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FEATURES OF CONSTRUCTION EDUCATION PROGRAMS IN KAZAKHSTAN

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Abstract. This paper examines the process of digitalization in construction education in Kazakhstan based on the analysis of 39 educational programs. The methodological framework included content analysis of educational programs and catalogs of elective courses from various universities, as well as a structural classification of disciplines into three blocks: constructive-technological, organizational-management, and digital. For quantitative interpretation of the data, statistical visualization methods were applied, including the construction of scatter plots and the analysis of discipline distribution. The results showed that a digital component is present in all analyzed programs, which confirms the systematic integration of digital elements into the training of future specialists. However, the analysis of teaching methods revealed that digital tools are used mainly as instruments of visualization and design, while their application in practice-oriented learning remains limited. Based on the findings, recommendations were formulated to expand digital practice-based training, integrate IoT and sensor technologies, and develop a unified educational resource that would consolidate digital elements into a coherent pedagogical system for preparing future builders. Such a resource will contribute not only to the formation of professional competencies but also to the development of transversal skills demanded by the modern labor market, including critical and creative thinking, digital literacy, collaboration, communication, and reflection.

Keywords: educational program, analysis, module, skills, discipline, digital platform, learning format, construction, recommendations

Introduction

In today's world, ensuring the quality of educational content is becoming a key factor in the successful digital transformation of the educational environment and effective digital management of the educational process [1]. High-quality content not only promotes knowledge acquisition but also fosters interest and motivation among students, which in turn affects academic achievements and acquired competencies. In this regard, studying the quality of educational material in the context of the digitalization of the educational process requires careful analysis.

Considering educational programs for training future builders, the main goal of which is to train specialists with professional competencies in the field of design, construction of buildings and structures for various purposes, engineering communications in cities and towns, as well as the inspection, reconstruction, and modernization of existing buildings and engineering infrastructure, an important step is the development of the content and scope of professional modules. In turn, studying best practices accumulated in both domestic and international educational environments provide a methodological basis for finding effective solutions [2]. Comparison with advanced experience makes it possible to determine which elements can be adapted and implemented in the specialist training system, and which require further development, considering local conditions.

In global educational practice, blended learning formats are becoming increasingly widespread, where virtual simulators [3], BIM technologies [4], and augmented and virtual reality tools [5], VR/AR [6], and sensors [7] are actively used alongside traditional lectures and practical work. This approach not only increases student engagement but also ensures practical learning [8]. Systematic analysis of existing construction-related educational programs at universities in Kazakhstan will reveal the structure of training and the content of programs. Based on the data obtained, solutions can be developed aimed at strengthening practical components through the introduction of digital tools.

The objectives of the presented research include systematization and quantitative analysis of the disciplines included in the curricula of construction programs, determining the level of representation of the digital component, and justifying the need to introduce practice-oriented digital platforms for training future engineers.

Background of Construction Education in Kazakhstan

The construction industry is a key component of Kazakhstan's economy and plays an important role in infrastructure development and socioeconomic development. According to the National Statistics Bureau of the Republic of Kazakhstan, the volume of construction work amounted to 4,934.1 billion tenge in 2020, increased to 5,530.7 billion tenge in 2021, and reached 6,304.3 billion tenge in 2022. In 2023, this indicator rose to 7,612.8 billion tenge, and in 2024 it exceeded 9 trillion tenge (Figure 1), indicating changes in the volume of construction work over the specified period [9].

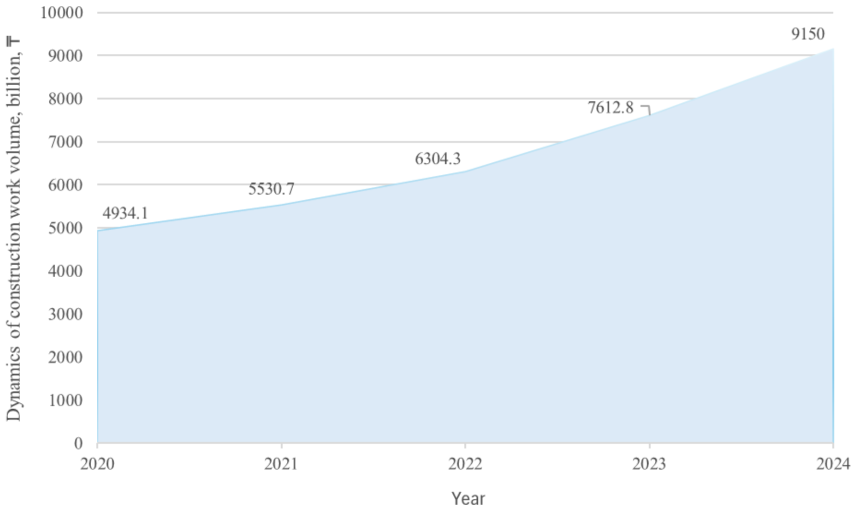

Figure 1 – Dynamics of construction work volume in the Republic of Kazakhstan

Engineering, manufacturing, and construction are among the major areas of higher education training in Kazakhstan. Over the past several academic years, these fields have accounted for approximately 16–17% of total student enrollment, consistently ranking among the leading areas of study (Table 1). Training in these fields is provided within the national higher education system at both national and regional universities.

Table 1. Dynamics of student distribution by field of study

Field of study	2022-2023 academic year, % [10]	2023-2024 academic year, % [11]	2024-2025 academic year, %[9]
Educational sciences	28.3	28.1	28.0
Engineering, manufacturing, and construction industries	16.8	16.5	16.4
Business, management, and law / Social sciences	17.1	14.0	14.5
Healthcare and social welfare	8.4	9.9	10.0
Information and communication technologies	8.1	9.5	9.5

The statistical information presented in Table 1 provides contextual background for the investigation of educational programs.

Methods and materials

The study employed both theoretical and empirical research methods. At the theoretical level:

– analysis and synthesis to examine the content of educational programs in construction;

– comparison to identify similarities and differences among educational programs of different universities;

– classification and systematization to group disciplines into three curriculum blocks;

– generalization to identify common core components of construction education programs.

These methods enabled the conceptualization of the structure of construction education programs. At the empirical level, the study involved the analysis of 39 educational programs in the field of construction. The following methods were applied:

– document analysis of curricula and elective course catalogs used as empirical data sources;

– content analysis to identify the distribution of disciplines across three curriculum blocks;

– quantitative analysis to determine the share of disciplines in each block and to compare educational programs;

– interpretation of results and formulation of a proposal for educational improvement.

Based on the described methodological approach, the empirical stage of the study focused on educational programs implemented at national and regional universities in Kazakhstan. Future builders are trained at several universities that offer educational programs in construction, engineering systems and networks, and related fields of engineering. These programs are designed to develop the basic and professional competencies that graduates need to design, construct, and operate facilities for various purposes. The educational program (EP) implemented by universities in the field of «Construction» is a regulatory and methodological document that reflects the regulatory and legal framework, the purpose and concept of training, the academic degree awarded, the field and types of professional activity of the graduate, as well as their functions. Table 2 lists the main universities in Kazakhstan that train personnel in the field of construction [12].

Table 2. Overview of Educational Programs in Kazakhstani Universities

№	Name of University	City	Educational program
1	ALT University	Almaty	6B07329 — Construction of industrial and civil buildings and structures 6B07347 Digital Construction in BIM Technology
2	Zhubanov University	Aktobe	6B07301 Construction

3	Atyrau University of oil and gas	Atyrau	6B07302 Industrial and Civil Construction
4	Baishev University	Aktobe	6B07311 Construction
5	East Kazakhstan technical university	Ust-Kamenogorsk	6B07305 Construction
6	L.N.Gumilyov Eurasian national university	Astana	6B07329 Design of Buildings and Structures 6B07330 Digital Design in Construction 6B07352 Engineering Systems and Networks
7	Ekibastuz technical and engineering institute named after the academician K.Satpayev	Ekibastuz	6B07310 Construction
8	Zhezkazgan University named after O. A. Baikonurov	Zhezkazgan	6B07301 Construction
9	Zhangir Khan University	Uralsk	6B07300 Construction Engineering
10	West University	Uralsk	6B07302 Construction
11	Kazakh automobile and road institute	Алматы	6B07308 Construction
12	Satbayev University	Алматы	6B07302 Civil Engineering 6B07306 Engineering Systems and Networks
13	KazNUVHI	Тараз	6B07303 Design of Buildings and Structures
14	QazIITU	Uralsk	6B07327 Construction
15	Karagandinsky Industrial University (KarIU)	Temirtau	6B07301 Industrial and Civil Construction
16	Abylkas Saginov Karaganda Technical university	Karaganda	6B07304 Construction 6B07307 Engineering Systems of Buildings and Structures
17	Caspian University	Almaty	6B07326 Construction
18	Yessenov University	Aktau	6B07303 Calculation and Design of Buildings and Houses
19	Ualikhanov University	Kokshetau	6B07303 Digital Design of Buildings and Structures
20	Open University of Kyzylorda	Kyzylorda	6B07365 Construction
21	Bolashak University	Kyzylorda	6B07301 Construction
22	Korkyt Ata Kyzylorda University	Kyzylorda	6B07365 Construction 6B07367 Engineering Systems and Networks
23	International Educational Corporation	Almaty	6B07321 Design of Buildings and Structures
24	International Transport-Humanitarian University	Almaty	6B07312 Construction
25	Regional Innovation University	Atyrau	6B07301 – Construction

26	Rudny Industrial University	Rudny	6B07303 Construction 6B07304 – Construction of Buildings and Structures
27	Manash Kozybayev North Kazakhstan University	Petropav-lovsk	6B07301 Construction
28	Toraighyrov University	Pavlodar	6B07302 Construction 6B07305 Engineering Systems and Net-works
29	Halyqtar dostyǵy	Shymkent	6B07320 Construction
30	Shakarim University	Semey	6B07302 Construction
31	M. Auezov South Kazakh-stan State University	Shymkent	6B07320 Construction

The structure of the program includes general education disciplines, basic and specialized modules, elective components, internships, and final assessment. For each group of disciplines, the number of teaching hours and forms of assessment are specified, which ensures the comparability of training at different universities. The competency profile map allows you to reflect on the compliance of learning outcomes with professional standards and determine the knowledge, skills, and abilities being formed. An additional tool is the catalog of elective disciplines, which allows students to familiarize themselves with a brief annotation of each discipline, its prerequisites, and possible educational trajectories.

The analysis considered all structural elements: basic and specialized modules that form fundamental and professional competencies; elective courses that give students the opportunity to individualize their educational trajectory; and alternative learning trajectories that arise depending on the chosen specialization. This approach made it possible not only to identify the main compulsory modules that ensure a uniform standard of training, but also to record differences in the variable parts of the programs, as well as to analyze the degree of academic freedom of students and determine areas of specialization within educational trajectories.

To ensure comparability, the disciplines were classified into three blocks:

– Technical block (TB) – includes design and technological cycles. This block is the core of engineering training, determining the professional competence of graduates.

– Organizational and management block (O) – reflects competencies related to construction process management, work organization, technical operation of buildings, reconstruction and reinforcement of structures, planning, and quality control. Despite its smaller quantitative representation compared to the technical block, it is this cycle that shapes the management skills of future specialists.

– The digital component (D) reflects the processes of digitalization in construction education and includes disciplines aimed at developing skills in working with modern digital tools and technologies. This component ensures that students develop the competencies necessary to work in the context of «smart construction», digital twins of buildings, and integration with Internet of Things technologies.

To analyze the teaching methods used in the implementation of educational programs in the field of construction were used: the content of educational programs, methodological materials of departments posted on university websites, descriptions of practical training for students (academic and industrial internships, course and diploma projects), university platforms open publications, and university reports on the implementation of digital forms of education.

Results

An analysis of the content of the EP showed that all universities are dominated by a constructive-technological block that provides fundamental engineering training. The organizational management block is represented in all programs to a lesser extent but plays a significant role in developing management competencies. There are characteristic common elements that form the so-called core or «basic standard» of training for future builders, which is a set of disciplines present in almost all educational programs, regardless of the university's regional affiliation, organizational and legal form, or profile.

The discipline of «Construction Materials» plays a central role in the training of builders. It is represented under various names at different universities, such as «Modern Construction Materials», «Chemistry of Construction Materials», and «Materials Science». Students learn about the classification, properties, and applications of materials, including traditional (concrete, metal, wood, brick) and innovative (composites, energy-efficient and environmentally friendly materials).

The presence of this discipline in all programs indicates that understanding the properties of building materials is a mandatory competency for future engineers. The next element of engineering training is the block of disciplines «Engineering Mechanics», which includes theoretical mechanics, strength of materials, and structural mechanics. This block develops the ability to analyze the action of forces, deformation, structural stability, and the reliability of construction objects. The analysis showed that this cycle is represented in all programs without exception. Moreover, in several universities, it is supplemented by courses in «Structural Dynamics» and «Probabilistic Methods of Calculation».

The «Building Structures» module is a mandatory part of all construction-related educational programs, which form the basis of professional training for civil engineers. Another universal element is the module combining the courses «Foundations and Basements», «Geotechnics», and «Soil Mechanics». Regardless of the wording, students study soil properties, methods of soil investigation, and principles of foundation design. This block is fundamental in Kazakhstan, where complex engineering and geological conditions are common, including earthquake-prone areas and collapsible soils. Therefore, the course is part of the «mandatory course» at all universities.

The block «Engineering Systems of Buildings and Structures» is a universal element. The presence of this block confirms that future engineers must know the internal engineering infrastructure of buildings, without which the full functioning of facilities is impossible. There are several other disciplines in the content of construction-related educational programs, including geodesy (under various names), which helps students develop skills in spatial referencing of objects and lays the foundation for accurate design solutions. The next discipline, Architecture of Civil and Industrial Buildings, forms a comprehensive understanding of design principles and combines the technical and artistic aspects of the profession.

Attention is also paid to courses on the reconstruction and inspection of buildings, which reflect the practice of modernizing and extending the life cycle of existing objects. This is complemented by courses on construction technology, which provide an understanding of the sequence of construction processes, as well as a course on construction machinery and equipment, which introduces students to modern means of mechanization and their role in ensuring construction efficiency.

From the 39 programs examined, Table 3 highlights two for comparison, including one with a strong emphasis on digital tools.

Table 3. List of disciplines with a digital component in ENU

№	*Educational program*	*Digital component*
1	6B07329 Design of Buildings and Structures at L. N. Gumilyov Eurasian National University [12]	Construction drafting with BIM and AI elements Applied programs and numerical methods BIM project management
2	6B07330 Digital Design in Construction at L. N. Gumilyov Eurasian National University [12]	Digital modeling of construction objects Construction drawing with BIM basics Fundamentals of theoretical mechanics with elements of digital modeling Engineering mechanics I with elements of digital modeling Engineering mechanics II with elements of digital modeling Engineering mechanics III with elements of digital modeling Applied mechanics using digital technologies Geoinformation technologies in construction Parametric design of civil buildings Parametric architecture of buildings Information modeling of engineering systems in buildings and structures

		Information technologies in engineering design systems Architectural modeling of industrial buildings Architectural modeling of energy-efficient buildings 3D modeling of buildings and structures BIM design and calculation of reinforced concrete structures Modeling in geotechnics Construction of bases and foundations with process digitization Modeling of reinforced concrete industrial buildings Digital design of light metal structures BIM project management (construction and operation) Seismic-resistant construction with elements of mathematical modeling Digital technologies for construction assessment Construction project management using digital solutions Digital modeling of construction production Information modeling of a construction object Special structure with elements of numerical modeling Design of construction objects and creation of a digital image

The degree of emphasis on the digital component in educational programs, according to Table 2, is presented in a coordinate map of shifts (Figure 2). The X axis reflects the difference between the digital component and the design and technology block (X = DC – DT). The design and technology block is taken as the base indicator, traditionally forming the basis of engineering and construction training. A shift to the right indicates programs where the digital component is more significant relative to DT. A shift to the left, on the contrary, indicates programs where the digital component is inferior to the design and technology block.

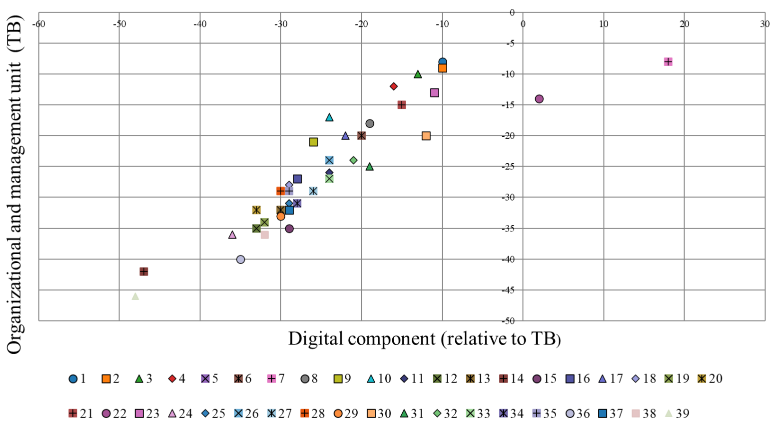

Figure 2 – Coordinate map of comparative analysis of educational programs

The Y-axis reflects the difference between the organizational and management block and KT (Y = OU – KT). An upward shift indicates a more prominent representation of the organizational block, while a downward shift indicates its lesser prominence compared to KT. Thus, the diagram represents a field of four quadrants:

– the upper right quadrant — programs with an increased share of both digital and organizational-management blocks.

– the lower right quadrant — programs in which the digital component occupies a relatively more significant place, with the dominance of the design and technological basis.

– upper left quadrant — programs with an organizational focus, but with a limited digital component.

– lower left quadrant — programs focused primarily on the structural and technological block, with less representation of both digital and organizational disciplines.

The analysis revealed the relative contribution of the digital component to the structure of educational programs. Most universities are located in the zone dominated by the design and technology block. At the same time, some universities, such as L. N. Gumilyov Eurasian National University and Sh. Ualikhanov Kokshetau University presents a significant shift towards the digital component. It should be emphasized that the educational programs of these universities are structured with a focus on digital training, which is directly reflected in their names («Digital Design of Buildings and Structures»). In addition, among the programs in which the digital component is secondary to the structural and technological component but is relatively more important than at other universities, Rudny Industrial University (EP 6B07303) stands out. Thus, the analysis allows us to identify not only the traditional core of training, but also the existence of individual programs characterized by a more pronounced digital component.

The identified features of educational programs form the basis for determining the methodological tools used in the educational process. The key teaching methods used in the Civil Engineering (Construction) educational program are traditional classroom methods (lectures, practical classes, laboratory work); practice-oriented forms (course and diploma projects, industrial practice); video lectures; research approaches (independent research work, student participation in conferences and mini-research projects); and innovative methods (interdisciplinary projects).

Thus, modern training for builders combines classical academic forms and partially digital elements. In recent years, universities have been practicing a blended learning format, in which traditional lectures are supplemented with video lectures. Organizing the educational process in a blended learning format involves several stages: identifying the characteristics of the student body, selecting the optimal model for a given audience, planning the educational process with an indication of the proportions of digital and traditional components, implementing the planned elements, evaluating and monitoring learning outcomes, and adjusting the educational process based on the results of monitoring.

An analysis of educational programs in the field of construction shows that, despite the presence of modern disciplines, the emphasis is mainly on theoretical training. To ensure that graduates are ready to meet the demands of the labor market, the educational process needs to be expanded to include practical training using digital resources such as simulators, AR/VR technologies, sensors, and remote interaction platforms.

The integration of such tools will allow students to develop not only professional competencies, but also key universal skills, including:

1. Creative thinking — the ability to find non-standard solutions and generate new ideas in learning.
2. Communication skills — the ability to interact effectively in an educational environment using digital tools.
3. Collaboration skills — the ability to work in a team and coordinate different points of view.
4. Digital literacy — confident use of digital tools, sensors, AR/VR technologies.
5. Self-management skills — setting goals, planning activities, and time management.
6. Problem-solving skills — analyzing technical situations and finding optimal solutions.
7. Emotional intelligence — understanding and managing one's own emotions and those of students.
8. Reflective skills — the ability to evaluate one's experience and adjust pedagogical activities.

Discussion

The development of professional competencies cannot be limited to lectures and online formats alone. A key role belongs to practical activities that allow students to apply theoretical knowledge, solve real engineering problems, and develop professional thinking skills [1–2]. Effective assessment of such work not only serves as a control function but also stimulates activity, supports motivation to learn, and develops critical thinking [3]. At the same time, digital modeling technologies, including virtual laboratories and simulators, are becoming an alternative to traditional practices. These tools make it possible to conduct classes without the need for physical equipment, ensure individualized learning, and reduce the cost of organizing experiments [7–9].

Global practice demonstrates the widespread adoption of digital platforms that combine traditional forms of training with virtual laboratories and simulations. Such platforms enable the development of practical skills, expand access to educational materials, and open new pedagogical opportunities.

The solution is an educational digital platform for future builders with a construction process simulation and integration with measuring devices via IoT. The pedagogical functions of the proposed digital platform and the competencies it helps to develop are summarized in Table 4.

Table 4. Pedagogical potential of the educational digital platform for future builders

Platform element	Pedagogical role	Skills developed
Simulations	Provide a safe and cost-effective environment for practicing construction processes and experiments	Critical thinking, problem-solving, and reflective skills
IoT & Sensors	Connect students to real-time measurements of soil, concrete, and other materials	Digital literacy, practical skills, and self-management
Cloud computing	Enable collaborative work, resource sharing, and remote access	Collaboration, communication, self-organization
Smart tools & digital resources	Support the learning process with interactive materials and professional software	Creativity, communication, and reflective learning

As shown in Table 1, the educational digital platform is not limited to providing technical training. Its modules have a clear pedagogical potential: stimulate the development of transversal skills, support student motivation, and ensure a closer link between theory and practice.

Global experience confirms that combining traditional education with virtual laboratories and cloud-based collaboration tools contributes to enhanced student engagement, motivation, and long-term professional readiness [10–12]. Thus, the proposed digital platform addresses both the engineering and pedagogical challenges of preparing market-ready specialists for the construction industry.

Conclusion

The analysis of 39 educational programs in construction has demonstrated that every curriculum already integrates a digital component, confirming the consistent introduction of digitalization into the field. The scope of this component varies from several courses to as many as 12, which reflects the diversity of approaches in construction education. At the same time, digital resources are applied in a fragmented manner, without a unified system that could consolidate them into a coherent pedagogical framework.

Based on the findings, the following recommendations are proposed:

– Strengthen the practice-oriented component by systematically expanding the use of digital laboratories, simulations, and virtual reality environments to bridge the gap between theory and practice.

– Integrate IoT and sensor-based tools into curricula to provide students with access to real-time measurements in soil mechanics, concrete testing, and building monitoring.

– Develop a unified digital educational platform that consolidates simulations, smart learning resources, and professional software into a coherent system accessible to both students and teachers.

– Ensure the development of transversal skills such as critical and creative thinking, collaboration, communication, digital literacy, self-management, and reflection, alongside professional competencies.

– Encourage interdisciplinary approaches, combining construction education with IT, data science, and management to better reflect modern industry requirements.

– Introduce systematic training for faculty members to ensure that educators are equipped to effectively use digital resources, AR/VR technologies, and IoT devices in their teaching.

Implementing these recommendations will improve graduates' readiness for the demands of the labor market and contribute to innovation and sustainable growth in the construction industry. It is important to note that the proposed educational digital platform is a practical tool for implementing these recommendations. By integrating simulations, IoT devices, and smart resources into a single digital space, the platform provides practice-oriented training, promotes the development of cross-cutting skills, and creates a sustainable foundation for the digital transformation of construction education in Kazakhstan.

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ҚАЗАҚСТАНДАҒЫ ҚҰРЫЛЫС САЛАСЫНДАҒЫ БІЛІМ БЕРУ БАҒДАРЛАМАЛАРЫНЫҢ ЕРЕКШЕЛІКТЕРІ

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Аңдатпа. Мақалада Қазақстандағы құрылыс білімін цифрландыру үдерісі 39 білім беру бағдарламасын талдау негізінде қарастырылады. Әдіснамалық базаға түрлі жоғары оқу орындарының білім беру бағдарламалары мен элективтік пәндер каталогтарының контент-талдауы, сондай-ақ пәндерді үш блок бойынша құрылымдық жіктеу енгізілді: конструктивті-технологиялық, ұйымдастырушылық-басқарушылық және цифрлық. Мәліметтерді сандық тұрғыда интерпретациялау үшін статистикалық визуализация әдістері қолданылды, оның ішінде шашырау диаграммаларын құру және пәндердің таралуын талдау. Нәтижелер көрсеткендей, цифрлық компонент барлық талданған бағдарламаларда бар және бұл болашақ мамандарды даярлауда цифрлық элементтердің жүйелі енгізілуін дәлелдейді. Алайда оқыту әдістемесін талдау барысында цифрлық құралдар негізінен визуализация мен жобалау құралы ретінде пайдаланылатыны, ал оларды тәжірибеге бағытталған сабақтарда қолдану шектеулі болып қалғаны анықталды. Алынған деректер негізінде цифрлық практикалық даярлауды кеңейту, IoT және сенсорлық технологияларды интеграциялау, сондай-ақ цифрлық элементтерді болашақ құрылысшыларды даярлаудың тұтас педагогикалық жүйесіне біріктіруге мүмкіндік беретін бірыңғай білім беру ресурсын құру бойынша ұсыныстар жасалды. Мұндай құрал кәсіби құзыреттерді, сыни және креативті ойлау, цифрлық сауаттылық, коллаборация, коммуникация және рефлексия дағдыларын қалыптастыруға ықпал етеді.

Тірек сөздер: білім беру бағдарламасы, талдау, модуль, дағдылар, пән, цифрлық платформа, оқыту форматы, ұсынымдар, құрылыс

ОСОБЕННОСТИ ОБРАЗОВАТЕЛЬНЫХ ПРОГРАММ В ОБЛАСТИ СТРОИТЕЛЬСТВА В КАЗАХСТАНЕ

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Аннотация. В статье рассматривается процесс цифровизации строительного образования в Казахстане на основе анализа 39 образовательных программ. Методологическая база включает контент-анализ образовательных программ различных вузов, а также структурную классификацию дисциплин по трём блокам: конструктивно-технологическому, организационно-управленческому и цифровому. Для количественной интерпретации данных применялись методы статистической визуализации, включая построение диаграмм рассеяния и анализ распределения дисциплин. Результаты показали, что цифровой компонент присутствует во всех проанализированных программах, что подтверждает системное внедрение цифровых элементов в подготовку будущих специалистов. Однако анализ методики обучения выявил, что цифровые инструменты используются преимущественно как средства визуализации и проектирования, тогда как их применение в практико-ориентированных занятиях остаётся ограниченным. На основе полученных данных сформулированы рекомендации по расширению цифровой практической подготовки, интеграции IoT и сенсорных технологий, а также созданию единого образовательного ресурса, который позволит объединить цифровые элементы в целостную педагогическую систему подготовки будущих строителей. Такой инструмент будет способствовать формированию профессиональных компетенций и навыков критического и креативного мышления, цифровой грамотности, коллаборации, коммуникации, и рефлексии.

Ключевые слова: образовательная программа, анализ, модуль, навыки, дисциплина, цифровая платформа, формат обучения, рекомендации, строительство

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