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Developing the readiness of higher school students for research activities through the means of Problem-Based Learning (PBL)

Desenvolvimento da aptidão de alunos do ensino superior para atividades de pesquisa por meio da Aprendizagem Baseada em Problemas (PBL)

Desarrollo de la preparación de los estudiantes de enseñanza superior para las actividades de investigación mediante el Aprendizaje Basado en Problemas (ABP)

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Effectiveness of problem-based learning (PBL)
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Problem-based learning tools had a positive impact on the development of students' independence, strategic and logical thinking, creative potential, and group work.
Originality/value:
This article presents original empirical evidence regarding the expanded use of problem-based learning tools in real educational settings. Future research will focus on comparing the effectiveness of problem-based learning when implemented with digital technologies versus without them.

ABSTRACT

Background: Deep understanding of professional knowledge is achieved through non-standard educational methods. This research aims to evaluate the effectiveness of problem-based learning (PBL) tools in preparing higher education students for research activities. **Methods**: The research utilized methods such as synthesis, comparison, effectiveness ratio calculation, performance indicators, and the J. Phillips coefficient. Problem-based learning is implemented by creating and analyzing problem situations aimed at studying theoretical material and developing professional and creative skills. **Results**: The training results indicated that three groups of students reached a high level of knowledge: Group 1 consisted of future physics teachers, Group 2 included future music teachers, and Group 3 comprised future Ukrainian language teachers. PBL tools positively impacted students' independence, strategic and logical thinking, creative potential, and ability to work in groups. **Conclusions**: The practical significance of this research lies in the expanded use of problem-based learning tools in real educational settings. Future research may involve comparing the effectiveness of problem-based learning when incorporating digital technologies versus traditional methods in the educational process.

Keywords: situational problem; student activity; basic level; productive level; creative potential; PBL.

RESUMO

Contexto: A compreensão profunda do conhecimento profissional é obtida por meio de métodos educacionais não padronizados. O objetivo desta pesquisa é avaliar a eficácia das ferramentas de aprendizagem baseada em problemas (PBL) na preparação de alunos do ensino superior para atividades de pesquisa. **Métodos**: A pesquisa utilizou métodos como síntese, comparação, cálculo da taxa de eficácia, indicadores de desempenho e o coeficiente de J. Phillips. A aprendizagem baseada em problemas é implementada por meio da criação e análise de situações-problema com o objetivo de estudar o material teórico e desenvolver habilidades profissionais e criativas. **Resultados**: Os resultados do treinamento indicaram que três grupos de alunos atingiram um alto nível de conhecimento: O Grupo 1 era composto por futuros professores de física, o Grupo 2 incluía futuros professores de música e o Grupo 3 era composto por futuros professores de língua ucraniana. As ferramentas de PBL afetaram positivamente a independência dos alunos, o pensamento estratégico e lógico, o potencial criativo e a capacidade de trabalhar em grupos. **Conclusões**: A importância prática desta pesquisa está no uso ampliado de ferramentas de aprendizagem baseada em problemas em ambientes educacionais reais. Pesquisas futuras podem envolver a comparação da eficácia da aprendizagem baseada em problemas ao incorporar tecnologias digitais versus métodos tradicionais no processo educacional.

Palavras-chave: problema situacional; atividade do aluno; nível básico; nível produtivo; potencial criativo; PBL.

RESUMEN

Antecedentes: La comprensión profunda de los conocimientos profesionales se consigue mediante métodos educativos no estándar. El objetivo de esta investigación es evaluar la eficacia de las herramientas de aprendizaje basado en problemas (ABP) en la preparación de estudiantes de enseñanza superior para actividades de investigación. **Métodos**: La investigación utilizó métodos como la síntesis, la comparación, el cálculo del ratio de eficacia, los indicadores de rendimiento y el coeficiente de J. Phillips. El aprendizaje basado en problemas se lleva a cabo mediante la creación y el análisis de situaciones problemáticas orientadas al estudio de material teórico y al desarrollo de competencias profesionales y creativas. **Resultados**: Los resultados de la formación indicaron que tres grupos de estudiantes alcanzaron un alto nivel de conocimientos: El Grupo 1 estaba formado por futuros profesores de física, el Grupo 2 por futuros profesores de música y el Grupo 3 por futuros profesores de lengua ucraniana. Las herramientas de PBL influyeron positivamente en la independencia, el pensamiento estratégico y lógico, el potencial creativo y la capacidad de trabajo en grupo de los estudiantes. **Conclusiones**: La importancia práctica de esta investigación radica en la ampliación del uso de las herramientas de aprendizaje basado en problemas en entornos educativos reales. La investigación futura puede consistir en comparar la eficacia del aprendizaje basado en problemas cuando se incorporan tecnologías digitales frente a métodos tradicionales en el proceso educativo.

Palabras clave: problema situacional; actividad del alumno; nivel básico; nivel productivo; potencial creativo, ABP.

INTRODUCTION

The educational process is directly related to research activity, which requires its effective implementation. Research activity reflects a search, experimental and theoretical processes for solving specific scientific problems. It requires students' purposefulness and independence, which can be developed under the influence of a non-standard educational process (Butler & Morrow, 2023). Therefore, the search for relevant mechanisms to ensure research activities in higher education institutions (HEIs) is a relevant issue for research.

The research activity should provide for the students' independent development, which is connected with the constant improvement of professional activity. Learning mechanisms should be aimed at student interest, focusing on efficiency and diversity (Peng et al., 2022; Othman et al., 2022). The problem-based learning is one of these approaches. Problem-based learning includes solving complex tasks based on complex problems, which ensures the development of critical thinking. Previously, problem-based learning was based solely on the active interaction of students to achieve educational goals (Heikkinen et al., 2023; Rudyshyn et al., 2020). Today, the concept of "problem-based learning" is expanded. Problem-based learning involves solving specific difficult situations, which are aimed at understanding practical approaches to the implementation of professional activities. Situations are formed from external circumstances, intellectual abilities, which ensures students' orderliness. Problem-based learning should include a preparatory stage for the perception of information, form the main problem and solve it (Elmoazen et al., 2022; Junedi et al., 2024). Problem-based tasks should include conflicting information to enhance students' cognitive interest. Students should actively use the acquired knowledge, focusing on confirmed theories and laws when solving problematic tasks (Fitriani & Herman, 2021).

Problem-based learning affects the independent study of educational information, rethinking existing knowledge. The study of Rahim et al. (2022) has found that problem-based learning affects the development of creative skills in students that contribute to developing research activities. It also affects the development of new knowledge, which measures research competence. During problem-based learning, students form a relationship between theoretical and practical knowledge, focusing on different levels of complexity of the assigned tasks (Rudyshyn et al., 2024). Students need to ensure the correct sequence when solving problem situations, which is aimed at the development of logical thinking (Betti et al., 2022). We found that the indicated data from the study of Rafiq et al. (2023) are aimed at the need for students to perform the assigned tasks based on the initial conditions. The obtained information is correlated with the following conclusions in (Marushkevy et al., 2022). This will enable the search for new material based on previously learned material, ensure a logical sequence in solving tasks, and eliminate gaps in knowledge during the search for information (Marushkevy et al., 2022).

Separate features of problem-based learning were established based on the analysis of the specified sources of literature. The method of implementing problem-based learning proposed in the presented studies is aimed at determining the advantages of practical implementation. The gaps in the research include the lack of specific mechanisms for implementing problem-based learning of students before their research activities. The aim of the research is to determine the peculiarities of higher school students' readiness for research activities through problem-based learning.

The research objectives:

- Develop ways of implementing problem-based learning for the purpose of preparing for research activities;

- Determine the achievement of basic, productive, creative level of knowledge by students of different groups, which were formed during the solution of problematic situational models;

- Compare the effectiveness of developed skills between students of different groups, which contribute to professional development;

- Determine the quality of implementation of problem-based projects by students for solving the set tasks.

Literature review

The development of students' research activities implies the development of creative abilities, which can be implemented with the help of an individualized approach. Problem-based learning approaches, a representative method, and digital tools can be used to implement an individualized approach. The interactive CoRT programme combines different educational approaches, which contributes to the students' creative development (Rudyshyn et al., 2022). The creative skills are developed based on in-depth study of educational materials, focusing on divergent and convergent thinking (Bulut Ates & Aktamis, 2024). The variety of educational approaches increase the level of students' knowledge, which promotes the focus on critical thinking, understanding of the studied topics. Culturally oriented learning affects a better understanding of educational materials, which broadens students' horizons. Students' interaction among themselves improves the quality of solving educational tasks, focusing on structured group activity (Ernawati et al., 2024). The proposed educational practice should be aimed at the active participation of students, which can be implemented with the help of problem-based thinking

training (Pereira et al., 2024). This involves structuring the educational process in such a way as to encourage students to create research projects. The educational process can be implemented with the help of gamification techniques, which will include problem-based learning, case-based learning, game-based approach. This contributes to developing students' consciousness by developing critical thinking (Pereira et al., 2024).

The problem-based learning can be implemented due to the use of STEM technologies. The quality of education can be ensured by conducting students' survey regarding existing advantages and disadvantages for further adjustment. This approach is aimed at providing students with motivation to gain professional experience (Gilbert et al., 2024). The combination of STEM technologies in the educational process is also included in the next article. Digital technologies are used in education to develop students' critical and creative thinking. The STEAM Problem-Based Learning model contributes to quality preparation for acquiring knowledge, identifying existing problems, and preparing solutions for their implementation. The model makes it possible to ensure students' high-quality assessment and receiving feedback. Students note the effectiveness of the presented model in terms of the completeness of information and minimalist content for learning the most important information (Suryani et al., 2024). The development of critical thinking is the basis of the development of professional and educational skills, which requires the selection of effective strategies. Problem-based learning helps to determine the main theoretical components for learning and search for effective practical approaches. This results in the development of students' cognitive abilities, which contributes to the achievement of high professional results (Hutsalo et al., 2024). Problem-based learning promotes the development of practical skills that correspond to further professional activity. STEM technologies make it possible to identify gaps in the educational process, focus on students' professional interest. Experiential learning contributes to obtaining the necessary information for the students' professional development (Su, 2024).

The effectiveness of problem-based learning can be increased due to the use of institutional, educational, and cultural factors that affect the provision of collective work. This contributes to enriching the educational process based on the regulation of theoretical and practical classes. This approach makes it possible to stimulate students to carry out reflective professional practice (Fonsêca Barros & Penna, 2023). Mobile learning affects the effectiveness of the educational process, focusing on the teachers' knowledge and experience. Mobile learning eliminates social, technological, pedagogical shortcomings and enables the development of a value-based educational programme for students' research activities (Naveed et al., 2023). The constant survey of students affects the improvement of the quality of the educational process and involves the search for effective educational solutions. The students' success and their motivation depend on the quality of the developed curriculum. Attention in the educational process should be paid to approaches that are problematic for students in terms of memorization. This will allow adjusting the submission of information for further professional development (Rocconi et al., 2020).

The analysis of academic articles showed the possibility of developing students' research activities based on the use of problem-based learning, STEAM technologies, and digital technologies. Attention was also paid to improving the educational process by conducting a survey among students regarding possible gaps in education. However, the published studies do not reflect the clarity of the organization of problem-based learning, which will contribute to the development of students' research activities.

METHODS

Research design

The first stage of the research provided for determining the ways of forming problem-based learning for the implementation students' research activities. The authors considered general educational approaches that can be implemented for different groups of students. The students' training lasted for five months, which made it possible further to determine the level of professional formation of students. The second stage of the research involved determining the level of students' professional training. The process involved the definition of theoretical, practical and creative knowledge. The results were obtained among students of 3 groups. Group 1, who were studying to be future physics teachers; Group 2 — future music teachers, and Group 3 — future Ukrainian language teachers. It was also determined what skills the students developed in the educational process. At the third level of research, students of different groups had to create real projects within the framework of problem-based learning. The projects provided the possibility of practical study of a separate topic as a result of solving the set problematic tasks.

Sampling

The study involved students of different majors to determine the effectiveness of problem-based learning in forming research activities. Students studying to become future physics teachers (Group 1), music teachers (Group 2), and Ukrainian

language teachers (Group 3) were involved in the study. The fourth-year students of Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Berdyansk State Pedagogical University, Vinnytsia National Agrarian University. The limitation of the students' year of study is related to the possibility of their preparing for the research activities. This is related to the admission of students to obtain the educational and qualification levels of Specialists, Masters. The sampling of respondents provided for a test for determining the level of knowledge. Groups of students with a sufficient and high level of knowledge were involved in the study. Limitations in the level of knowledge are aimed at students' understanding of the specifics of their professional activities. It is also important to be able to freely vary terminology, which would allow students to be actively involved in solving problem situations. In a sample of 209 students, eight were excluded from possible participation in the research programme because they did not meet the specified norms. So, the study involved 201 respondents, who were divided into groups 67 each according to their specialization.

Approach

The ways of applying problem-based learning for the development of higher school students' research activities were elaborated using the general theoretical methods of synthesis and comparison (Diachenko et al., 2022). This approach enabled the authors to determine the peculiarities of problem-based learning, possible advantages and disadvantages that influenced the development of specific mechanisms. It was planned to implement situational tasks as the basis of problem-based learning. This contributed to forming a separate problem, the definition of tools for its solution and specific mechanisms for achieving results. Students took part in solving problems independently and in groups, which became possible by using role-playing games. The creation of situational models also involved the use of digital applications (Padlet, Slides), which were selected experimentally by studying the relevant interactive tools. Digital technologies were used to present the material, which involved the creation of appropriate models.

The basic, productive, creative levels of students' knowledge were determined by comparing research results before the training and after five months of training. The results were calculated using the performance indicator developed by the authors (Equation 1). The authors assumed that the basic level provided for determining students' theoretical knowledge. The productive level considered the students' practical knowledge, which reflected professional development. The creative level was associated with students' use of a creative approach during research training.

$$r_o = \frac{l_a}{s_t} \times c_a \qquad (1)$$

l_a – reflects the level of students' necessary level of theoretical / practical / creative knowledge in the specified period of time;

s_t – the total score that could be achieved in the specified time period;

c_a – a criterion that reflects the number of attended classes (equals 1 if students attended 97%-100% of classes);

The level of students' skills was also determined by comparing their results with the initial ones. The results were obtained through the active involvement of all students in problem-based learning. The process involved determining the approaches used by students to solve problems, the accuracy of information use, and the depth of immersion in a particular topic. The skills were determined among all students according to high, medium, and low levels. The results of the number of students who achieved the appropriate level of knowledge were presented as a percentage.

The development of specific projects by students related to the solution of the set tasks because of practice teaching. To develop projects, the students were required to build an effective model for first-year students to study a separate topic. The students of Group 1 had to develop an effective model for learning the basics of kinematics. The students of Group 2 were given the task of developing a model for achieving emotionality in vocal performance. The students of Group 3 had to develop a model for preparation of syntactic parsing of sentences. The models were developed among students in groups (8 students each), which involved the assessment of each model. The results were obtained based on the calculation of the effectiveness ratio developed by the authors (Equation 2).

$$k_p = (q_c + q_i) \times \frac{1}{(1+a_{t+p})^t}, \qquad (2)$$

q_c – a score for the quality of creating a situational model for solving a problem situation; q_i – a score that reflects the quality of tools proposed by students for solving a problem situation; a_{t+p} – a score that reflects the level of correspondence between theoretical and practical laws for solving a problem situation; t – a ratio that reflects the time required to create a situational model by students (if students created a project within the specified time of one month, the ratio equals 1).

Data analysis

Statistical processing of the research results was based on the calculation of J. Phillips coefficient (Kumaş & Kan, 2022). Using the calculation, the students were able to confirm the obtained results regarding the performance of students of different groups. The calculation of J. Phillips coefficient also provided the possibility of comparing the results of three groups of students during their creation of specific projects. Phillips coefficient enables comparing the results between several indicators. If its value approaches 1, the indicators are correlated (Equation 3).

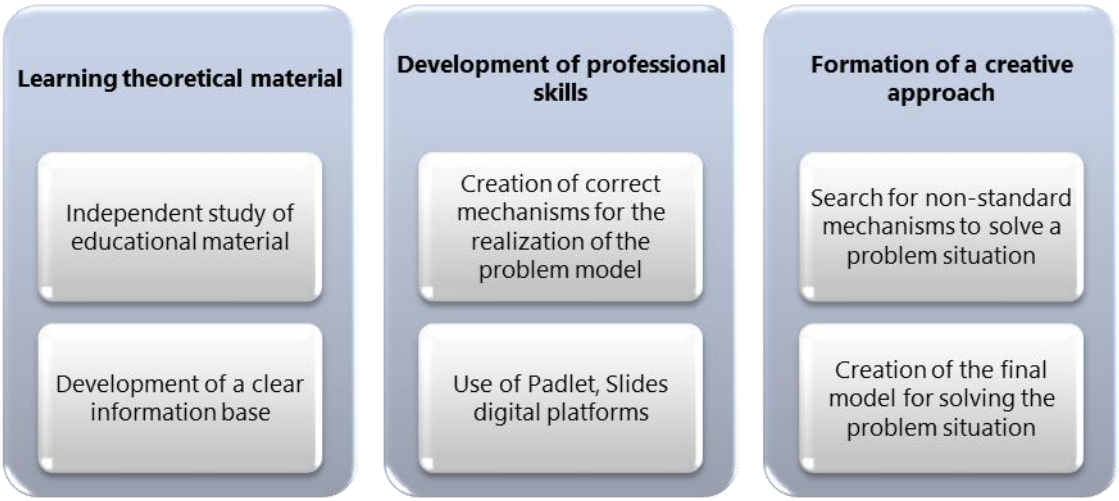
$$p = 1 - \frac{6\sum d^2}{n^3 - n} \quad (3)$$

d – the difference in rank indicators, which reflect the value of one number relative to others (related to the calculation of average deviations); n – the total number of calculated parameters.

RESULTS AND DISCUSSION

Developing the readiness of higher school students for research activities involved the authors' creation of ways to implement the educational process. The main directions of the scientific research process were problem-based learning. For the possibility of its implementation, the authors planned to focus on the development of theoretical, professional, and creative skills (Figure 1).

Figure 1. The ways of implementing problem-based learning for the development of research activities



Note. Authors' development

During the research activities, it was planned to ensure the relationship between the assimilation of theoretical material, the development of professional skills, and the implementation of a creative approach. It became possible due to creating a problem situation corresponding to a particular professional activity. The study of theoretical material related to the independent deeper study of information that expands the perception of previously learned topics. Students had to apply previously learned rules, which became the basis for building a model for solving a problem situation to learn theoretical information. The creation of the model is aimed at the development of professional skills using a creative approach.

Developing practical skills involved the creation of correct mechanisms for the high-quality implementation of the developed model. At the same time, it was necessary to prepare the information base and use digital technologies. Padlet and Slides applications were used to create the problem model, which presented materials in the most receptive form. The students had to focus on a creative approach, which contributed to the search for mechanisms to solve a problem situation in a non-standard way. A non-standard approach should be supported by appropriate theoretical knowledge, excluding possible contradictions between the solution of the set practical problems and theoretical possibilities.

The preparation of the problem model should be aimed at solving specific professional problems. The teachers exercised control of the created models while preparing for research activities. Knowledge correction was implemented with the help of additional questions by teachers, which contributed to forming the correct professional point of view among students. This allows students to develop thinking, understand the correct sequence in solving tasks, and the accuracy of

working with theoretical materials. Based on teachers' corrections, students can develop critical thinking, motivation for deeper assimilation of information and free variation of professional hypotheses.

The level of professional training was determined based on the application of problem-based learning approaches among students. Students' training envisaged the creative, basic, and productive level of students' knowledge. The results were obtained after 5 months of continuous training (Table 1).

Table 1. The level of students' knowledge achieved during problem-based learning

Level of knowledge	Group 1			Group 2			Group 3			p
	r_o	M	SD	r_o	M	SD	r_o	M	SD	
Basic level (theoretical knowledge)	0.95	39.8	7.6	0.92	36.4	8.0	0.94	37.2	7.9	0.811
Productive level (practical knowledge)	0.96	40.2	6.5	0.96	40.3	6.4	0.95	39.5	7.2	0.826
Creative level (creative knowledge)	0.90	34.2	8.2	0.95	40.1	6.7	0.97	40.1	6.4	0.743

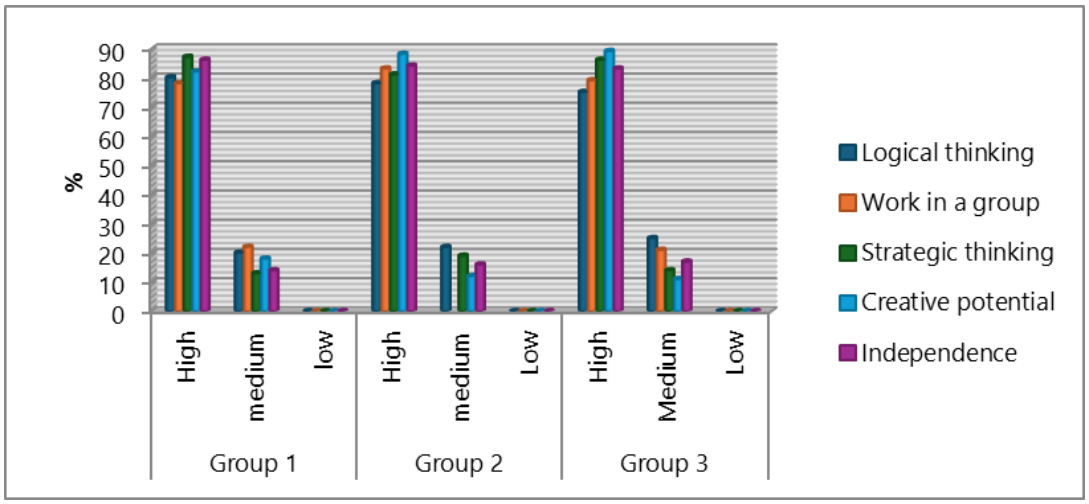
Note. Authors' development with the research data

Our study shows that the ratio of basic knowledge among the students of the three groups was almost the same ratio. The basic level of knowledge required fluency in theoretical information that was used during the development of situational models. At the same time, students were able to provide an understanding of a particular problem, focusing on professional subjects based on the acquired basic level of knowledge. The assimilation of theoretical material motivated to solve the tasks. The basic level of knowledge contributed to the correct understanding of the approaches to formulating the research problem during the development of the model.

The productive level provided for the development of students' professional practical knowledge. The results showed that students harmoniously used theoretical knowledge, which contributed to the practical solution of the problems. The interpretation of the results showed that students' achievement of a high productive level was connected with ensuring students' purposefulness and initiative. This contributed to developing educational and research models associated with a thorough analysis of a separate topic. The assimilation of theoretical rules influenced the possibility of using effective mechanisms to implement the tasks.

Students of Group 3 (Ukrainian language) and Group 2 (Music art) showed the greatest creativity in learning. Because during training, they used innovative approaches to creating models that were based on solving a separate situational problem. In this way, students learned educational topics more deeply and developed professional competence. Students of Group 1 (Physics) also achieved a high creative level, but they used a more academic approach than a creative one. The skills that the students of three groups developed in the educational process were determined. The results were obtained among all students, which involved rating a particular skill as high, medium, or low. Levels of skill formation were presented using percentage ratios (Figure 2).

Figure 2. The level of skills achieved by students of different groups



Note. Authors' development with the research data

The proposed method of problem-based learning had a positive impact on the development of various student skills that ensured professional competence. It was found that the students of Group 1 had the following most pronounced skills: logical and strategic thinking, development of independence. Based on strategic thinking, students could predict the effectiveness of the created models for solving problem situations. Strategic thinking influenced the clarity of setting tasks for the realization of a particular goal. Logical thinking influenced the consistency and validity of the use of theoretical materials. Developing students' independence contributed to a deeper analysis of educational materials, which influenced the search for favourable model creation mechanisms. The most pronounced skills among the students of Group 2 were group work and creative potential. Working in a group contributed to the search for the most optimal solutions to a problem situation. The process reflected the provision of quality communication between students, which influenced the possibility of taking into account the opinion of others and expressing one's own opinion. The development of creative potential involved the use of creative solutions in fulfilling tasks. Students of Group 3 developed strategic thinking and creative potential at the highest level, which enhanced their professional development.

At the last stage of the research, it was envisaged that the quality of the projects created by the students be determined. The quality assessment included their realism and compliance with existing theoretical laws. Projects that could be used when solving real practical tasks were considered high-quality (Table 2).

Table 2. Quality of projects created by students to solve problem situations

Group number	k_p	M	SD	p
Group 1	1.49	40.6	8.3	0.871
Group 2	1.57	41.3	7.5	
Group 3	1.52	41.1	7.4	

Note. Authors' development with the research data

Students achieved high results in creating practical projects that were aimed at fulfilling specific tasks. Our study shows that students of Group 2 have formed the most effective approaches to ensuring the quality of vocal performance, which excludes low performance. The students preserved the logical sequence of the development of emotional vocal data, methods of voice correction in problematic moments. The students also considered the peculiarities of different voices (alto, soprano), which ensured the development of more effective models. The projects created by the students of Group 1 were also effective, and they involved the development of a curriculum for learning the basics of kinematics. The students examined formulas, theoretical material and examples of using knowledge in practice (in various fields). However, the students did not achieve a high level of creativity in developing a model to define kinematic concepts because of the complexity of the presented material.

Students of Group 3 created a model for preparing syntactic parsing of sentences. The students considered various topics, including features of syntactic norms and possible syntactic errors. The students also pondered complex and simple cases of syntactic agreement. However, the students had minor gaps in explaining the rules of syntactic control and agreement.

Discussion

Problem-based learning improves students' ability to solve various problems and develop their activities. The implementation of problem-based learning involved the creation of initial organizational plans, the selection of appropriate tasks, which were aimed at practical application and increasing efficiency. Learning design pathways were implemented based on the Plomp interactive model, which allowed 85% of students to achieve a pass score (Yendra et al., 2023). Problem-based learning should involve the use of mixed approaches, which will increase students' self-efficacy. STEM approaches can be used as blended learning, which not only improves the educational process, but also eliminates knowledge gaps. Interaction between students and teachers promotes growing interest in learning and understanding educational topics (Su, 2022). Pedagogical educational online platforms contribute to meeting the students' needs in the educational process. The online platforms can be used due to the assessment of pedagogical parameters, as well as used literature for the formation of educational programmes. The EDAS, COPRAS interactive models are used to make informed decisions about the effectiveness of a particular online platform. Such an approach not only makes students interested in the learning process but also allows them to fulfil the set problematic tasks (Al-Gerafi et al., 2024). The examples of these studied articles show the comprehensive possibility of implementing the educational process using digital technologies and STEM approaches. However, they reflect problem-based learning only as an addition to the main process. In our article, we have developed ways of problem-based learning aimed at students achieving high results due to active interaction.

An innovative pedagogical approach in the format of a virtual flipped classroom can be used to implement post-graduate studies. This approach affects the achievement of active learning by students, developing research approaches (Rudyshyn et al., 2021). The students positively evaluated this approach to learning using the Interface Student Experience

Questionnaire, which allowed them to achieve a high level of research competence (Peng et al., 2023). Based on Peng et al. (2023), deeper knowledge is needed regarding how to adapt the virtual flipped classroom to the students' level of knowledge. The development of students' information competence is possible due to active learning. Active learning can be ensured by applying student information search approaches, ensuring students' interaction with each other. It should be coordinated with the curriculum and focused on increasing students' competence (Caetano et al., 2022). Selected learning strategies are related to academic performance. Based on the students' performance, it was established that the highest results were obtained due to the use of the deep learning strategy. On the other hand, superficial learning had an impact on students' achievement of lower results. Problem-based learning makes it possible to ensure the depth of information perception based on the use of modern technologies. It should be considered that the choice of numerical technologies should be aimed at ensuring the activity of students in the educational process (Saqr et al., 2023). The published works describe problem-based learning from the perspective of active students' involvement in the educational process. Our article provided an analysis of the effectiveness of the knowledge of students of different groups at the basic, productive, and creative levels. Also, the skills formed by students for the possibility of implementing scientific and research activities were determined. This made it possible to approach the solution of research problems more deeply.

The use of problem-based learning for students studying computer science, physics, biology, chemistry, philosophy, media communication, and psychology has been found to improve the research experience. The combination of educational conditions should involve the creation of critical courses to stimulate the study of information, expanding the range of perception of academic subjects (Delogu et al., 2023). Alternative learning can consist in creating problem-based learning. Constant communication with students made it possible to achieve high success and improve educational competencies. Oriented learning helps pay attention to each student, improving their ability to demonstrate their skills (Kumaş, 2023). Fulfilling complex tasks requires the creation of an appropriate learning model that uses mixed approaches (online and offline approaches). This ensures problem-oriented activities, focusing on academic sustainability and the possibility of developing students' professional abilities. The process has the effect of increasing students' efficiency and confidence (Fitriani et al., 2023). During training, it is necessary to focus on developing flexible thinking among students, which will contribute to solving the set problems. Educational materials can be presented upon solving various problems, which will contribute to obtaining useful knowledge (Riyanto et al., 2023).

A comparison of published articles with our research made it possible to identify several differences and gaps in already published works. Existing works have studied the positive impact of problem-based learning on students' professional development. Emphasis was also placed on the possibility of developing scientific research activities using similar approaches – alternative, interactive, active learning- related to problem-based learning. In our study, specific ways were developed to implement problem-based learning to develop students' research activities. Digital technologies were also used during the development of learning trajectories, but they were not the basis of learning, they only contributed to creating a problematic model. Our work also studied the positive impact of problem-based learning among students of different groups who studied physics, music, and the Ukrainian language. The work also determined the quality of students' creation of problem models based on specific tasks.

Limitations and recommendations

In this article, a comprehensive study of the peculiarities of problem-based learning was carried out. However, further research may be needed to expand practical effectiveness, especially about different levels of student preparation. The research limitations are related to the respondents' year of study – the involvement of only fourth-year students. In further studies, the authors plan to compare the effectiveness of research activities between students of the second and third years. Such an approach will allow a more in-depth identification of the benefits of problem-based learning and problems that may arise for students of different years of study.

Our study demonstrates that the effectiveness of developing students' professional competence depends on the chosen approach. One of the effective methods is problem-based learning, as it promotes active students' participation. Problem-based learning makes it possible for students to study real problem situations and their solution mechanisms, affecting qualified personnel's training. So, students can implement not only research projects but also fulfil complex professional tasks.

FINAL REMARKS

Recent observations show gaps in studying the specifics of problem-based learning. Our findings provide convincing evidence of the need to involve problem-based learning in the educational process. During the problem-based training, the authors proposed learning theoretical material, developing professional skills, and the creative approach based on solving problem situations. The Padlet, slides digital applications were used to create models in the educational process.

Completion of problem-based training for five months made yielded high results among students of different groups. The basic level of knowledge (theoretical knowledge) at the highest level was achieved among students of Group 1 who were studying to be future physics teachers (0.95). The students of Groups 2 (0.96) and Group 3 (0.96) achieved higher results at the productive level, which involved determining the practical level of knowledge. Students of Group 2 studied to become future music teachers, Group 3 — to become future Ukrainian language teachers. The creative level, which involved the use of a creative approach by students, was achieved at a higher level by the students of Group 3 (0.97).

It was established that practical training had a positive effect on the development of students' logical and strategic thinking, creative potential, independence, and teamwork. The development of these skills influenced the creation of high-quality project models among students, which were aimed at solving problematic tasks. The practical significance of the work lies in the demonstration of more stable mechanisms of formation of scientific and research productivity of students of different groups during their studies. Research perspectives can be aimed at comparing the effectiveness of problem-based learning for students of different courses.

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