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ЖАРАТЫЛЫСТАНУ-МАТЕМАТИКАЛЫҚ БІЛІМ ЖӘНЕ ОҚЫТУ ТЕХНОЛОГИЯСЫ
ЕСТЕСТВЕННО-МАТЕМАТИЧЕСКОЕ ОБРАЗОВАНИЕ И ТЕХНОЛОГИЯ ПРЕПОДАВАНИЯ

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FORMATION OF PRACTICAL PROFESSIONAL SKILLS OF STUDENTS IN POWER ENGINEERING AND AUTOMATION THROUGH THE INTEGRATION OF PHYSICS WITH CORE ENGINEERING DISCIPLINES

The preparation of specialists in power engineering and automation requires learning formats that support the formation of practical professional skills applicable to engineering contexts. Physics in technical higher education is often delivered as a largely theoretical course, which complicates the transfer of fundamental concepts to professional tasks. This paper presents a methodological model for integrating physics with core engineering disciplines based on curriculum and syllabus analysis (mandatory first–second year courses, 2022–2025) and the design of professionally oriented learning tasks. The proposed approach operationalizes integration through a skill-focused mapping that links structured physics concepts to engineering applications, types of integrated activities, and observable skill outcomes. The paper illustrates the integration procedure with a sample transformation of traditional physics problems into interdisciplinary, decision-oriented tasks. The results are methodological and analytical in nature and do not include empirical validation through a pedagogical experiment. The proposed framework may be used for curriculum-level coordination of physics and engineering modules in technical higher education and vocational training in Kazakhstan.
Keywords: physics education; interdisciplinary integration; power engineering education; automation training; professional skills; practice-oriented learning.

MAIN PROVISIONS

The preparation of engineers in the modern world increasingly demands educational models that go beyond the transfer of theoretical knowledge. Students are expected to demonstrate readiness for professional action — the ability to analyze situations, apply physical and engineering principles, and make justified decisions under real-world constraints. This requirement is especially relevant for power engineering and automation programs, where foundational sciences and professional disciplines must function as an integrated system rather than separate academic subjects. The present study addresses this challenge by developing a structured methodology for integrating physics with core engineering disciplines in Kazakhstan's technical higher education.

The scientific basis for this approach draws on classical theories of curriculum design, including Bruner's concept of structured knowledge, Taba's sequencing principles, and Biggs's constructive alignment. These frameworks converge on the idea that education achieves professional results when content, activities, and assessment are deliberately organized around observable competencies. Complementing these perspectives, contemporary research in STEM education — including studies conducted in Kazakhstan — confirms that interdisciplinary integration positively influences student

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engagement, problem-solving skills, and professional readiness.

INTRODUCTION

The training of specialists in power engineering and automation in Kazakhstan is increasingly oriented toward practice-based learning outcomes, where graduates are expected to demonstrate not only theoretical knowledge but also the ability to apply it in real professional contexts [1]. These requirements are reflected in national regulatory documents, including professional standards of the Republic of Kazakhstan, which define qualification levels through specific labor functions, skills, and types of professional activity related to the operation, maintenance, and diagnostics of electrical and power equipment.

At the same time, the design of engineering education programs is influenced by the principles of the European Higher Education Area, where learning outcomes are described through integrated categories of knowledge, skills, and competencies. The Dublin Descriptors emphasize graduates' ability to apply knowledge, solve professional problems, and make justified judgments in their field, rather than merely reproduce theoretical content [2].

Physics plays a fundamental role in the preparation of future power engineers and automation specialists, as it forms the scientific basis for understanding electromagnetic processes, energy conversion, electrical measurements, and the operation of technical systems. However, in many engineering curricula physics is still taught as a predominantly theoretical discipline, with limited methodological alignment with core engineering subjects. This makes it difficult for students to translate theory into practice. When faced with applied tasks — like interpreting data or explaining how a system works — students often encounter significant difficulty. This highlights a fundamental contradiction: professional standards require well-rounded engineers, yet curricula frequently treat physics and engineering as completely disconnected disciplines.

Kazakhstan's pedagogical research includes studies addressing interdisciplinary connections between physics and profile disciplines. Available works, however, are often oriented toward general didactics or individual instructional techniques rather than offering a structured methodology targeted specifically at power engineering and automation programs with clear mapping between physics content, engineering applications, and measurable professional skills [3].

The limited number of studies that systematically describe methods for integrating physics with core engineering disciplines in the context of power engineering and automation indicates an unresolved methodological problem in national higher education practice. This gap reduces the effectiveness of professional skill formation and complicates the alignment of physics education with employer and qualification requirements.

Therefore, the relevance of this study lies in the need to develop and substantiate a methodology for integrating physics with core engineering disciplines aimed at forming practical professional skills of students in power engineering and automation programs. The purpose of this article is to propose and justify such a methodology based on the alignment of physics content with professional tasks, interdisciplinary coordination of courses, and the use of practice-oriented learning and assessment tools.

MATERIALS AND METHODS

The study was conducted using a qualitative educational design focused on curriculum and syllabus analysis combined with methodological modeling. This approach was chosen to examine how practical professional skills in power engineering and automation are formed through the integration of physics with core engineering disciplines. The design is consistent with experiential learning theory, which views learning as a process in which knowledge is constructed through purposeful activity and reflection on experience [4].

The empirical base of the study consisted of official syllabi and working programs of mandatory disciplines taught in the first and second years of technical bachelor's degree programs related to

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power engineering, electrical engineering, and automation. The analysis was based on educational documentation from three technical universities in Central Kazakhstan: Karaganda Technical University named after Abylkas Saginov; Karaganda Industrial University; and L.N. Gumilyov Eurasian National University. The document corpus covered the period 2022–2025.

The research procedure consisted of four successive stages.

Stage 1. Document selection and structuring. Physics and engineering syllabi were collected and systematized into two groups. For each syllabus, the following elements were extracted: stated learning outcomes, thematic structure, laboratory and practical work descriptions, typical assignments, and assessment methods.

Stage 2. Qualitative content analysis. A qualitative content analysis was conducted to identify physics topics with direct professional relevance (electric circuits, electromagnetic phenomena, energy conversion, measurement principles) and to determine how these topics are subsequently used in engineering disciplines.

Stage 3. Interdisciplinary mapping. Based on the results of content analysis, an interdisciplinary mapping was performed (physics topic → engineering discipline → type of professional task), making it possible to identify gaps where physics knowledge is required in engineering practice but is not methodologically supported at the physics course level.

Stage 4. Development of skill indicators. To operationalize practical professional skills, a system of performance indicators was introduced, adapted from outcomes-based assessment approaches used in engineering accreditation [5, 6]. The indicators included: identification of relevant physical principles in an engineering task; correctness of calculations and interpretation of physical parameters; competent use of measuring instruments; and justification of technical decisions under practical constraints.

RESULTS

Theoretical Framework of Physics–Engineering Integration

The theoretical framework of this study is grounded in interdisciplinary integration as a pedagogically justified approach to enhancing the meaningfulness and applicability of learning in engineering education. A foundational cognitive basis is provided by Jerome Bruner's concept of structured knowledge: meaningful learning occurs when students grasp the underlying principles that organize a discipline [7]. The cognitive perspective of structured knowledge is methodologically extended by the theory of constructive alignment, proposed by Biggs and Tang, which requires that intended learning outcomes, teaching and learning activities, and assessment tasks are coherently connected [8].

From a curriculum design perspective, the integration of physics with professional disciplines is supported by Hilda Taba's emphasis on logical sequencing and functional relevance of educational content [9]. In modern higher education, this principle is increasingly realized through blended learning models, where sequencing is achieved through the distribution of learning activities across modalities — lectures, online modules, virtual labs, and applied projects [10].

Thus, the theoretical framework combines classical theories of cognitive learning and curriculum design with contemporary perspectives on constructive alignment and blended learning. It conceptualizes the integration of physics with core engineering disciplines as a theoretically grounded, methodologically structured, and technologically compatible approach, operationalized through the skill-focused mapping presented in Table 1.

Methodology of Integrating Physics with Core Engineering Disciplines

The proposed methodology is based on the principle of practical relevance and professional orientation of learning content. Key sections of physics — particularly electricity and magnetism, electromechanical phenomena, energy conversion, and measurement principles — are correlated with corresponding topics in electrical engineering, electronics, electrical measurements, and automation systems. This alignment allows students to encounter physical concepts in a professional context.

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Following Taba's principle of sequencing, physics content was organized in a progression reflecting its functional use in engineering practice. In accordance with Biggs's concept of constructive alignment, each physics concept was linked to a specific type of learning activity and an observable professional skill. This alignment is explicitly presented in Table 1.

Table 1 — Alignment of Physics Topics, Engineering Disciplines, and Professional Skills

Physics concept (structured knowledge)	**Core engineering discipline**	**Professionally oriented learning activity**	**Observable learning outcome / professional skill**
Electric circuits and basic laws (Ohm's law, Kirchhoff's laws)	Electrical Engineering	Solving applied circuit problems with parameter justification	Ability to analyze electrical circuits and calculate operating parameters under given constraints
Electromagnetic fields and induction	Electrical Machines and Apparatus	Laboratory investigation of electromagnetic processes in machines	Ability to interpret electromagnetic phenomena in electrical equipment operation
Physical principles of measurement and uncertainty	Electrical Measurements	Instrument-based laboratory work with data analysis	Ability to use measuring devices and interpret measurement results with consideration of errors
Energy conversion and efficiency	Power Systems	Context-based case analysis of power system operation	Ability to evaluate energy efficiency and operating modes of power systems
Physical foundations of automation (signals, feedback, dynamics)	Automation and Control Systems	Integrated practical tasks involving automated systems	Ability to analyze parameters and functioning of basic automated systems

An important methodological principle underlying this approach is contextual learning. According to Brown, Collins, and Duguid, knowledge is inseparable from the context in which it is learned, and situations co-produce knowledge through activity [11]. In this study, contextualization is achieved by embedding physics problems and laboratory tasks into engineering-related situations that reflect real professional practice.

The methodology emphasizes the use of integrated practical tasks as a key instrument for linking physics content with professional engineering activity. Such tasks require students to apply physical laws and formulas when solving engineering-oriented problems, including the analysis of electrical circuits, interpretation of measurement results, and evaluation of operating parameters of technical systems. A representative example of such task transformation is presented in Table 2.

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Table 2 — Sample physics task before and after interdisciplinary integration

Aspect	Traditional physics task (before integration)	Integrated physics – engineering task (after integration)
Task context	An electrical circuit consisting of a resistor connected to a DC voltage source	A section of an electrical supply circuit used in a low-voltage industrial installation
Task statement	*A resistor with resistance R = 10 Ω is connected to a voltage source U = 20 V. Determine the current in the circuit.*	*A low-voltage power supply line feeds a technological unit through a resistive load with R = 10 Ω at U = 20 V. Determine the operating current and assess whether the conductor cross-section (rated for 3 A) is sufficient for safe operation.*
Required physics knowledge	Ohm's law	Ohm's law, interpretation of current values in practical operation
Student action	Substitution into formula and numerical calculation	Calculation of current, interpretation of the result in terms of operational limits and safety
Expected result	I = 2 A	I = 2 A; conclusion that the operating current does not exceed the permissible limit and the conductor cross-section is adequate
Formed skill	Ability to apply a physical formula	Ability to apply physical laws to justify an engineering decision under practical constraints

The integrated version retains the same physical core but introduces a professional layer by incorporating operational limits, safety considerations, and an explicit requirement to interpret results and justify a decision. This example illustrates the methodological principle underlying the proposed approach: physics knowledge is mobilized as a functional tool for engineering reasoning and decision-making in a realistic professional context.

To further illustrate the methodology, a second example focuses on diagnostic and measurement-based activities, demonstrating how physics laboratory work can be transformed into a professionally oriented diagnostic assignment.

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Table 3 — Sample diagnostic and measurement task before and after interdisciplinary integration

Aspect	Traditional physics laboratory task (before integration)	Integrated physics – engineering diagnostic task (after integration)
Task context	Measurement of electrical resistance using a voltmeter and ammeter	Diagnostic assessment of an electrical circuit section in an operating installation
Task statement	Measure the resistance of a conductor by recording voltage and current values and calculating R using Ohm's law.	Measure voltage and current in a circuit section supplying a load. Determine the actual resistance and assess whether the measured values indicate normal operation or possible contact degradation.
Required physics knowledge	Ohm's law; basic measurement principles	Ohm's law; measurement uncertainty; interpretation of deviations
Student action	Record readings; calculate resistance	Record readings; calculate resistance; analyze deviations from nominal values; formulate a diagnostic conclusion
Expected result	Numerical value of resistance	Resistance value with interpretation of measurement results and a conclusion about circuit condition
Formed professional skill	Ability to perform basic electrical measurements	Ability to use measurement data for diagnostic evaluation of electrical system condition

Unlike the traditional laboratory task, which focuses on obtaining a numerical result, the integrated version requires students to interpret measurement data in terms of system condition and operational reliability. Physics laboratory experiments are designed or modified to include elements of engineering analysis, such as working with technical documentation, performing measurements using professional instruments, and interpreting experimental data from an engineering perspective.

In addition to laboratory activities, the methodology incorporates problem-based learning elements. Students are presented with applied problem situations that simulate professional tasks in power engineering and automation, requiring an understanding of both physical principles and engineering constraints [12].

Figure 1 illustrates the structure of interdisciplinary integration between physics and core engineering disciplines aimed at the formation of practical professional skills.

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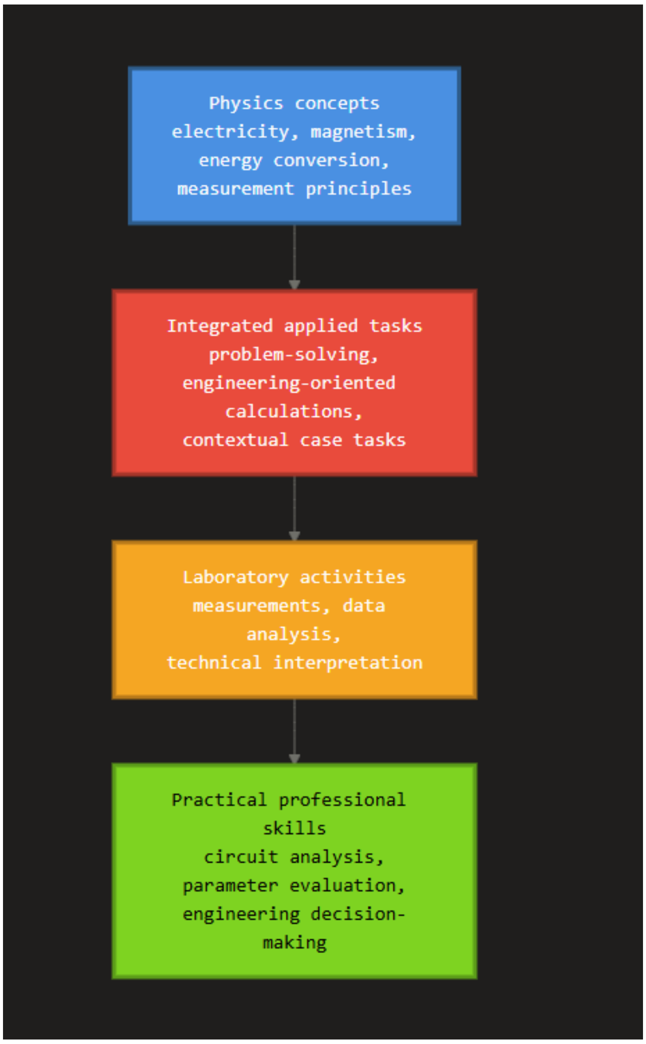

Figure 1 — Structure of interdisciplinary integration between physics and core engineering disciplines

DISCUSSION

The proposed methodology demonstrates a structured approach to integrating physics with core engineering disciplines in power engineering and automation programs. Its main strength lies in the explicit alignment between physics content, professionally oriented learning activities, and observable skill outcomes. By shifting the focus from isolated theoretical problem-solving to decision-oriented tasks embedded in engineering contexts, the methodology addresses a well-documented gap between fundamental science education and professional engineering practice.

At the same time, this study has several limitations that should be acknowledged. Most importantly, the proposed integration model has not yet been empirically validated through large-scale experimental implementation or longitudinal assessment of student performance. The conclusions are based on curriculum analysis and methodological modeling rather than on comparative learning outcome data. Future research should include pilot implementations of the integrated tasks, followed by quantitative and qualitative evaluation of their impact on students' professional skill development.

An important practical challenge identified in the study concerns the coordination of instructors teaching physics and core engineering disciplines. In the context of Kazakhstan's higher education system, where departments often function autonomously, informal coordination between individual instructors may be insufficient to ensure sustained integration across courses. To address this issue, the creation of interdisciplinary curriculum committees is proposed as a practical institutional mechanism, uniting physics and engineering instructors with program leaders to jointly map out the

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curriculum.

The proposed framework can be adapted for various technical disciplines. Its focus on constructive alignment — linking tasks to real-world skills — aligns with current accreditation requirements. Effective integration requires not only good teaching methods but also organizational coordination at the program level.

CONCLUSION

The purpose of the research — to substantiate a methodology for integrating physics with core engineering disciplines aimed at forming practical professional skills — has been achieved through curriculum analysis, theoretical justification, and methodological modeling.

The scientific novelty of the study lies not in proposing new physics content or additional interdisciplinary links as such, but in the methodology of structuring and aligning these links around skill formation. The proposed integration model introduces a skill-focused logic in which physics concepts are systematically mapped to engineering applications and further to observable professional skills, rather than being treated as self-contained learning outcomes.

The matrix presented in Table 1 differs fundamentally from conventional curriculum descriptions: it operationalizes the transformation by linking physics concepts to types of professionally oriented activities and clearly defined skill outcomes, making the integration process transparent and assessable.

The example of task transformation illustrates that integration does not require abandoning traditional physics problems but rather reformulating them to include engineering constraints, interpretive steps, and decision-oriented conclusions. In this way, physics knowledge is mobilized as a functional tool for engineering reasoning.

The proposed methodology can be applied and adapted in other technical education contexts where fundamental sciences support professional disciplines. Its effective implementation requires institutional conditions, including coordination between instructors and curriculum-level planning. Further research should focus on empirical validation of the methodology through pilot implementations and assessment of its impact on students' professional skill development.

REFERENCES

1 IEEE Education Society. Trends in engineering education research, IEEE Transactions on Education, 65 (4), 497–505 (2022).

2 Bologna Working Group on Qualifications Frameworks. A Framework for Qualifications of the European Higher Education Area (Copenhagen, 2005).

3 Mukamedenkyzy V., Moldabekova M., Fedorenko O., Asembaeva M. Integrated knowledge of the basic discipline "Physics" and profile disciplines as a means of implementing practice-oriented student learning, Recent Contributions to Physics, 2019(3), 92–99 (2019). https://doi.org/10.26577/RCPh-2019-i3-11

4 Kolb D. A. Experiential Learning: Experience as the Source of Learning and Development (Englewood Cliffs, NJ: Prentice Hall, 1984).

5 ABET. Criteria for Accrediting Engineering Programs (2025–2026) (Baltimore, MD: Accreditation Board for Engineering and Technology, 2025).

6 ASIIN. Subject-Specific Criteria for Electrical Engineering and Information Technology. Available at: https://www.asiin.de

7 Bruner J. S. The Process of Education (Cambridge, MA: Harvard University Press, 1960).

8 Biggs J., Tang C. Teaching for Quality Learning at University (4th ed.) (Maidenhead: Open University Press, 2011).

9 Taba H. Curriculum Development: Theory and Practice (New York: Harcourt, Brace & World, 1962).

10 Garrison D. R., Vaughan N. D. Blended Learning in Higher Education:

ISSN 2708-5295 (print), ISSN 3078-4948 (online)

Framework,Principles, and Guidelines (San Francisco: Jossey-Bass, 2008).

11 Brown J. S., Collins A., Duguid P. Situated cognition and the culture of learning, Educational Researcher, 18(1), 32–42 (1989).

12 Savery J. R. Overview of Problem-Based Learning, Interdisciplinary Journal of Problem-Based Learning, 1(1), 9–20 (2006).

13 Subramaniam K., Kautz C., Ross B. Ways of thinking in engineering design-based physics learning environments, Journal of Engineering Education, 113(2), 345–367 (2024).

14 Akeshova A., Nurgaliyeva G., Sarsembekova Z. Effects of integrated STEM approaches on students' cognitive and professional skills: A meta-analytic review, International Journal of STEM Education, 12(1), 44–59 (2025).

15 Zhumabay B., Tolkynbayeva A., Baikulova M. Mapping the Kazakhstani STEM education landscape: A review of national research, Bulletin of the National Academy of Sciences of the Republic of Kazakhstan, 3, 45–60 (2024).

Физиканы негізгі инженерлік пәндермен кіріктіру арқылы энергетика және автоматика мамандықтары студенттерінің практикалық кәсіби дағдыларын қалыптастыру

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Энергетика және автоматика саласындағы мамандарды даярлау студенттердің инженерлік контекстe қолданылатын практикалық кәсіби дағдыларын қалыптастыруды қамтамасыз ететін оқу форматтарын талап етеді. Техникалық жоғары оқу орындарында физика көбіне теориялық пән ретінде оқытылады, бұл іргелі ұғымдардың кәсіби міндеттерге ауысуын қиындатады. Бұл мақалада оқу жоспары мен силлабустарды талдауға (2022–2025 жж. міндетті 1–2 курс пәндері) және кәсіби бағдарланған оқу тапсырмаларын жобалауға негізделген физиканы негізгі инженерлік пәндермен кіріктірудің әдістемелік үлгісі ұсынылады. Ұсынылған тәсіл физикалық тұжырымдамаларды инженерлік қолданыстармен, кіріктірілген іс-әрекет түрлерімен және байқалатын дағды нәтижелерімен байланыстыратын дағды-бағдарлы картографиялау арқылы кіріктіруді іске асырады. Зерттеу нәтижелері әдістемелік және аналитикалық сипатта болып, педагогикалық эксперимент арқылы эмпирикалық тексеруді қамтымайды. Ұсынылған шеңбер Қазақстанның техникалық жоғары оқу орындары мен кәсіптік оқытуда физика мен инженерлік модульдерді оқу жоспары деңгейінде үйлестіру үшін пайдаланылуы мүмкін.

Кілт сөздер: физика білімі; пәнаралық кіріктіру; энергетика білімі; автоматика оқыту; кәсіби дағдылар; практикаға бағдарланған оқыту.

ӘДЕБИЕТТЕР ТІЗІМІ

1. IEEE Education Society. Trends in engineering education research, IEEE Transactions on Education, 65 (4), 497–505 (2022).
2. Bologna Working Group on Qualifications Frameworks. A Framework for Qualifications of the European Higher Education Area (Copenhagen, 2005).
3. Mukamedenkyzy V., Moldabekova M., Fedorenko O., Asembaeva M. Integrated knowledge of the basic discipline "Physics" and profile disciplines as a means of implementing practice-oriented student learning, Recent Contributions to Physics, 2019(3), 92–99 (2019). https://doi.org/10.26577/RCPh-2019-i3-11
4. Kolb D. A. Experiential Learning: Experience as the Source of Learning and Development (Englewood Cliffs, NJ: Prentice Hall, 1984).

ISSN 2708-5295 (print), ISSN 3078-4948 (online)

5. ABET. Criteria for Accrediting Engineering Programs (2025–2026) (Baltimore, MD: Accreditation Board for Engineering and Technology, 2025).

6. ASIIN. Subject-Specific Criteria for Electrical Engineering and Information Technology. Available at: https://www.asiin.de

7. Bruner J. S. The Process of Education (Cambridge, MA: Harvard University Press, 1960).

8. Biggs J., Tang C. Teaching for Quality Learning at University (4th ed.) (Maidenhead: Open University Press, 2011).

9. Taba H. Curriculum Development: Theory and Practice (New York: Harcourt, Brace & World, 1962).

10. Garrison D. R., Vaughan N. D. Blended Learning in Higher Education (San Francisco: Jossey-Bass, 2008).

11. Brown J. S., Collins A., Duguid P. Situated cognition and the culture of learning, Educational Researcher, 18(1), 32–42 (1989).

12. Savery J. R. Overview of Problem-Based Learning, Interdisciplinary Journal of Problem-Based Learning, 1(1), 9–20 (2006).

13. Subramaniam K., Kautz C., Ross B. Ways of thinking in engineering design-based physics learning environments, Journal of Engineering Education, 113(2), 345–367 (2024).

14. Akeshova A., Nurgaliyeva G., Sarsembekova Z. Effects of integrated STEM approaches on students' cognitive and professional skills: A meta-analytic review, International Journal of STEM Education, 12(1), 44–59 (2025).

15. Zhumabay B., Tolkynbayeva A., Baikulova M. Mapping the Kazakhstani STEM education landscape: A review of national research, Bulletin of the National Academy of Sciences of the Republic of Kazakhstan, 3, 45–60 (2024).

Формирование практических профессиональных навыков студентов специальностей энергетика и автоматика посредством интеграции физики с профильными инженерными дисциплинами

Дилмаханова М.М. [1], Абдикаримов Б.Ж. [1], Турсыматова О.И. [1], Аймырзаева А.Б. [1]

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Подготовка специалистов в области энергетики и автоматики требует форматов обучения, обеспечивающих формирование практических профессиональных навыков, применимых в инженерных контекстах. Физика в техническом высшем образовании нередко преподаётся преимущественно как теоретическая дисциплина, что затрудняет перенос фундаментальных понятий на профессиональные задачи. В данной статье представлена методологическая модель интеграции физики с профильными инженерными дисциплинами, основанная на анализе учебных планов и рабочих программ (обязательные дисциплины 1–2 курсов, 2022–2025 гг.) и разработке профессионально ориентированных учебных заданий. Предложенный подход операционализирует интеграцию посредством картографирования, ориентированного на формирование навыков, и связывает структурированные физические концепции с инженерными применениями, видами интегрированной деятельности и наблюдаемыми результатами формирования умений. Результаты исследования носят методологический и аналитический характер и не включают эмпирическую проверку посредством педагогического эксперимента. Предложенная модель может применяться для координации модулей физики и инженерных дисциплин на уровне учебного плана в техническом высшем образовании и профессиональном обучении Казахстана.

Ключевые слова: физическое образование; пространственная интеграция; инженерное образование в области энергетики; подготовка по автоматике; профессиональные навыки; практико-ориентированное обучение.

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СПИСОК ЛИТЕРАТУРЫ

1. IEEE Education Society. Trends in engineering education research, IEEE Transactions on Education, 65 (4), 497–505 (2022).
2. Bologna Working Group on Qualifications Frameworks. A Framework for Qualifications of the European Higher Education Area (Copenhagen, 2005).
3. Mukamedenkyzy V., Moldabekova M., Fedorenko O., Asembaeva M. Integrated knowledge of the basic discipline "Physics" and profile disciplines as a means of implementing practice-oriented student learning [Интегрированные знания базовой дисциплины «Физика» и профильных дисциплин как средство реализации практико-ориентированного обучения студентов], Recent Contributions to Physics, 2019(3), 92–99 (2019). https://doi.org/10.26577/RCPh-2019-i3-11 [in Russian]
4. Kolb D. A. Experiential Learning: Experience as the Source of Learning and Development (Englewood Cliffs, NJ: Prentice Hall, 1984).
5. ABET. Criteria for Accrediting Engineering Programs (2025–2026) (Baltimore, MD: Accreditation Board for Engineering and Technology, 2025).
6. ASIIN. Subject-Specific Criteria for Electrical Engineering and Information Technology. Available at: https://www.asiin.de
7. Bruner J. S. The Process of Education (Cambridge, MA: Harvard University Press, 1960).
8. Biggs J., Tang C. Teaching for Quality Learning at University (4th ed.) (Maidenhead: Open University Press, 2011).
9. Taba H. Curriculum Development: Theory and Practice (New York: Harcourt, Brace & World, 1962).
10. Garrison D. R., Vaughan N. D. Blended Learning in Higher Education (San Francisco: Jossey-Bass, 2008).
11. Brown J. S., Collins A., Duguid P. Situated cognition and the culture of learning, Educational Researcher, 18(1), 32–42 (1989).
12. Savery J. R. Overview of Problem-Based Learning, Interdisciplinary Journal of Problem-Based Learning, 1(1), 9–20 (2006).
13. Subramaniam K., Kautz C., Ross B. Ways of thinking in engineering design-based physics learning environments, Journal of Engineering Education, 113(2), 345–367 (2024).
14. Akeshova A., Nurgaliyeva G., Sarsembekova Z. Effects of integrated STEM approaches on students' cognitive and professional skills: A meta-analytic review, International Journal of STEM Education, 12(1), 44–59 (2025).
15. Zhumabay B., Tolkynbayeva A., Baikulova M. Mapping the Kazakhstani STEM education landscape: A review of national research, Bulletin of the National Academy of Sciences of the Republic of Kazakhstan, 3, 45–60 (2024).