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Application of project-based learning method in supplementary chemical education as a way to develop creative competencies and prepare future specialists

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Abstract

Quality education is a central goal of the Sustainable Development Concept, playing a critical role in the advancement and improvement of the quality of life in human society. In this regard, the purpose of this research work is to investigate the impact of using the PBL method in additional chemistry education on increasing students' creative competencies for the preparation of future specialists. Mixed research methods were used in the study. The three main parameters of the students participating in the study were assessed: participation in the study, the level of application of theoretical knowledge, and their motivational behavior towards studying chemistry. According to the results, it turned out that the indicators of student participation in research and motivational activities were 25-45% in the first quarter, and increased by up to 2 times in the second quarter. The third quarter saw continued upward dynamics. And in the last quarter, it was 100%. It was observed that the skills of applying theoretical knowledge gradually increase through the performance of experimental work. The students presented their research results to the Republican competition of research projects for students and won prizes. This had a positive effect on increasing students' interest in chemistry. Therefore, it is clear that the use of the PBL method in additional chemistry education will contribute to the training of highly competent engineers in the future.

Keywords: Chemistry science, Creative competence, Education, Project based learning, Research project.

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1. Introduction

Currently, the development of individuals with strong independent thinking skills and creative abilities is one of the most important tasks in the education systems of all countries. In the third decade of this century, Kazakhstan plans to join the ranks of developed countries [1]. In this regard, the youth of Kazakhstan are undoubtedly entrusted with significant tasks and responsibilities. Increasing the level of competitiveness while preserving their national cognitive skills is one of the key challenges faced by the education authorities. Human capital, ready for technological progress, is inseparably linked to the upbringing of the younger generation. To achieve this, it is necessary to focus on acquiring competencies that foster the development of social productive forces, aligning the education system with global standards. In this context, expanding the creative potential of schoolchildren and youth, creating pathways and mechanisms for realizing their ideas, and developing skills in the use of effective modern technologies is of great importance.

During the periods of the collapse of the Soviet Union and the reconstruction after Kazakhstan gained independence, the education sector underwent numerous changes, and the quality of education deteriorated due to insufficient material and technical resources and a lack of teachers [2]. In particular, natural sciences such as chemistry, physics, and biology moved away from practical activities. As a result, there was a sharp decline in students' interest in natural and technical professions. This, in turn, had a negative impact on the preparation of quality engineering specialists [3]. However, as a result of reforms in the education sector over the past decade, the socio-economic status of teachers and the material and technical infrastructure of educational institutions have improved. As a result, it can be stated that the comprehensiveness and quality of education have improved [4].

Recently, in natural sciences such as chemistry, there has been an increased interest among students in the content beyond the curriculum and creative work related to the applied field of science [5]. In this process, the importance of supplementary education outside the school curriculum has grown, aiming to enhance students' critical thinking skills and creative activity. This is because supplementary education in chemistry is an effective tool for the deep assimilation of content and theoretical knowledge not included in the school curriculum, as well as for the development of creative competencies. Creative competence refers to a person's ability to generate new, unique ideas and solutions, as well as the ability to apply them effectively in various situations. These competencies include creative thinking, the development of imagination, finding unconventional approaches, and implementing innovative ideas.

Creative competence is closely linked to personal experience, knowledge, mental flexibility, and inventiveness in problem-solving. It plays a crucial role in various fields such as education, business, art, and science.

This will increase students' interest in science and elevate their creative abilities to a new level. To achieve this, it is crucial to effectively utilize modern methods, project-based learning, and research approaches [6, 7]. In this process, Project-Based Learning (PBL) helps to develop modern skills through open-ended tasks. It motivates students to refine the knowledge acquired during lessons and conduct independent research [8, 9]. Project-based learning facilitates the connection between theory and practice, thinking and action, school and society. It also positively influences the development of students' independence, creativity, problem-solving abilities, sense of responsibility, and teamwork skills [10, 11]. Project-based learning has been widely used around the world [12]. However, Project-Based Learning (PBL) is still a new and significant approach in supplementary education in Kazakhstan.

In studies on teaching chemistry using the Project-Based Learning (PBL) method [13-16] projects were presented based on specific problems, either individually or by grouping students according to the characteristics of the class. During the research, changes in students' cognitive and non-cognitive competencies were tracked through focus group student interviews each quarter over the course of the year. As a result, signs of cognitive competence, such as students' understanding of the main idea and hypothesis of the work, scientific and practical skills, independent consideration of problem-solving approaches, and creativity, were found to increase. Additionally, interest in chemistry was sparked, and students' awareness of environmental hazards expanded. It was also discovered that communication skills and the ability to express oneself fully improved. Meanwhile, Balemen and Keskin [17] and Purnama, et al. [18] the authors of the study concluded that science education using the PBL method is 86% as effective as traditional education.

It is now well-known that the rapidly developing artificial intelligence and virtual world have begun to negatively impact the cognition and spiritual revival of students [8]. According to the results of the conducted literature review, it is evident that supplementary education plays a very important role in the development of students' creative competencies. In this regard, the study aimed to examine the impact of Project-Based Learning (PBL) on enhancing students' creative competencies in chemistry within supplementary chemistry education.

2. Research Methods

The study was conducted from 2020 to 2024 at the "Zhambyl Regional School-Gymnasium" located in the city of Ust-Kamenogorsk, East Kazakhstan region. The study involved 10th-grade students who received their school education during the specified period. These students were familiar with the core content of inorganic and organic chemistry according to the school curriculum. The study included students who voluntarily expressed interest in participating. The total number of students who took part in the study was five. The participants were as follows: one student in 2020 (labeled A_{20}), one student in 2021 (labeled A_{21}), one student in 2022 (labeled A_{22}), one student in 2023 (labeled A_{23}), and one student in 2024 (labeled A_{24}).

During the study, students were given research topics aimed at solving environmental problems in accordance with the principles of "sustainable development" and "green chemistry." The project topics were chosen by the students themselves, following the guidelines presented in Table 1. The organization of the research was carried out according to the scheme shown in Figure 1. The study took place over the course of a year, in line with the project topics chosen by the students and in connection with the experimental work conducted in the laboratory.

Mixed research methods were used during the project. Throughout the study, the systematic participation of students in the project, the application of theoretical knowledge learned in the school curriculum during the experiment, the development of creative thinking skills, and motivational actions toward studying chemistry were assessed qualitatively and quantitatively on an individual basis for each student participating in the study each year.

During the application of the PBL method, students developed competencies in using technological tools such as OriginPro and Excel to process the results of experimental research. At the end of each quarter, students presented and discussed the results of their research in the form of slides. The experimental work carried out in the laboratory depended on the chosen project topics. These were conducted at the National Scientific Laboratory of Amanzholov East Kazakhstan University (Ust-Kamenogorsk). Each student determined the research methods related to their topic based on the works of other researchers, as a result of a literature review. The study was focused on independent analysis of the obtained results, particularly graphs, spectra, data related to mechanical properties, microstructures, etc.

As a result of the research conducted upon completion of the project work, students were engaged in regional and national project competitions to clearly assess the development of their creative competencies and interest in chemistry through the use of the PBL method in supplementary chemistry education (Figure 1).

Table 1.
The project topics selected by the students.

Student	Topic of the project	Research Directions
A_{20}	Development of Biodegradable Composite Materials Based on Natural Polymers	Sustainable development, Green chemistry
A_{21}	Production of Soil "Conditioner" for Agriculture	
A_{22}	Production of Packaging Materials from Agricultural Waste	
A_{23}	Synthesis of Sorbents Based on Surface-Modified Carbon Materials	
A_{24}	Development of Biodegradable Composite Material Based on Biopolymer	

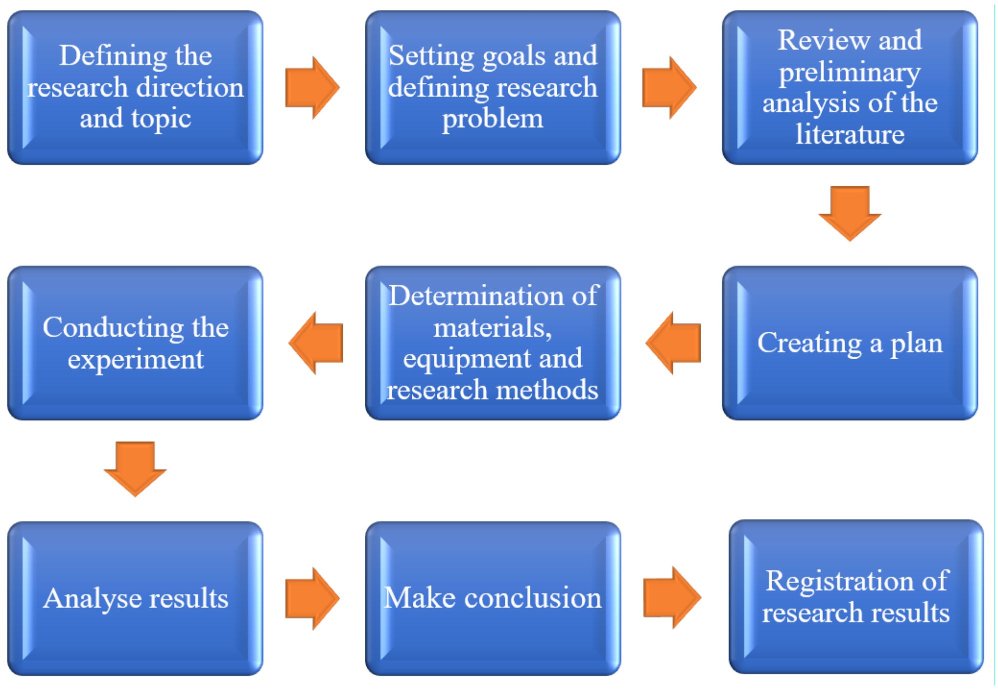

Figure 1.
Algorithms for Organizing Student Projects Based on the PBL Method.

3. Resultes and Discussion

3.1. Indicators of Student Participation in the Research

Figure 2 shows the indicators of student engagement, with data reflecting their participation in the research each year from 2020 to 2024, tracked quarterly over the course of one year. We can observe that student attendance in the first quarter over all years was up to 45%. This is closely related to the initial activities. In the beginning, students focus on selecting research topics, determining their relevance, exploring potential solutions to the problems, reviewing the work of global scientists, formulating hypotheses for their research, and determining the methods and ways to prove them. In this case, as the research work is based solely on assumptions, students' reluctance to achieve the expected results or the formation of incomplete understanding of the work can lead to a negative psychological effect. As a result, a decrease in student engagement in the research was observed.

Starting from the second quarter, it was noted that student participation in the research increased by 1.4 times compared to the first quarter. Based on the information gathered in the first quarter and the plan developed for the second stage, experimental work in the laboratory began. This positively influenced the increase in participation indicators. The reason for this is that the organization of laboratory work, along with students' practical application of the theoretical knowledge they acquired, enhances their interest in the subject. According to Keith [19] and Shana and Abulibdeh [20] the study summarizes that organizing practical work in chemistry teaching positively impacts the teacher's objective evaluation, including deepening students' theoretical knowledge and increasing their interest in the subject.

In the third quarter, it was observed that participation increased relative to the two previous stages, being 1.8 times higher than in the first quarter. This increase can be attributed to the reasons outlined in the second stage. In the final quarter, all students were fully engaged. At this stage, students had achieved relatively developed and concrete research results, with a clear understanding of their research and creative competencies, allowing them to independently solve the problems they encountered. This is considered the most important stage, as students begin preparing to participate in competitions, summarizing the results they have obtained. It was found that during this process, students become more responsible.

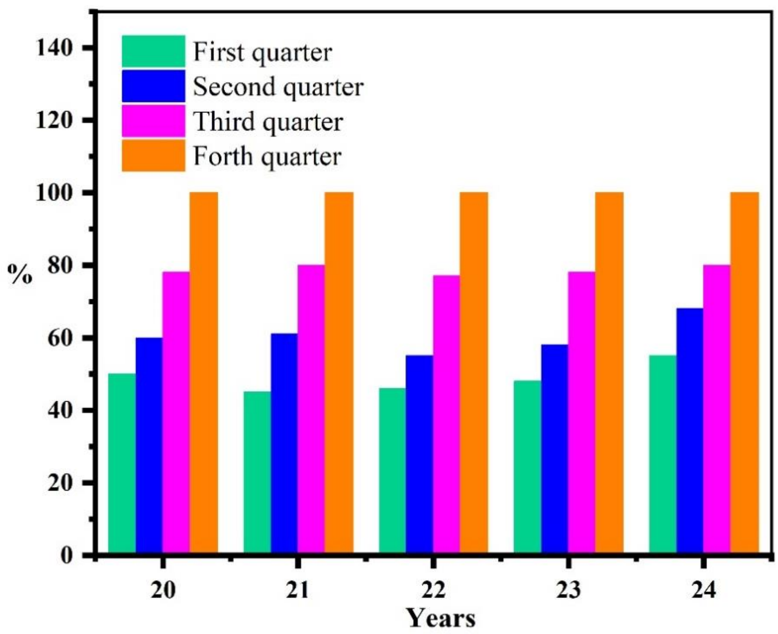

Figure 2.
Indicators of Student Participation in Research Work.

3.2. Formation of Skills in Applying Theoretical Knowledge

According to the topics listed in Table 1, students used various research methods in accordance with the research plan. All research topics were related to solving environmental problems in the field of applied scientific research in line with the principles of "sustainable development," i.e., the development of biodegradable composite materials based on biopolymers obtained through the recycling of agro-industrial waste. For this reason, students independently carried out experimental procedures, such as assembling and drying plant biomass, setting up the installation for cellulose and phytomelanin extraction, filtration, neutralization of the obtained materials, centrifugation, drying in an oven, and more. Additionally, following the methodology for calculating mass, volume, number of moles, or the concentration of dissolved substances when preparing solutions of a specific concentration, students gained skills in applying the knowledge they had acquired in practical conditions. A special course on laboratory safety rules was also conducted. Figure 3 illustrates the scheme for extracting natural compounds from plant biomass.

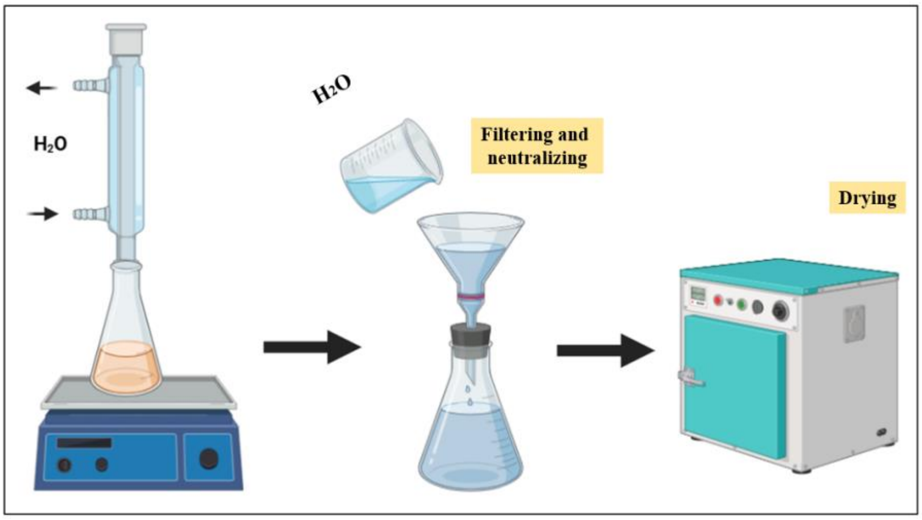

Figure 3.
The diagram of extracting natural compounds from plant biomass.

Figures 4-8 show the research results obtained by students on their chosen topic. Before starting their work, the students conducted a literature review on the assigned topic, studying its relevance and practical significance, particularly the impact of the local region on solving economic and social issues. They also sought answers to questions about the economic feasibility of the obtained product. Since the raw materials used in the research are waste from the local agro-industrial complex, the students gathered information on the extent of its accumulation, availability, and existing disposal technologies. It was clearly explained to them that the results of these actions positively influence the organization and effectiveness of the upcoming research work.

Figure 4 shows the diagram of the research work of student A_{20} and the resulting outcome. This research is aimed at obtaining biodegradable bioplastics containing cellulose, a natural polymer suitable for use in various production fields. Currently, plastic products made from synthetic polymers further exacerbate environmental pollution problems. Studies have shown that plastic accumulated in soil and water sources fragments into micro- and nanoparticles, which begin to accumulate in the bodies of animals and humans [21-23]. In light of this, student A_{20} explored the possibility of developing bioplastics. As a result, a sample of bioplastic was developed, as shown in Figure 4.

The chemical structure of the biomaterial obtained from cellulose was investigated using an infrared spectrometer. The absorption properties of C-O, C-H, $C\text{-}H_2$, and O-H bonds, which are characteristic of the cellulose molecule, were studied in the spectrum. The crystalline structure was analyzed using an X-ray diffractometer, and theoretical data indicated that diffraction peaks at 2θ values of 18.3°, 22.4°, and 34.6° are cellulose-specific. The morphology of the surface of the obtained product was found to be fibrillar. The results were compared with those of other researchers.

The results of the research conducted over the year secured 1st place in the regional competition for Republican school projects (Appendix 1a). As a result, from April 20 to 22, 2020, the students were awarded invitations to the XX International Scientific Research Project Competition on Environmental Issues. Based on the competition results, they achieved 2nd place (Appendix 1b). Currently, the student has successfully completed the Bachelor's program in Chemistry at S. Amanzholov East Kazakhstan University and continues his studies in the Master's program. During his Bachelor's program, he received an invitation to an internship at Mahatma Gandhi University (India, Kottayam) in the summer semester, where he spent three months conducting research with Indian scientists (Appendix 1c).

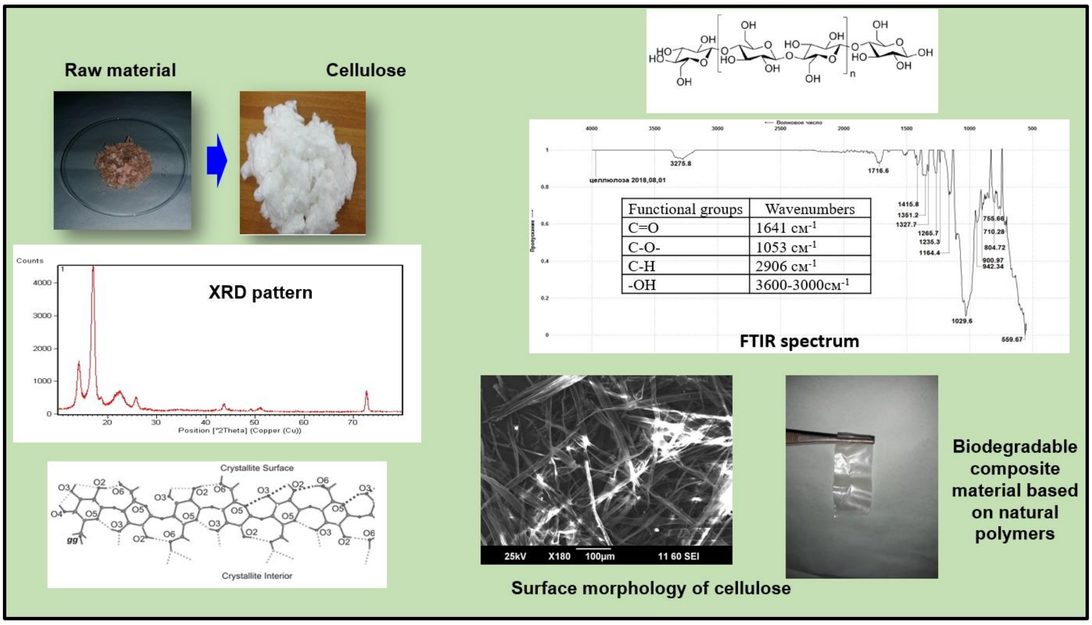

Figure 4.
The scheme and the obtained result of the research work of student A_{20}.

Figure 5 shows the schematic of the hydrogel synthesis and the hydrogel subjected to biodegradation in the soil layer, which helps retain soil moisture, in line with the research tasks of student A_{21}. The study addresses issues related to water scarcity and improving agricultural crop yields on farmland in Kazakhstan.

The student conducted research on the synthesis of biopolymer hydrogel and its physicochemical properties using gravimetric and instrumental methods of analysis. By preparing solutions of various concentrations of humic substances such as NaCl, KCl, and $CaCl_2$, which influence the swelling kinetics of the biogel, the student successfully applied theoretical knowledge related to the topic of solutions studied in the school curriculum. In addition, initial concepts in materials science were developed.

After successfully defending the research results at the regional stage of the project competition, the student took 1st place and earned a spot in the national stage (Appendix 2a). At the national stage, due to the novelty and significance of the project aimed at solving an environmental issue, the student won 1st place (Appendix 2b) [24]. As a result, 24 universities in Kazakhstan awarded the student an educational grant. The student is currently studying in the bachelor's program in Chemistry-Biology at S. Amanzholov East Kazakhstan University and continues research at the university's National Scientific Laboratory.

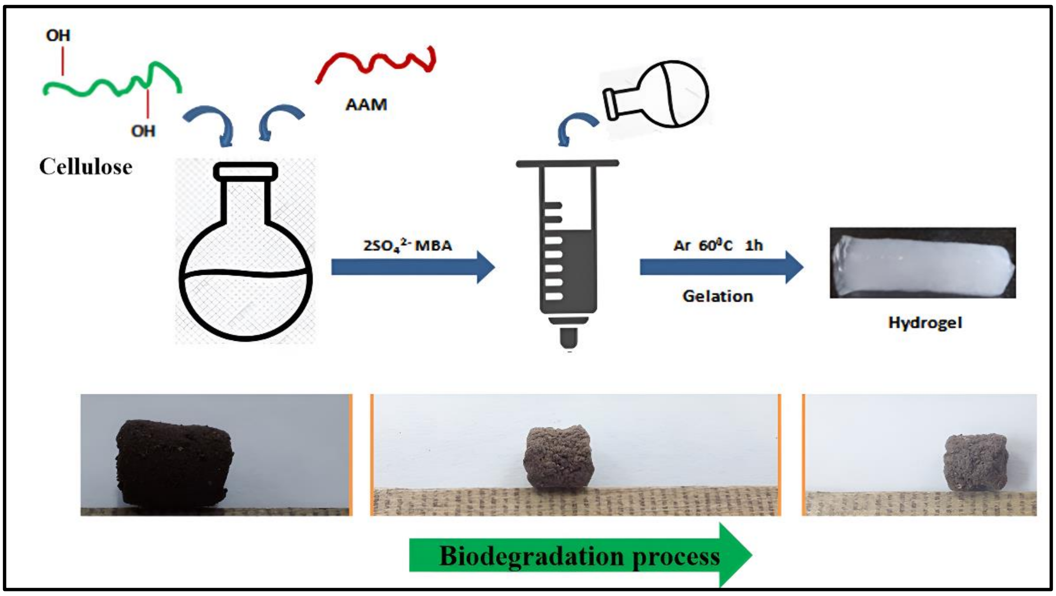

Figure 5.
The results of the research project on obtaining a "soil conditioner" for agriculture (project A_{21}).

The research conducted by student A_{22} is aimed at developing domestic packaging materials for food products made from cellulose, which is obtained through the recycling of agricultural waste. Many studies have found that packaging based on synthetic polymers negatively impacts the environment and human health [25-27]. In this context, the student intends to explore effective ways of recycling waste from the local agro-industrial complex and minimizing environmental problems. During the research, the student fully examined the optimal ratio of cellulose to water, the effective concentration of the binding glue, volume, and all other parameters influencing the properties of the resulting paper packaging (Figure 6). As a result, packaging was developed with a mechanical strength of 22.33 MPa. Based on the research findings, the student secured 1st place in the national scientific research project competition for school students (Appendix 3). Currently, the student A_{22} is studying the field of nanomaterials chemistry.

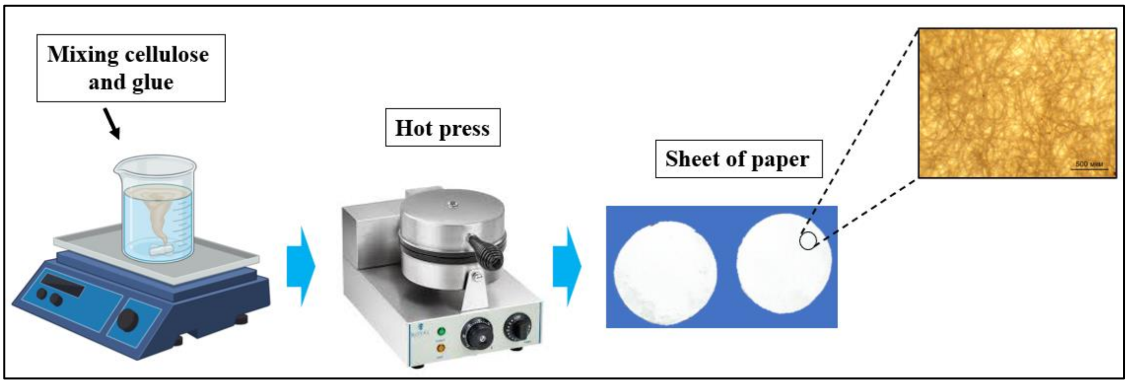

Figure 6.
The diagram of the project "Production of Packaging Materials from Agricultural Waste" (A_{22}).

The goal of "Sustainable Development" ensuring access to clean water through "Clean Water and Sanitation," is one of the most important tasks. In this regard, student A_{23} chose the task of developing an innovative sorbent for cleaning dirty water in their research project (Figure 7). The main composition of the filtering material is carbon-based material, such as modified graphene oxide, the surface of which is derived from biomass of agricultural crops. In recent years, graphene oxide and materials with similar chemical structures have been used to clean polluted water from heavy metal ions. Extensive research is being conducted in the fields of electronics, biomedicine, and sensor development [28, 29].

Student A_{23} synthesized a material similar to graphene oxide by extracting carbon material from plant biomass through carbonization and introducing -OH, -COOH, and -COHO groups, which enhance its ability to capture heavy metal ions by modifying its surface. The sorption of the synthesized material on heavy metal ions was investigated. The research showed that the obtained material can remove up to 92% of heavy metal ions from water. Based on the results, A_{23} became the winner of first place in the annual republican scientific project competition among school students (Appendix 4).

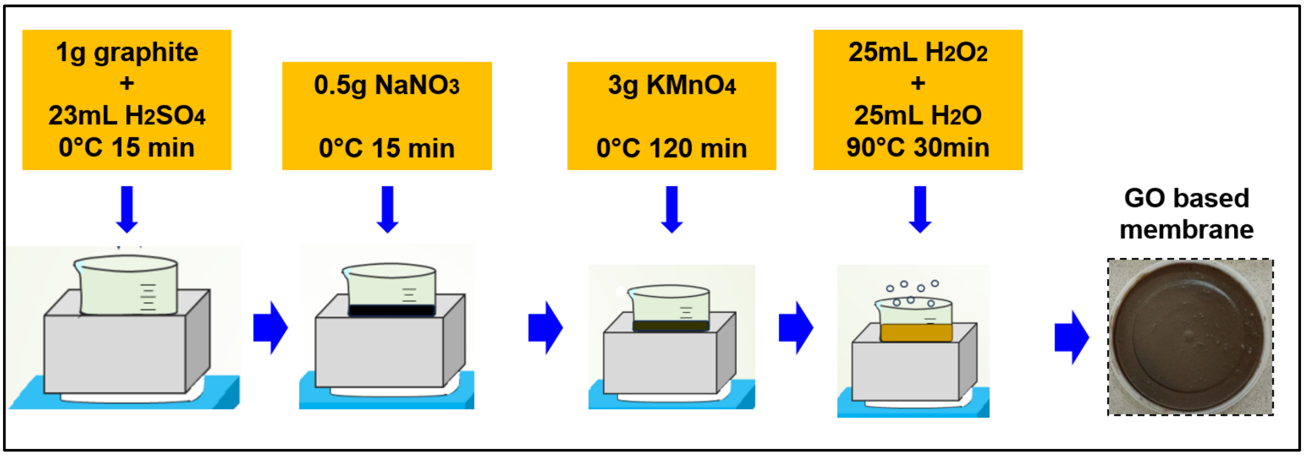

Figure 7.
Diagram of the project "Synthesis of sorbents based on surface-modified carbon material" (Student A_{23}).

Figure 8 shows a brief outline of the research and the results obtained by the student who participated in the study in 2024, depending on the selected topic. According to the study Asim, et al. [30] and Ruzi, et al. [31] global production of food packaging materials is expected to reach 464 billion dollars by 2027. This, in turn, highlights the significant role of biodegradable products, considering the growing environmental concerns that demand recycling and proper disposal. Therefore, the development of biodegradable packaging materials based on natural polymers is a common goal for all researchers. In this regard, student A_{24} was tasked with studying the possibility of producing a biopolymer film based on nanocellulose obtained from agricultural waste. The student independently carried out all procedures, from preparing the necessary materials for the experimental work to the extraction of nanocellulose and the synthesis of the biopolymer film. The resulting material was analyzed using FTIR, XRD, and tested for mechanical strength and hydrophobic properties. In processing the obtained results, knowledge gained from the school curriculum was applied to determine concentrations, mass fractions, and ratios of components in solutions, while analytical research techniques and the ability to analyze results were utilized during the project.

The final result of the research work was a second-place winner at the regional stage of the national scientific research project competition for schoolchildren (Appendix 5). Currently, the research work continues within the framework of this project.

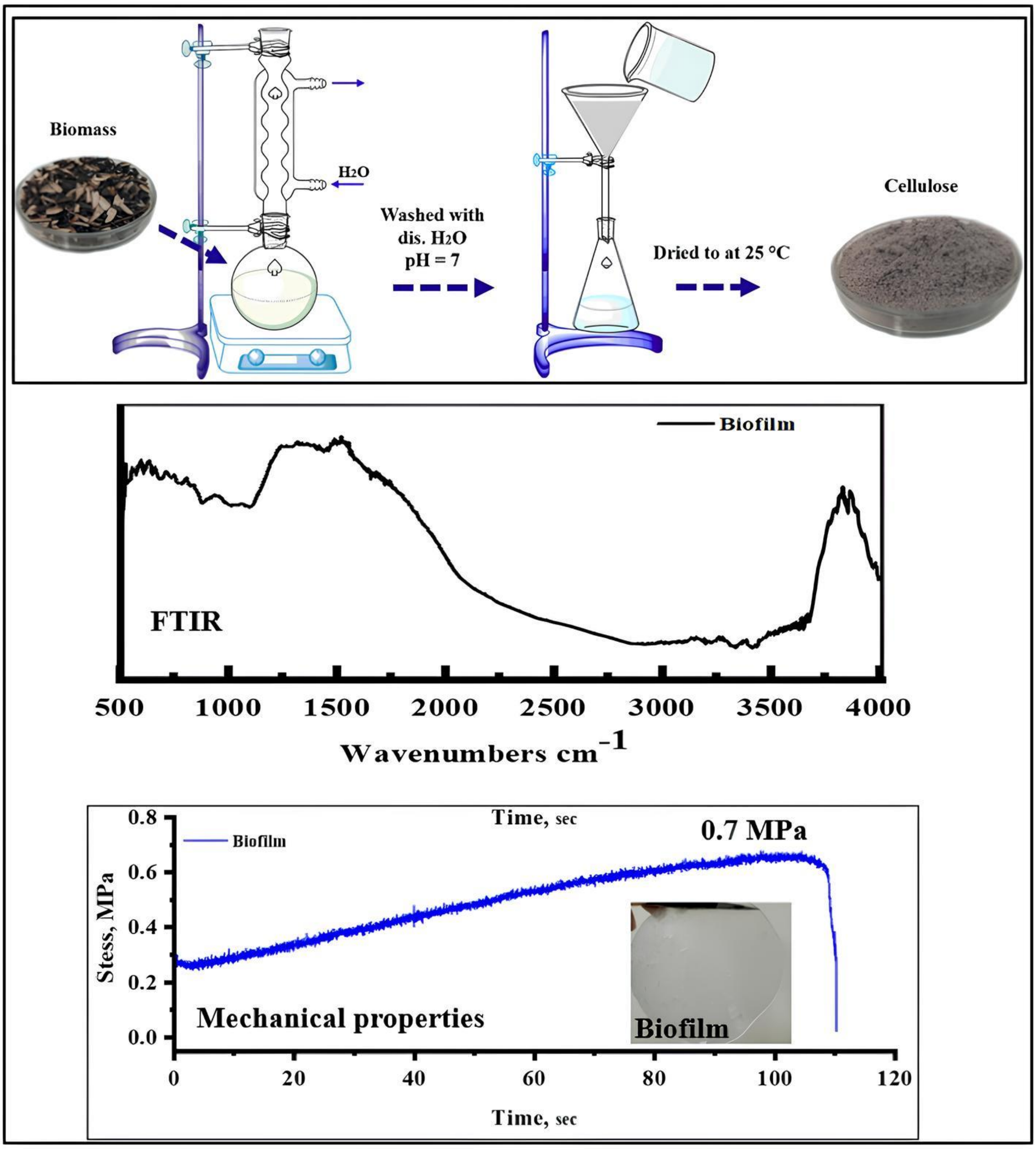

Figure 8.
The diagram of the project "Development of a biodegradable composite material based on a biopolymer" (student A_{24}).

3.3. Motivational attempts to study Chemistry

Motivational actions of students to study the subject were tracked throughout the year. Figure 8 shows the motivation levels for each quarter. In the first quarter, we see that the motivation level of all students is up to 25%. This, depending on the chosen research topic, may be related to the introduction of new information and theoretical content outside the school curriculum [32]. The study examines the specific competencies that students develop in chemistry using the PBL method. According to the results obtained by the authors, no significant changes in students' motivation indicators occur at the initial stage. In conclusion, it can be said that this is influenced by the new content and activities.

In the second quarter, there was a 52% increase in motivational indicators of students towards chemistry, doubling compared to the first quarter. This increase was due to the start of independent experimental work in the laboratory and obtaining the first results, which positively affected the students' interest in the project. In turn, chemistry was able to demonstrate the importance and appeal of the subject. Faizal et al. and Gozde et al. in their studies summarize that performing experimental work in the laboratory using the PBL method in chemistry teaching increases students' interest in the subject [15, 33, 34].

By the end of the third quarter, the motivational levels of students reached 85%, increasing by 3.4 times compared to the first quarter, and in the final quarter, they reached 100%. It can be assumed that in the last two quarters, the students were influenced by the achievement of concrete results in their research projects and the acquisition of practical skills with some theoretical content beyond the school curriculum. With the results of the research work, it became clear that participating in competitions and becoming a winner increases interest in chemistry and science [35, 36]. The study mentions that teaching chemistry using the additional PBL method sparks students' interest in science, including the development of creative thinking skills. This shows that the results obtained in this study are similar.

Students A_{20} and A_{21} are currently conducting research in collaboration with scientists on the development of bionanocomposite materials and the study of their practical applications in the National Scientific Laboratory at S. Amanzholov East Kazakhstan University. Based on the results obtained, we can see that the PBL method in supplementary chemistry education can enhance students' creative competencies. Moreover, it can be said that this will contribute to preparing future engineers and scientists.

4. Conclusions

The development of creative thinking skills in students through supplementary chemistry education will help prepare qualified specialists. In this regard, the current research provided students with research projects aimed at solving environmental problems using the PBL method in supplementary chemistry education. The students who participated in the research evaluated three main parameters: participation in the research, the level of application of theoretical knowledge, and motivational activity in learning chemistry. According to the results, it was found that the participation and motivational activity levels of students in the research in the first quarter were 25-45%, in the second quarter it doubled. In the third quarter, there was a dynamic increase, and in the final quarter, it reached 100%.

Based on the results of the research, the students participated in the national competition of research projects for schoolchildren and won prizes. This, in turn, increased students' interest in chemistry. As a result, students A_{20}, A_{21}, and A_{22} chose chemistry and continued their research, while students A_{23} and A_{24} continue working on their research topics. Therefore, we can conclude that the use of the PBL method in supplementary education to develop creative competencies in chemistry can increase students' interest in science and help prepare future engineers.

References

[1] Republic of Kazakhstan, "National statement of commitment of the Republic of Kazakhstan, adopted at the UN summit on education for Ssustainable development," 2023. https://adilet.zan.kz/rus/docs/P2300000249

[2] E. Sadykov, "Aimagambetov identified the main problems facing education in Kazakhstan. Liter.kz," 2021. https://liter.kz/121544-2/

[3] I. Tshe, "30 years of independence and education priorities. 365info.kz," 2021. https://365info.kz/2021/11/30-let-nezavisimosti-i-prioritety-v-obrazovanii

[4] D. Tsybulsky and Y. Muchnik-Rozanov, "The development of student-teachers' professional identity while team-teaching science classes using a project-based learning approach: A multi-level analysis," *Teaching and Teacher Education,* vol. 79, pp. 48-59, 2019. https://doi.org/10.1016/j.tate.2018.12.006

[5] S. A. Adah, "Effect of problem-based learning on acquisition of creative thinking skills among chemistry students in Ogoja Education Zone, Cross River State, Nigeria," *International Journal of Education and Evaluation,* vol. 8, no. 7, pp. 1–10, 2022. https://doi.org/10.56201/ijee.v8.no7.2022.pg1.10

[6] W. Apriwanda and C. Hanri, "Level of creative thinking among prospective chemistry teachers," *Jurnal Pendidikan IPA Indonesia,* vol. 11, no. 2, pp. 296-302, 2022. https://doi.org/10.15294/jpii.v11i2.34572

[7] S. U. Laiskhanov and S. A. Barat, "Increasing the efficiency of geographical education at school through project-based teaching technology," *Foundations and Trends in Modern Learning,* vol. 3, no. 1, pp. 45–52, 2023.

[8] A. S. Nurtayev and A. Z. Muslimova, "Project-based learning is a modern educational technology," *Teoriya i praktika sovremennoy nauk,* vol. 1, no. 55, pp. 306–309, 2020.

[9] V. T. Yen, "Applying project-based learning in teaching quantitative analytical chemistry at the University of Pedagogy," Doctoral Thesis, Hanoi National University of Education, 2014.

[10] H. B. Pham, "Applying the project-based learning method in teaching non-metallic chemistry in high school chemistry program," Doctoral Thesis, Hanoi National University of Education, 2013.

[11] T. T. Ninh and N. T. T. Thuy, "Applying WebQuest method in teaching chemistry for grade 10 to assess students' collaboration problem solving skills," *Journal of Education,* vol. 444, pp. 37–41, 2018.

[12] M. J. Reiss, R. Sheldrake, and W. Lodge, "Investigative research projects for students in science: The state of the field and a research agenda," *Canadian Journal of Science, Mathematics and Technology Education,* vol. 23, pp. 80-95, 2023. https://doi.org/10.1007/s42330-023-00263-4

[13] A. Vergara-Castañeda, T.-E. Chávez-Miyauchi, A. Benítez-Rico, and A.-B. Ogando-Justo, "Implementing project-based learning as an effective alternative approach for chemistry practical courses online," *Journal of Chemical Education,* vol. 98, no. 11, pp. 3502-3508, 2021.

[14] S. McLaughlin *et al.*, "Evaluating the impact of project-based learning in supporting students with the A-level chemistry curriculum in Northern Ireland," *Journal of Chemical Education,* vol. 101, no. 2, pp. 537-546, 2024. https://doi.org/10.1021/acs.jchemed.3c01184

[15] F. A. A. M. Masbukhin, S. S. Adji, and A. F. D. Wathi, "Project-based learning (PjBL) model in Chemistry Learning: Students' perceptions," *European Journal of Education and Pedagogy,* vol. 4, no. 1, pp. 93-98, 2023. https://doi.org/10.24018/ejedu.2023.4.1.567

[16] N. D. Nguyễn, "Design tools to assess the problem-solving and creativity for students in the northern mountainous provinces through project-based learning in chemistry," *Vietnam Journal of Education,* vol. 443, no. 1, pp. 47–53, 2018.

[17] N. Balemen and M. Ö. Keskin, "The effectiveness of Project-Based Learning on science education: A meta-analysis search," *International Online Journal of Education and Teaching,* vol. 5, no. 4, pp. 849-865, 2018.

[18] R. D. A. Purnama, R. Situmorang, and Z. Syahrial, "Project-based learning approach to science process skills chemistry learning," in *Proceedings of the International Seminar and Conference on Educational Technology (ISCET 2022) (Vol. 106, pp. 153–162). Atlantis Press*, 2023.

[19] S. T. Keith, "The role of" practical" work in teaching and learning chemistry," *School Science Review*, vol. 96, no. 357, pp. 75-83, 2015.

[20] Z. Shana and E. S. Abulibdeh, "Science practical work and its impact on high students' academic achievement," *Journal of Technology and Science Education*, vol. 10, no. 2, pp. 199-215, 2020. https://doi.org/10.3926/jotse.888

[21] P. Mulindwa, J. S. Kasule, F. Nantaba, J. Wasswa, and A. J. Expósito, "Bioadsorbents for removal of microplastics from water ecosystems: A review," *International Journal of Sustainable Engineering*, vol. 17, no. 1, pp. 582-599, 2024. https://doi.org/10.1080/19397038.2024.2374003

[22] N. A. Anuwa-Amarh, M. Dizbay-Onat, K. Venkiteshwaran, and S. Wu, "Carbon-based adsorbents for microplastic removal from wastewater," *Materials*, vol. 17, no. 22, p. 5428, 2024. https://doi.org/10.3390/ma17225428

[23] K. Zhao *et al.*, "Separation and characterization of microplastic and nanoplastic particles in marine environment," *Environmental Pollution*, vol. 297, p. 118773, 2022. https://doi.org/10.1016/j.envpol.2021.118773

[24] Ministry of Education and Science of the Republic of Kazakhstan, "Results of schoolchildren's participation from East Kazakhstan region in the Republican Competition of Research Projects," 2023. https://www.gov.kz/memleket/entities/vkobilim/press/news/details/534328?lang=en

[25] A. Kaur and S. Sharma, "A sustainable replacement for conventional petrochemical-based packaging materials as bio-based food packaging," *The Pharma Innovation Journal,*, vol. 12, no. 5, pp. 3347-3357, 2023.

[26] V. A. Harkal and S. P. Deshmukh, "A review on biodegradable polymers: Used as packaging materials," *GSC Biological and Pharmaceutical Sciences*, vol. 25, no. 2, pp. 107-15, 2023. https://doi.org/10.30574/gscbps.2023.25.2.0423

[27] R. R. Ali, W. W. A. Rahman, N. Ibrahim, and R. Kasmani, *Starch-based biofilms for green packaging. In Developments in sustainable chemical and bioprocess technology*. Boston, MA: Springer US, 2013.

[28] B. Anegbe, I. H. Ifijen, M. Maliki, I. E. Uwidia, and A. I. Aigbodion, "Graphene oxide synthesis and applications in emerging contaminant removal: A comprehensive review," *Environmental Sciences Europe*, vol. 36, p. 15, 2024. https://doi.org/10.1186/s12302-023-00814-4

[29] A. T. Smith, A. M. LaChance, S. Zeng, B. Liu, and L. Sun, "Synthesis, properties, and applications of graphene oxide/reduced graphene oxide and their nanocomposites," *Nano Materials Science*, vol. 1, no. 1, pp. 31-47, 2019. https://doi.org/10.1016/j.nanoms.2019.02.004

[30] N. Asim, M. Badiei, and M. Mohammad, "Recent advances in cellulose-based hydrophobic food packaging," *Emergent Materials*, vol. 5, pp. 703-718, 2022. https://doi.org/10.1007/s42247-021-00314-2

[31] M. Ruzi, N. Celik, and M. S. Onses, "Superhydrophobic coatings for food packaging applications: A review," *Food Packaging and Shelf Life*, vol. 32, p. 100823, 2022. https://doi.org/10.1016/j.fpsl.2022.100823

[32] Y. Zhao and L. Wang, "A case study of student development across project-based learning units in middle school chemistry," *Disciplinary and Interdisciplinary Science Education Research*, vol. 4, p. 5, 2022. https://doi.org/10.1186/s43031-021-00045-8

[33] G. Kurt and K. Akoglu, "Project-based learning in science education: A comprehensive literature review," *Interdisciplinary Journal of Environmental and Science Education*, vol. 19, no. 3, p. e2311, 2023. https://doi.org/10.29333/ijese/13677

[34] Y. A. Tsvirko, "Analysis of the situation in the education system in Kazakhstan and ways of further development," *Problems of Engineering and Professional Education*, vol. 22, no. 1, pp. 19–20, 2023. https://doi.org/10.32523/2220-685X-2014-22-1-19-20

[35] E. A. Pratiwi and J. Ikhsan, "Project based learning (PjBL) in chemistry learning: Systematic literature and bibliometric review 2015-2022," *Jurnal Penelitian Pendidikan IPA*, vol. 10, no. 6, pp. 343-354, 2024. https://doi.org/10.29303/jppipa.v10i6.7017

[36] T. S. Alrajeh, "Project-based learning to enhance pre-service teachers' teaching skills in science education," *Universal Journal of Educational Research*, vol. 9, no. 2, pp. 271-279, 2021. https://doi.org/10.13189/ujer.2021.090202


ШЫҒЫС ҚАЗАҚСТАН ОБЛЫСЫНЫҢ БІЛІМ БАСҚАРМАСЫ

ДИПЛОМ

ЖАЛПЫ БІЛІМ БЕРЕТІН ПӘНДЕР БОЙЫНША РЕСПУБЛИКАЛЫҚ ҒЫЛЫМИ ЖОБАЛАР КОНКУРСЫНЫҢ ОБЛЫСТЫҚ КЕЗЕҢІНДЕ

Химия секциясы бойынша

I орын алғаны үшін

11 сынып оқушысы

Кайырбеков Нариман

МАРАПАТТАЛАДЫ

БАСШЫ С. ЖУМАДИЛОВА

a


МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ
МЕЖДУНАРОДНАЯ КАФЕДРА-СЕТЬ ЮНЕСКО/МЦОС
"ПЕРЕДАЧА ТЕХНОЛОГИЙ ДЛЯ УСТОЙЧИВОГО РАЗВИТИЯ" ПРИ МЕЖДУНАРОДНОМ ЦЕНТРЕ ОБУЧАЮЩИХ СИСТЕМ
НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ЦЕНТР «СОЗВЕЗДИЕ»

UNESCO ICES CENTRE

ДИПЛОМ

II степени

ҚАЙЫРБЕКОВ НАРИМАН

(Химия)

награждается призёр двадцатой Всероссийской олимпиады научно-исследовательских проектов по проблемам защиты окружающей среды "Человек-Земля-Космос"

Директор Департамента Международной кафедры-сети ЮНЕСКО/МЦОС В. Васильев

22-27 апреля 2019 года
г. Королев, Россия

b


SCHOOL OF ENERGY MATERIALS,
M.G. University, Kottayam

IIUCNN

CERTIFICATE

This is to certify that Mr. Nariman Kaiyrbekov a student from Sarsen Amanzholov East Kazakhstan University has completed research internship in Mahatma Gandhi University for a period of 3 months started from 06 June ·2022 to 20 August 2022 at the School of Energy Materials, Mahatma Gandhi University, Kerala. His research internship topic "*Study of the processes of complex formation of silver, copper and boron with derivatives of succinic acid*" was conducted under my supervision.

Prof. (Dr.) SABU THOMAS, D.Sc., Ph.D.
FRSC, FEurASc Vice-Chancellor
Mahatma Gandhi University,
Kottayam, Kerala, India -686 560

c

Appendix 1.
Student $A_{20's}$ certificates for the scientific project competition: a) 1st place at the regional stage of the Republican project competition (Kazakhstan, Ust-Kamenogorsk, in Kazakh); b) 2nd place at the International Scientific Project Competition (Russia, Moscow, in Russian); c) Internship certificate from Mahatma Gandhi University (India, Kottayam).


ШЫҒЫС ҚАЗАҚСТАН ОБЛЫСЫНЫҢ БІЛІМ БАСҚАРМАСЫ

ДИПЛОМ

ЖАЛПЫ БІЛІМ БЕРЕТІН ПӘНДЕР БОЙЫНША РЕСПУБЛИКАЛЫҚ ЗЕРТТЕУ ЖОБАЛАР КОНКУРСЫНЫҢ ОБЛЫСТЫҚ КЕЗЕҢІНДЕ

Химия

СЕКЦИЯСЫ БОЙЫНША I ОРЫН АЛҒАНЫ ҮШІН

11 СЫНЫП ОҚУШЫСЫ

Демеухан Аңсаған

МАРАПАТТАЛАДЫ

ЖЕТЕКШІСІ

БАСШЫНЫҢ М.А. И. ЧЕРНЫШЁВА

Өскемен қаласы, 2022 жыл

a


ҚАЗАҚСТАН РЕСПУБЛИКАСЫНЫҢ ОҚУ-АҒАРТУ МИНИСТРЛІГІ

I дәрежелі Диплом

Жалпы білім беретін пәндер бойынша республикалық ғылыми жобалар конкурсының жеңімпазы

Демеухан Аңсаған

Шығыс Қазақстан облысы

марапатталады

Министр Ғ. Бейсембаев

№ RGJK-2023-D-I-005

b

Appendix 2.

Certificates of student A_{21} for the scientific project competition. a) 1st place at the regional stage of the national project competition (Kazakhstan, Ust-Kamenogorsk, in Kazakh); b) 1st place at the national stage (Kazakhstan, Almaty, in Kazakh).

Appendix 3.
Certificates of student A_{22} at the Republican Scientific Project Competition (Kazakhstan, Almaty, in Kazakh).

Appendix 4.
Certificate of student A_{23} at the Republican Scientific Project Competition (Kazakhstan, Almaty, in Kazakh).

Appendix 5.
Certificate of student A_{24} at the Republican Science Projects Competition (Kazakhstan, Ust-Kamenogorsk, in Kazakh).