16.04.2024. Students of the 9th grade took part in the approbation of the developed case-study chemistry tasks; there are a total of 36 students (14 girls and 22 boys). Lessons in the 9 “A” class (experimental group) were provided using case-study tasks in chemistry. Lessons in the 9 “B” class (control group) were provided in a traditional style. Traditional instruction entails passively obtaining information that the teacher possesses.

Three phases were established to experiment:

1) The ascertaining stage is used to assess students' enthusiasm for learning new information, their readiness to deal with novelty and their general understanding of chemistry and biology, to investigate the significant challenges that arise when using the case study technique, to analyse complex topics studied in chemistry and biology subjects and to prepare cases for use in chemistry and biology classes.

2) The formative (training) stage includes the introduction of the studied method into the pedagogical process, the familiarisation of the students and the subject teacher with the purpose of the method, the familiarisation of the students with the principles of casework and evaluation criteria, and the evaluation of the effectiveness of the work.

3) The control stage assesses the student's knowledge, skills and abilities based on the results of a training experiment.

According to the plan for determining the effectiveness of the method, chemistry, and biology lessons were conducted according to the topics in the curriculum listed in Table 1.

Table 1. Topics of lessons using the case study method

Subject	Topic	Date
Chemistry	Properties, production and use of ammonia	30.01.2024
Biology	Meiosis and its phases. Comparison of meiosis and mitosis	08.02.2024
Chemistry	Phosphorus	13.02.2024
Chemistry	Mineral fertilisers	20.02.2024
Chemistry	Chemical composition of the human body	05.03.2024
Biology	The genetics of gender. Gender-linked inheritance	07.03.2024
Biology	Inheritance patterns of human blood groups and the Rh factor	14.03.2024
Biology	Secondary sexual characteristics, puberty. Biological and social maturity	04.04.2024
Chemistry	Saturated hydrocarbons (alkanes or paraffins)	16.04.2024

We preferred to divide the students into groups consisting of four students since this number is optimal for real learning conditions. The distribution of functional roles in the group could be as follows:

The moderator organises the discussion of the topic and the problem, involving all members of the group.

The analyst asks questions of the participants during the discussion of the problem, challenging the ideas and formulations expressed.

The recorder notes everything related to the solution of the problem; at the end of the first discussion, it is usually the recorder who speaks to the group to present the opinion and the position of his team.

The observer evaluates the participation of each member of the group in solving the problem according to the criteria set by the teacher (Ellet, 2018: 122).

The algorithm for working with the case:

1. The first step is to become familiar with the scenario and its characteristics.
2. The second stage involves outlining the major problem. Knowledge of case-specific questions.
3. The third step involves the proposal of thoughts or subjects for “brainstorming.”
4. The fourth stage is the implementation of a problem.
5. The fifth step involves offering one or more solutions to the situation.
6. The sixth stage – reflection (discussion of cases).

Preparatory moments are also crucial for the method's effectiveness, in addition to the integral and methodological parts. When preparing for the analysis of the case, as well as when summarizing the material in the lessons, you can use one of the techniques of critical thinking technology, the so-called “PRES” formula (Rahmawati, et al, 2022: 3556):

P — position (what is the point of view) – I believe that...

R — reason (arguments supporting the position) — ... because...

E — explanation (facts illustrating the argument) — ...for example...

S — summary (conclusion, call to take a position) — ...therefore...

Examples of developed case study tasks for 9th grade

1. Saturated hydrocarbons (alkanes or paraffins) (chemistry)

Case type: research

The tragedy at the Kostenko mine "ArcelorMittal Temirtau" occurred on the night of 28.10.2023. Forty-six people died as a result of the incident. On 9 December, the final meeting of the government commission investigating the causes of the fire and explosion at the Kostenko mine in the Karaganda region took place. "As a result, it was established that the fire and subsequent explosion of the methane-air mixture occurred as a result of the ignition of gas (methane) by a mechanical spark created by the impact and friction of the scraper conveyor elements. The gas itself was released from the underlying reservoir," the Ministry of Emergency Situations said on its official website. In addition, the commission found violations of industrial safety requirements. In particular, it noted the unsatisfactory organisation of work and the lack of the necessary industrial control over hazardous production factors (figure 1).



Figure 1. Case study tasks on the topic “Saturated hydrocarbons (alkanes or paraffins)”

Case questions:

What chemical and physical properties of alkanes caused the explosion at the Kostenko mine?

Is it possible to detect the appearance of methane in the mine organoleptically, i.e., with the help of sensory organs? Why?

What types of reactions do saturated hydrocarbons typically undergo? Under what conditions (exposure to light, temperature, or catalyst) are they most likely to degrade?

2. Inheritance patterns of human blood groups and the Rh factor (biology)

Case type: practical.

The Rh factor does not affect the chances of conception. When an RH-negative (Rh-) woman conceives a Rh-positive (Rh+) child, the Rh factor can affect the health of the embryo. During pregnancy, fetal red blood cells cross the placenta and enter the mother's bloodstream. Fetal red blood cells have a positive Rh factor (Rh+), an antigen foreign to the mother. The expectant mother's body reacts by producing antibodies against the erythrocytes. This process is called sensitisation. The anti-rhesus antibodies can enter the fetal circulation and kill Rh-positive (Rh+) fatal

erythrocytes. Fatal haemolytic jaundice causes anaemia, liver damage, hypoxia and other serious consequences. If therapy is not completed in time, the baby may die (figure 2).

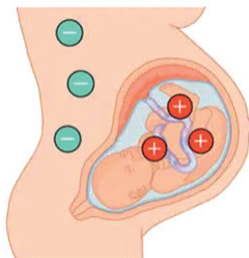


Figure 2. Case study tasks on the topic “Inheritance patterns of human blood groups and the Rh factor”

Case questions:

How does the Rh factor affect childbearing and pregnancy?

Does the negative Rh factor of the father affect the embryo?

What methods are known to reduce the risk of rhesus conflict?

Can negative-rhesus offspring be born to positive-rhesus parents? (Prove your answers by calculating them).

Results.

1. Chemistry.

A final test was developed for 9 grades, taking into account the age of the students and the knowledge acquired. The tests were administered on A4 sheets of paper. Ninth graders had 30 minutes to complete the final test, which consisted of 11 questions. This means that it took about 3 minutes to complete each item. The topics included in the testing: “Halogens”, “Group 16 (A) elements”, “Group 15 (A) elements”, “Group 14 (A) elements”. Diagrams 1-2 showed the average score and grades for the final test in grades 9 “A” (experimental group) and 9 “B” (control group).

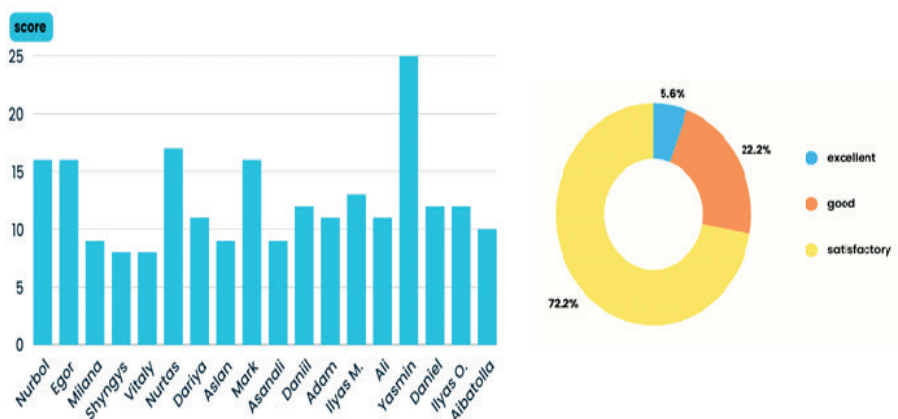


Figure 3. Results of final testing in grade 9 “B” (control group)

13 students – satisfactory (72,2%);

4 students – good (22,2%);

1 student – excellent (5,6%).

Based on the final testing data, the quality of knowledge was 27,8 %. The average score was 12.44 points.

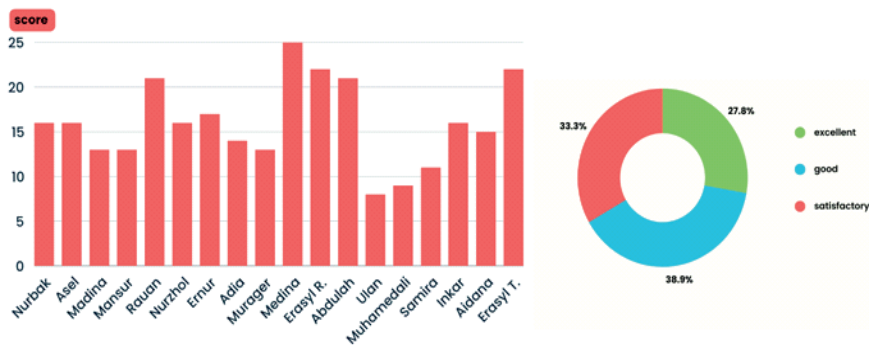


Figure 4 - Results of final testing in grade 9 "A" (experimental group)

6 students – satisfactory (33,3%);

7 students – good (38,9%);

5 students – excellent (27,8 %).

Based on the final testing data, the quality of knowledge was 66,7%. The average score was 16,22 points. There was a major difference in the degree of knowledge, skills, and abilities between the two groups 9 "A" (experimental group) and 9 "B" (control group). 9 "A" (experimental group) scored 3.78 more points than the second 9 "B" (control group).

2. Biology

The topics included in the testing: "Cell cycle", "Patterns of heredity and variability", "Microbiology, and biotechnology". Diagrams 3-4 showed the average score and grades for the final test in grades 9 "A" (experimental group) and 9 "B" (control group).

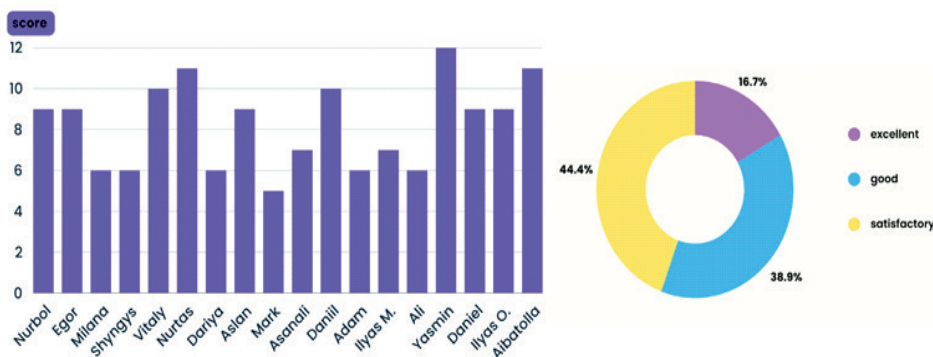


Figure 5. Results of final testing in grade 9 "B" (control group)

8 students – satisfactory (44,4%);

7 students – good (38,9%);

3 students – excellent (16,7%).

Based on the final testing data, the quality of knowledge was 55,6 %. The average score was 8,38 points.

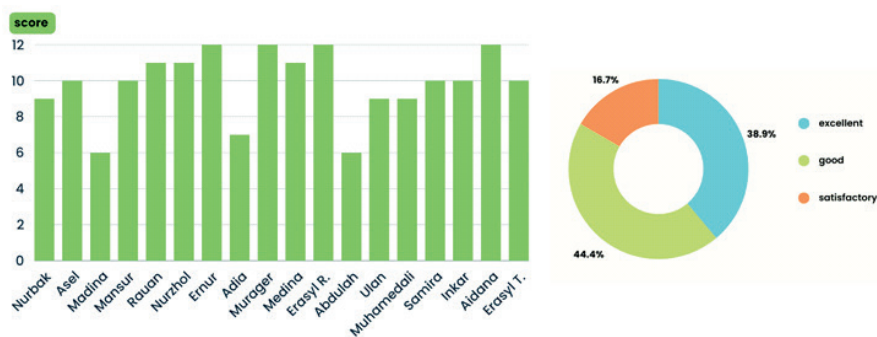


Figure 5 - Results of final testing in grade 9 “A” (experimental group)

3 students – satisfactory (16,7%);

8 students – good (44,4%);

7 students – excellent (38,9 %).

Based on the final testing data, the quality of knowledge was 83,4%. The average score was 9,83 points. There was a major difference in the degree of knowledge, skills, and abilities between the two groups 9 “A” (experimental group) and 9 “B” (control group). 9 “A” (experimental group) scored 1.45 more points than the second 9 “B” (control group).

3. *Diagnostics of the structure of the student's educational motivation* (Matyukhina, 1984: 72).

This technique allows the determination of the major factors affecting student motivation. All motives investigated using this technique are classified as educational (connected to the content and process of learning) and non-educational). Students of 9 “A” (the experimental group) completed the questionnaire before and after the experiment (diagram 5).

Matyukhina distinguishes the following types of motives:

Cognitive motives are related to the content of the educational activity and the process of its implementation. The pupil strives to master new knowledge and educational skills.

Communicative motives are the reasons why students choose to communicate with each other.

Emotional motives stimulate students to take an active or passive role in the learning process.

The student's position motives are an expression of his or her understanding of the importance of learning for the future.

Achievement motives are an expression of a student's desire to achieve great results and a position of honour among their classmates.

External motives show a desire for recognition and/or good grades.

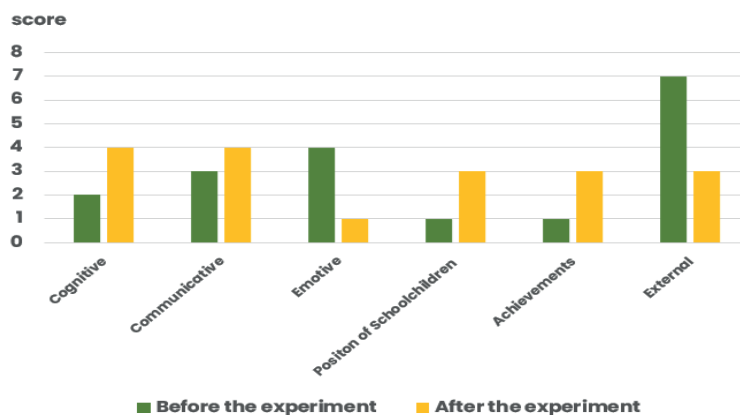


Figure 7- Diagnostics of the structure of the student's educational motivation

According to the results of the survey conducted before the experiment began, the majority of students were initially motivated by external factors: 2 students – cognitive; 3 students – communicative; 4 students – emotive; 1 student – position of schoolchildren; 1 student – achievement; 7 students – external (rewards, punishments). This motivation occurs when an activity is carried out out of duty or responsibility to achieve a certain status among classmates, and pressured by others. As a result, the students had low and unstable motivation to study the subject.

After completing the experiment: 4 students – cognitive; 4 students – communicative; 1 student – emotive; 3 students – position of schoolchildren; 3 students – achievement; 3 students – external (rewards, punishments). Based on the results of the questionnaire and a personal interview using the case study method has a positive effect on students' motivation, helps them to develop new interests and certain communication skills, and thus improves the microclimate in the classroom.

Discussion. The case study method provides several chances and improves the efficacy of the learning process:

1. The case study method plays a key role in developing critical thinking. It equips students with the ability to distinguish between data and information, to categorise, to identify important and unimportant information, to analyse, present and extract it, to identify information gaps and to fill them.

2. The case's problem is more accessible than the actual scenario, which helps students develop practical abilities in employing economic theory, methodologies, and principles.

3. Creative abilities are critical in developing alternate answers that cannot be discovered rationally.

4. The case study method fosters a collaborative environment, encouraging

students to lead discussions, persuade others, use visuals and other media tools, and write compelling reports. These results are supported by (Abdykerimova, et al, 2023; Sadykov, et al, 2024: 188; Sarimbayeva, et al, 2023: 224).

There are three problems in implementing the case-study method:

1. Time-consuming. The case study approach is indeed time-consuming, but it is also intellectually challenging. This narrative aspect is based on the reality that the case study technique requires time from all parties (e.g. professors and students). If a teacher wants to use the case study technique effectively, he or she must either acquire an existing case and adapt it for that specific class, or construct an entirely new example, which can be very time-consuming.

2. Pedagogical and managerial difficulties. Although the case study method is used in the classroom to teach students new material, it is not the most effective pedagogical tool. Students are usually not given a thorough understanding of the ideas but are taught when and how to apply the theories, rather than the practical skills needed to fully understand the theories.

3. Number of students. If the number of students is small, implementation will be easier than if the number of students is large. This is due to several factors. In other words, the case study method has the potential to push students out of their comfort zone, which is a good thing. When using the case study technique, one issue that arises is how the teacher will involve all the individual students in the case discussion. The teacher has an incredible responsibility in this situation, as students can simply sit back and listen to the discussion without participating. This is particularly important when using the case study method in larger classes (Hua, 2020: 80; Hoque et al, 2024: 267).

Conclusion. According to the outcomes, the case study method has the potential to increase the efficacy of chemistry and biology lessons significantly. The technique, focused on studying real-life situations and issues, helps students put theoretical knowledge into practice while fostering critical thinking, analytical ability, and interpersonal abilities. The case method has become a crucial instrument in the current educational setting, where it is essential to convey information and develop skills for application in practical situations. A pedagogical experiment was conducted with 9th-grade students. The case-study tasks we developed were successfully applied in chemistry and biology lessons. Lessons in the 9 “B” class (control group) were provided in a traditional style. Lessons in the 9 “A” class (experimental group) were provided using case-study tasks in chemistry and biology. Based on the observation results, it became clear that students were more engaged in tasks that had practical applications and involved them actively in the process. The results of the final control work in Chemistry showed a quality of knowledge of 27,8% in the control group and 66.7% in the experimental group. The results of the final control work in Biology showed a quality of knowledge of 55,6% in the control group and 83,4% in the experimental group. These significant improvements in knowledge retention, with the quality of knowledge in the experimental group increasing by 38,9% in chemistry and 27,8% in biology, underline the effectiveness of the case study method.

Eighteen students responded positively to a survey administered as part of this study when asked how they felt about case method classes and whether they would like to take them more frequently. Also, after analyzing the survey results using methods to determine the level of motivation used before and after the experiment under the research methodology, we were convinced that external and internal motivation significantly affects the student's ability to learn. The students had low motivation on average before using the case method. After using the process, many students in the experimental class had increased motivation levels, which improved their perception and attitude to the study of chemistry and biology. The case study method is best suited to developing students' analytical and evaluative skills and developing and improving their relationships through teamwork. This method actively equips students with theoretical and practical knowledge that can be applied to real life, blurring the line between life and the subject matter of the case.

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