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Article

From classroom to industry: Developing universal competencies and AI integration in engineering education for technological advancements

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Abstract: The purpose of this study is to develop strategies for enhancing higher and postgraduate education in Kazakhstan, with a focus on improving graduate readiness for professional roles and building predictive models to analyze and assess doctoral graduation rates in technical fields for 2023–2025. This research emphasizes a flexible framework that integrates universal competencies into engineering programs, adaptable to various institutional and national contexts. Active learning methods, including project-based tasks, problem-solving exercises, internships, and lab work, are employed to cultivate practical skills aligned with real-world engineering demands. The study also highlights the need for comprehensive assessment systems that extend beyond theoretical testing, incorporating continuous feedback and curriculum adjustments to align with labor market needs and scientific developments. Results reveal key areas for higher education reform, as outlined in Kazakhstan's State Program for Education and Science Development (2020–2025). These include implementing a competency-based approach, optimizing interdisciplinary and practice-oriented teaching methods, and enhancing the global competitiveness of Kazakhstani universities. Additionally, through time-series analysis of doctoral graduation data, a trend model was created, showing a steady increase in graduates, tested for anomalies and trend adequacy, making it reliable for forecasting graduate numbers. The scientific significance of this work lies in its contributions to models that improve graduate training, fostering high-quality education to enhance Kazakhstani universities' global competitiveness. By integrating AI-driven strategies and emerging technologies, the research provides an adaptive educational model to equip students with essential professional and universal competencies, essential for navigating the evolving labor market and supporting sustainable development.

Keywords: universal competencies; competency-based approach; active learning; AI integration; labor market; technological advancement

1. Introduction

Higher education institutions are increasingly guided by targeted programs and regulatory frameworks aimed at fostering innovation and aligning academic outcomes with industry needs. In this context, universities are not only tasked with advancing scientific knowledge but also with ensuring that new technologies are efficiently transferred from research labs to industrial applications. This dual role emphasizes the need for institutions to intensify innovation processes, enhance scientific research, and produce graduates who are well-prepared to address the demands of modern industries. The overarching goal for many institutions is transformation into globally recognized research universities, capable of driving socio-economic growth through innovation.

To achieve this transformation, universities must address several strategic priorities:

- Integrating technical knowledge with educational processes merging theoretical instruction with practical, hands-on training at both undergraduate and postgraduate levels, ensuring that students gain the skills needed for innovation and technological development.
- Promoting educational models that prioritize academic leadership, fostering a culture of high academic standards and research-driven education; institutions can enhance their role as leaders in both the academic and industrial sectors.
- Enhancing the impact of university research on national socio-economic growth aligning their scientific research with the economic priorities of their respective countries, thus playing a role in driving industry-relevant innovation.
- Developing sustainable business models to ensure long-term growth, allowing for continuous investment in research, technology transfer, and educational excellence.

Fulfilling these strategic objectives opens the door to greater opportunities. In particular, scientists who were unable to bring projects to production due to various circumstances can improve their research and further commercialize it. The task of integrating technical action and the instructive procedure at all heights of advanced and postgraduate teaching is of scientific activity and educational process at all levels of higher education and postgraduate education read importance. In the context of the rapid growth of the labor market and technology, formation of universal competencies among university graduates is becoming one of the key tasks of higher education. For engineering areas of training, this is especially important, since graduates must not only be technically savvy specialists, but also have a wide range of skills necessary for successful professional activity in modern conditions.

In response to these needs, this study aims to develop a flexible framework that integrates universal competencies into engineering education, equipping graduates with both technical expertise and adaptable skills essential for a dynamic labor market. Universal competencies—such as critical thinking, communication, collaboration, and adaptability—are crucial in modern engineering fields, where professionals must navigate complex, interdisciplinary environments. The study also explores the role of artificial intelligence (AI) in enhancing engineering education, particularly as a tool to optimize learning processes, support decision-making, and foster continuous curriculum improvements aligned with industry developments.

To achieve these objectives, this research focuses on creating adaptive educational strategies that blend theoretical knowledge with hands-on training, including active learning methods like project-based learning, internships, and laboratory work. This approach aims to ensure that graduates not only possess strong technical skills but also the practical, interdisciplinary competencies needed to succeed in industry settings. Moreover, by incorporating AI-driven feedback systems, the study seeks to provide a mechanism for ongoing curriculum adjustments that respond to labor market shifts and technological advancements.

The significance of this study lies in its contribution to Kazakhstan's higher education reform, aligning educational practices with socio-economic objectives and responding to globalization demands. By developing strategies for integrating universal competencies and AI-driven tools, this research supports the transformation of Kazakhstani universities into innovation-driven institutions capable of producing graduates who can drive sustainable development both nationally and globally. This flexible, adaptive framework not only prepares students for technical challenges but also equips them with critical competencies for leadership and innovation, establishing an essential link between education, industry, and technological advancement. Furthermore, it provides a model that can modernize engineering education to meet contemporary industry expectations and support sustainable growth within engineering fields worldwide.

2. Literature review

Higher education institutions involve many managerial and theoretical processes that make information through their activities. The question is whether the correct use of that knowledge can add worth to the crops and facilities providing. The management of universal training for engineering graduates plays a key role in improving the quality of technical research and, consequently, in increasing the number of journals and citations:

- Quality improvement in education and research skills involves the effective organization of universal competencies among engineering students, leading to an upsurge in their training level. This includes the development of critical thinking and analytical skills, enabling students to analyze and interpret data more effectively, and the improvement of scientific writing and presentation skills, which helps in writing scientific articles and presenting them at international conferences.
- Stimulating innovation activities is another important aspect. Graduates with well-developed universal competencies are more inclined to embrace innovation and adopt an interdisciplinary approach in their research, which leads to the generation of new ideas and solutions, often reflected in scientific publications. Interdisciplinary projects, which integrate knowledge from various fields, tend to attract greater attention and citations.
- Strengthening collaboration and networking is vital for scientific cooperation. The formation of teamwork and networking competencies among students promotes international partnerships, allowing graduates to participate in joint research, thereby increasing the visibility and citation of their publications. Participation in scientific networks and consortia expands opportunities for publication and knowledge exchange.
- Support for scientific infrastructure includes developing research infrastructure such as access to modern laboratories and equipment, which enables advanced research and high-level results. Funding and grant support also play a significant role in increasing the number and quality of scientific publications.
- Participation in international scientific projects is facilitated by forming competencies for international collaboration, allowing graduates to engage in global scientific research. Involvement in global initiatives and consortia enhances the visibility and recognition of Kazakh research, while joint international research is often published in high-ranking journals, increasing citation rates.

- Strengthening academic culture through the development of universal competencies affects the quality of scientific publications. High standards of scientific ethics and integrity lead to reliable and cited research. Promoting open access policies and creating repositories for scientific publications increase their accessibility and citation.

Thus, the strategic management of education and scientific activities in Kazakhstan's universities It is a key factor for the successful development of the country's scientific capacity. Universities must join forces to develop strategies for the effective use of official information, to progress their work. This must be quickly adapted to fast moving technologies and theoretical wants (González-Campo et al., 2021). To achieve this goal, it is necessary to identify, capture, transform, and properly transfer knowledge within the organization, so it is necessary to know the importance of organizational learning (Haqani and Rahman, 2015). Tessema and Nicola-Gavrilă (2023) highlight that managing a Learning Management System (LMS) involves effectively utilizing the system to facilitate online learning. An LMS has become an indispensable tool for higher education institutions and organizations. It empowers educators to create engaging learning experiences, offers students flexible learning opportunities, streamlines administrative tasks, and facilitates data-driven decision-making.

The application of a comprehensive vision of management contributes to the integration of information in a comprehensive, reactive and integrated organization, which improves the distribution of knowledge, planning, the adoption of solutions and the quality of work (Nawaz, 2015). Individuals, groups, and institutions can develop, share, and use information collaboratively and systematically to healthier attain their goalmouths finished information organization (Sardjono and Firdaus, 2020). In academia, knowledge management is a fairly new discipline. This topic will address numerous upcoming state and universal actions and sessions (Prahiawan et al., 2021). Several global colleges are energetically complicated in information organization and investigate operations (Masete and Mafini, 2018). Nowadays, knowledge management is to gain prestige in the educational field, due to the need to unleash the intellectual potential of institutions and share experiences. It is very promising and must be significant, if not more so, in the teaching part. Material is based on prior information, and past actions help to create novel information (Ahmad et al., 2020). The main source of knowledge development is human effort through actual instructive actions, technical investigate and the creation of new concepts in a field of interest Kimeto (2021), says that refining the services and material of the staff can improve attractiveness and contribute to creating and sustaining a viable industry (Piróg et al., 2021). are conducting an analysis of the main ingredients to identify the skills that significantly influence young people's perception of the chances of finding a job.

As noted by Civera et al. (2017), Colleges are at the center of information generation then use and remain straight subsidized to establish a combination of novelty and free enterprise policies. In many European countries, policies to improve academic performance (Menter et al., 2018; Sørensen et al., 2016), initiative (Daraio et al., 2019) and performance-based financing mechanisms (Meoli et al., 2017) stand out. The general impartial of these rule creativities is straight or circuitously directed at the different levels (Lehmann and Stockinger, 2018), innovation, entrepreneurship or university and productivity (Froehlich, 2016), as well as the advanced teaching scheme and socio-economic environment impact—improve Vocational training and education are becoming increasingly flexible to encounter the individual wants and interests of the work marketplace. Although there are devices and replicas that have demonstrated output in other republics, the individualities of the socioeconomic construction of our country require the growth of the organization of the training of advanced education organizations with innovative activity. The competence of the use of ground-breaking possible depends not only on the degree of investigate and growth, but also on the set of technological, productive, structural, advertising, and monetary tasks that are part of the novelty procedure (Krokhmal et al., 2019).

3. Methodology

This study adopts a mixed-methods approach to design, implement, and assess a flexible framework for integrating universal competencies in engineering education. The research combines qualitative and quantitative methods to analyze educational needs, evaluate competency development, and assess the effectiveness of AI-driven tools in enhancing learning outcomes.

Data was collected from multiple sources, including surveys distributed to engineering students and faculty, interviews with industry professionals, and analysis of student performance records. A purposive sampling technique was applied to ensure that participants represented diverse perspectives on competency needs and educational practices. To evaluate the impact of the framework on competency development, statistical analyses, including regression analysis and factor analysis, were conducted on survey data and student performance metrics. These analyses provided insight into the relationships between specific competencies and student readiness for industry demands.

The concept of universal competencies refers to foundational skills, knowledge, and abilities that go beyond specific professional tasks and can be applied across various fields. These include critical thinking, adaptability, teamwork, creativity, and communication—skills essential for adapting to new roles and technologies in fast-evolving work environments.

Practical skills development involves acquiring and refining the technical abilities needed for specific professional tasks, such as working with technical devices, data analysis, programming, and applying specialized engineering tools. This is typically achieved through laboratory work, hands-on training, and real-world projects, enabling students to apply theoretical knowledge to concrete problems.

The methodology establishes a structured approach to developing universal competencies that are closely aligned with real-world market requirements, supporting the training of engineers who are equipped with both specialized technical skills and adaptable, interdisciplinary abilities. The effective development of these competencies in engineering graduates calls for an integrated approach, one that combines curriculum updates, innovative teaching and assessment methods, and robust partnerships with industry and professional organizations.

As shown in **Figure 1**, the foundational universal competencies emphasized in this study encompass a range of skills critical for adaptability and continuous professional growth.

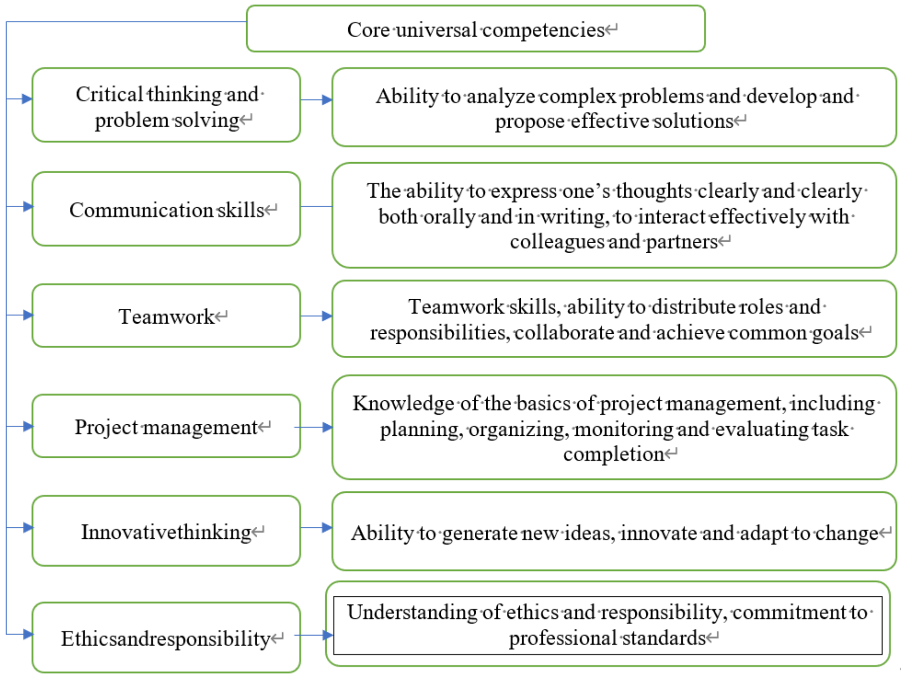

Figure 1. Basic universal competencies.

To address the evolving demands of graduate professional training in a changing technological landscape, this study proposes a two-tier model. A two-tier model refers to a structure organized into two distinct levels or components, each serving a specific function or purpose. In the context of AI integration in engineering education, such model could consist of two interconnected layers: a foundational framework (e.g., core competencies, skills, or strategies) and an applied or advanced framework (e.g., specific programmatic or professional activities). These layers work together to achieve a particular outcome. The model is designed to focus on two levels, where one tier supports or complements the other, creating a more comprehensive, adaptable, and flexible system. In this case, it organizes both graduate professional strategies and the integration of generic competencies into a coherent approach for engineering education.

This flexible structure for integrating universal competencies into engineering programs enables universities to produce more adaptive and competitive graduates, as outlined below:

- Graduate Professional Activity Strategy Model: This model focuses on adapting to the dynamic labor market conditions and fostering flexibility and self-directed learning. It includes:
    - Adaptive skills: Developing students' competencies to quickly master new technologies, maintain flexibility, and reconfigure professional activities.
    - Cross-functional teams and project-based activities: Learning projects in which students collaborate with peers from various disciplines, enhancing

their ability to function in a multidisciplinary environment and take on diverse roles.
    - Experiential learning and digital thinking: Students learn to solve problems using digital tools and technologies, equipping them with the necessary skills to thrive in a technologically advanced environment.
- Model Framework for Integrating Generic Competencies into University Engineering Education Programs: This framework includes four key components:
    - Interdisciplinary modules: Curriculum modules covering areas such as critical and systems thinking, which help students analyze and solve complex problems.
    - Digital learning and project management platforms: Implementation of platforms like Learning Management Systems (LMS) and Project-Based Learning (PBL), enabling students to develop and implement engineering projects using digital resources.
    - Practice-oriented courses and labs: Creation of training labs that simulate real-world conditions, allowing students to develop and test solutions.
    - Development of soft skills and intercultural competence: Courses designed to improve communication skills, foster collaboration in international settings, and enhance adaptability to cultural differences.

There are several methods for developing universal competencies, each incorporating distinct approaches and tools to enhance students' readiness for the labor market. These methods are detailed in **Table 1**, which organizes key strategies for competency development. The table highlights how each method contributes to fostering students' professional skills and adaptability. Additionally, the last column provide practical examples of how AI and data-driven learning tools are integrated into these approaches, showcasing real-world applications and demonstrating their impact on optimizing educational outcomes.

Table 1. Methods for advancing learning through competency building and AI integration.

Method	**Description**	**Outcome**	**AI and Data-Driven Learning Practical Example:**
Integrating Competencies into Curricula	Inclusion of specialized modules focused on universal competencies. Interdisciplinary courses that integrate multiple disciplines to solve complex problems.	Prepares students for problem-solving in diverse professional contexts and fosters adaptability.	AI-driven platforms like Coursera analyze student learning patterns and recommend customized courses, enhancing skills in areas like communication, leadership, and critical thinking.
Project Activities	Real-world projects where students apply theoretical knowledge to practical challenges. Engineering and research projects aimed at solving specific issues.	Encourages innovation, project management, and critical thinking, ensuring students are ready for industry challenges.	AI tools like Microsoft Azure AI and IBM Watson assist students in analyzing large datasets for projects, offering real-time insights and improving decision-making and outcomes.
Practice and Internships	Hands-on industry experience through internships. Academic exchanges that expose students to diverse professional environments.	Enhances practical skills and broadens global perspectives, bridging the gap between academia and industry.	AI-driven platforms like LinkedIn or InternMatch match students to internships based on their skills, interests, and career goals, ensuring relevant industry experience.

Table 1. (*Continued*).

Method	**Description**	**Outcome**	**AI and Data-Driven Learning Practical Example:**
Additional Courses and Trainings	Courses on soft skills such as communication, leadership, and teamwork. Flexible online courses that address both technical and interpersonal competencies.	Strengthens interpersonal skills and supports lifelong learning, increasing professional adaptability.	AI-based platforms like Duolingo and Grammarly offer personalized learning experiences, providing real-time feedback to help students develop language and communication skills.
Mentoring	Professional guidance through mentorship programs. Ongoing feedback from academic supervisors to refine skills.	Provides personalized career advice, accelerating professional development and easing transition into the workforce.	AI-powered platforms like Mentorloop analyze mentoring sessions, offering actionable recommendations and tailored resources to both mentors and mentees, enhancing career growth.
Active Learning Methods	Case studies and problem-based learning to encourage analytical thinking. Structured discussions and debates to develop critical thinking and reasoning.	Develops decision-making abilities, critical thinking, and the capacity to present and defend arguments in collaborative settings.	AI platforms like Kialo Edu and Perusall support collaborative learning by tracking participant input and suggesting content, fostering deeper engagement and enhancing critical thinking skills.
AI and Data-Driven Learning	Integrating AI and data analytics into the learning process to tailor content and improve learning outcomes.	Increases technical and analytical skills, helping students stay competitive in a technology-driven job market.	Adaptive learning platforms like Smart Sparrow or Knewton use AI to adjust content and assessments in real time based on individual student needs, ensuring personalized learning experiences.
Industry Collaboration	Partnerships with industry professionals to provide real-world insights and technological advancements.	Ensures alignment between academic learning and industry standards, enhancing employability upon graduation.	AI-powered tools like Google Cloud's BigQuery enable students to work with industry data, helping them understand current trends and make data-driven recommendations in collaborative projects.

The inclusion of artificial intelligence (AI) in engineering education, particularly through data-driven learning, offers new opportunities for developing practical competencies that are essential for students' professional growth. Nicola-Gavrilă (2024) explains that intelligent education uses technology, data, and personalized learning to support students. Approaches like personalized learning, virtual reality, intelligent tutoring systems, and open educational resources can make education more adaptive and prepare students for future challenges.

In the case of engineering students, they can work with large datasets from industrial sensors or devices, applying machine learning algorithms to find optimal solutions. AI-powered tools like Microsoft Azure AI provide real-time insights for project-based learning, enabling students to analyze data and improve their decision-making skills."

Using Digital Twins to simulate engineering systems helps students experiment with system behaviors, offering insights that align with current industry practices, and allows them to test virtual prototypes using real data. In the fields of robotics and automation, AI enables the creation of labs where students can program and control robots in real time, learning machine learning principles and control algorithms. AI-powered robotics platforms offer hands-on experiences where students practice real-time coding, receive feedback, and refine their skills in automation and control systems.

The approaches and tools discussed are designed to develop a broad range of skills essential for successful professional activities. The acquirer of these competencies will enable graduates to remain competitive in the labor market and effectively adapt to changes in their professional fields.

To ensure the effective application of methods for developing universal competencies, the following key elements are necessary:

- Establish measurable criteria for assessing the development of universal competencies among students, ensuring that progress can be tracked consistently.
- Implement regular tests, surveys, and feedback mechanisms to evaluate the level of competency development. Students should maintain a portfolio reflecting their achievements, including projects, participation in competitions, and extracurricular activities, all of which highlight the growth of universal competencies.
- Leverage online platforms for interactive learning and enhanced communication between students and instructors. Virtual laboratories and simulators should be integrated into practical sessions to enable hands-on learning experiences.
- Encourage involvement in student clubs, associations, and volunteer programs, which help students develop leadership, organizational, and social responsibility skills.

When used together, these methods ensure the comprehensive development of universal competencies among engineering students, equipping them to excel in professional environments and adapt to evolving labor market demands.

4. Results and discussions

The data selection process for the "Productive Employment" program of the Office of Teaching and Discipline of the State of Kazakhstan followed a systematic approach to ensure that the selected data met the study's objectives. The process involved strict inclusion and exclusion criteria, with justifications to guarantee the representativeness and relevance of the data to the research objectives. This approach ensures that the data provides a robust basis for evaluating the impact of AI on engineering education in the country ensuring that the conclusions drawn from the study are valid and reliable.

Inclusion Criteria:

- Compliance with Study Objectives: Data directly related to the development of universal competencies and practical skills in engineering education were selected. Specifically, data on the use of AI and data-driven technologies in the educational process were prioritized.
- Relevance: Only recent studies, particularly publications from the last 5 years, were included to ensure the incorporation of current trends and technologies in engineering education.
- Regional Context: The data focused on universities in Kazakhstan, aligning with the study's aim of adapting and implementing international experience in the Kazakhstan education system.
- Qualitative and Quantitative Metrics: Both quantitative data on student performance and qualitative data on the results of participation in AI-driven

experiments and projects were included to provide a comprehensive view of the impact.

Exclusion Criteria:

- Lack of Specific Impact of AI: Data that did not directly reflect the impact of AI on the development of practical skills or universal competencies were excluded from the study.
- Outdated Data: Data describing outdated approaches or technologies no longer applicable to modern engineering education were excluded to ensure the study's relevance to current practices.
- Insufficient Representativeness: Studies with a small sample size or unvalidated methods that could compromise the accuracy and validity of conclusions were not considered.

Justification for Representativeness and Relevance:

- Representativeness: The sample encompassed several universities and various study programs to reflect the diversity of educational approaches in Kazakhstan. Data were collected across different academic levels (bachelor's, master's) to ensure broad representation and reflect a comprehensive range of student preparation.
- Relevance to Research Objectives: The data selection process focused on obtaining information that aligned closely with the research objectives. Particular emphasis was placed on study programs that incorporated AI-supported methods and developed practical skills, as they offer the most accurate reflection of the current application of AI in Kazakhstan's engineering education system.

The 'Productive Employment 2021–2025' program, initiated by the Office of Teaching and Discipline of the State of Kazakhstan, includes a series of systemic initiatives aimed at adapting to the new employment structure. These efforts are designed to enhance the quality of teaching in colleges and technical-vocational training institutions by modernizing curricula, improving faculty composition, and increasing the number of university and college graduates.

The **Table 2** presents the forecasted number of graduates in key sectors, including healthcare, agro-industrial, ICT, and education, from state-funded universities and colleges. The data highlights the expected growth in graduates across these fields, signifying the government's effort to address labor market needs. For example, healthcare is projected to produce a total of 142,535 graduates, with 38,235 from universities and 104,300 from colleges; the ICT sector is forecasted to graduate 140,529 students, ensuring a skilled workforce to support Kazakhstan's digital transformation; and Education tops the list with 295,161 total graduates, emphasizing the country's commitment to enhancing the quality and supply of educators.

Table 2. Forecasted number of university and college graduates (2021–2025).

Indicator	Graduates of State-Funded Universities	University graduation	Graduates of State-Funded Colleges	College graduation	Total
Healthcare	25,250	38,235	24,574	104,300	142,535
Agro-industrial complex	11,575	17,575	35,847	52,365	69,940
Tourism	2995	7760	10,505	19,213	26,973

Table 2. (*Continued*).

Indicator	Graduates of State-Funded Universities	University graduation	Graduates of State-Funded Colleges	College graduation	Total
Trade	1470	14,960	3693	5041	20,001
Transport and logistic	5570	22,295	41,420	54,069	76,364
ICT	28,670	71,670	37,213	68,859	140,529
Construction	7460	17,595	35,207	51,937	69,532
Education	52,160	186,160	33,565	109,001	295,161

Source: Project of the Department of Teaching and Learning of the State of Kazakhstan "Productive Employment" for 2021–2025.

Figure 2 provides a more detailed set of forecast indicators for the projected number of university graduates for the period 2021–2025. It breaks down the data into specific yearly estimates, allowing for a clearer understanding of trends in graduation rates over time. These indicators offer insights into the expected growth or decline in the number of graduates, helping to identify potential challenges or opportunities in higher education over the forecasted period.

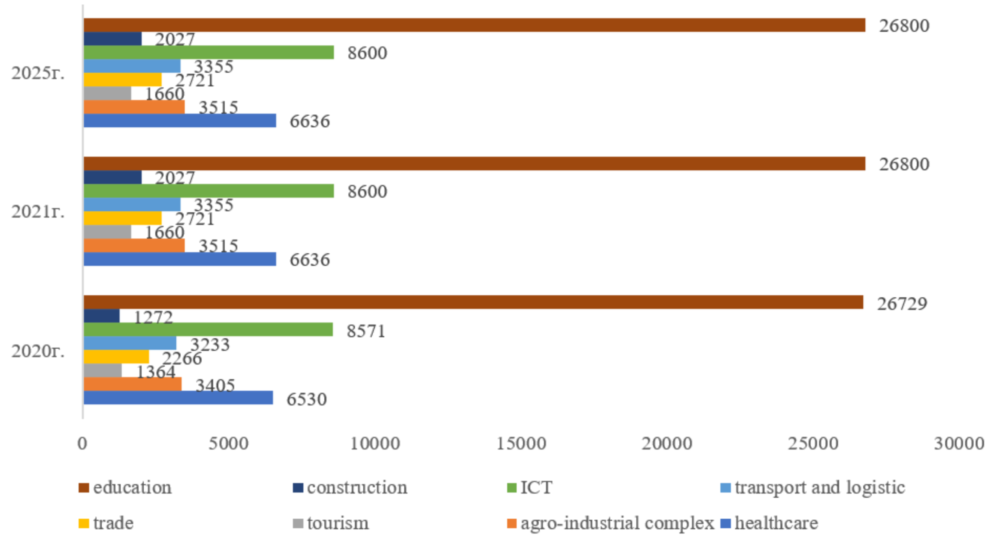

Figure 2. Forecasted number of university graduates by 2021–2025.

Source: Project of the Ministry of Education and Science of the Republic of Kazakhstan "Productive Employment" for 2021–2025.

Refining the excellence of skilled workers and aligning educational programs with budgetary allocations is essential for the future well-being of the populace and civilization as a whole. Skilled workers serve as a critical intellectual resource for the competitiveness of the modern economy in the Republic of Kazakhstan. The growth of key budgetary sectors, beyond just the social sphere, will lead to an increase in the number of highly qualified specialists, positively impacting the overall well-being and engagement of the republic's citizens.

A key factor in improving education quality has been the active involvement of teachers and industry representatives in the educational process. This collaboration has strengthened the connection between theoretical training and the practical needs of the labor market, resulting in a more effective development of essential skills among students.

We refer to **Table 3** below to better understand the current landscape of technical education in Kazakhstan, highlighting the need for continuous improvement and adaptation to ensure that all universities can effectively prepare students for the workforce.

Table 3. National ranking of leading technical universities, Kazakhstan, 2023.

Rating	Name of the university	Total, %
1	Satbayev University	97.52
2	Kazakh National Agrarian Research University	88.90
3	Almaty Technological University	85.32
4	International University of Information Technologies	77.17
5	Civil Aviation Academy	76.77
6	West Kazakhstan Agrarian-Technical University named Zhangir Khan	74.98
7	Academy of Logistics and Transport	66.08
8	International University of Engineering and Technology	54.04

Source: compiled by the authors https://iqaa-ranking.kz/rejting-vuzov/natsionalnyj-rejting-vedushchikh-vuzov-kazakhstana-2023/natsionalnyj-rejting-vedushchikh-mnogoprofilnykh-vuzov-kazakhstana-3.

The **Table 3** presents the national ranking of leading technical universities in Kazakhstan for 2023, highlighting the performance of various institutions based on their total percentage scores. Satbayev University emerges as the top performer with an impressive score of 97.52%. This high percentage reflects exceptional academic excellence, research output, and strong industry collaboration, underscoring its status as a leader in technical education. Following closely are the Kazakh National Agrarian Research University and Almaty Technological University, with scores of 88.90% and 85.32%, respectively. While these institutions demonstrate competitive programs, there is a noticeable gap between them and Satbayev University, indicating that they may need to enhance certain areas to further improve their standings. Moderate performers such as the International University of Information Technologies and Civil Aviation Academy have scores of 77.17% and 76.77%. Although these scores are respectable, they suggest that these universities could benefit from improvements in their academic offerings, industry connections, or research initiatives to elevate their performance. Conversely, institutions like the West Kazakhstan Agrarian-Technical University named Zhangir Khan (74.98%), Academy of Logistics and Transport (66.08%), and International University of Engineering and Technology (54.04%) are positioned at the lower end of the ranking. The lower percentages indicate challenges in meeting educational standards or aligning with labor market needs, suggesting a pressing need for reform. The disparities in scores highlight varying levels of educational quality and institutional effectiveness across these universities. Those with lower scores may benefit from evaluating their curricula, teaching methodologies, and partnerships with industry to better prepare their graduates for the labor market. Overall, the data reflects a competitive environment among technical universities in Kazakhstan, where continuous improvement and adaptation are essential for ensuring that all institutions can effectively equip students for success in the workforce.

Engineering represents the scientific specialization of the country throughout all periods of time, the share of publications for 2020–2022. 32% higher than 1. At the same time, the citation rate in the last 2 periods also exceeds the world average by 4%–6%. In 2022, the field of engineering and technology accounts for 4.2 thousand people (24%) (**Table 4**). In the reporting year, out of 100 research specialists, 36 people had the highest scientific qualifications in the field of engineering development and technology.

Table 4. Distribution of research specialists in engineering development and technology.

Indicator	**Total**	**Engineering and technology (2022)**	**%**
Research specialists, human	18,014	4278	23,74
of which those with a degree:			
Doctors	1,743	315	18,07
Candidates	3,945	635	16
PhD	2,460	592	24,06
PhD of the direction	96	6	6,25
Masters	5,397	1,182	21,09
Availability of Personnel with Highest Scientific Qualifications per 100 Research Specialists	46	36	

Source: Compiled by the authors
https://www.gov.kz/uploads/2023/11/17/e76d83989b2cae13d8fb1e12cc31e83c_original.3751084.pdf.

The quality of scientific research depends not only on the content and methods of preparation and application of research results, but also on the qualification and, above all, on the quality of the training of scientific personnel. This process refers to the reproductive character of scientists through master's and doctoral studies within postgraduate education programs. In the 2022/2023 academic year, the field of engineering, manufacturing, and construction industries saw the distribution of doctoral students as follows: A total of 1032 doctoral students were accepted. Out of these, 294 were actively pursuing their studies in the reporting year. During the same period, 267 doctoral students graduated. Additionally, 7 dissertations were successfully defended, resulting in a share of 2.6% of graduates with protected dissertations. This data, compiled by the authors, reflects the current state of doctoral education in these specialized fields.

In 2022, there was a consistent rise in expenditures across all scientific disciplines, reflecting a broad-based commitment to advancing research and development. Notably, the field of engineering and technology continued to dominate in terms of funding allocation, maintaining its position as a primary focus of investment. As in previous years, this sector accounted for 40% of all internal research and development costs, demonstrating its critical role in driving innovation and technological progress. **Figure 3** illustrates this distribution, highlighting the ongoing prioritization of engineering and technology within the overall funding landscape.

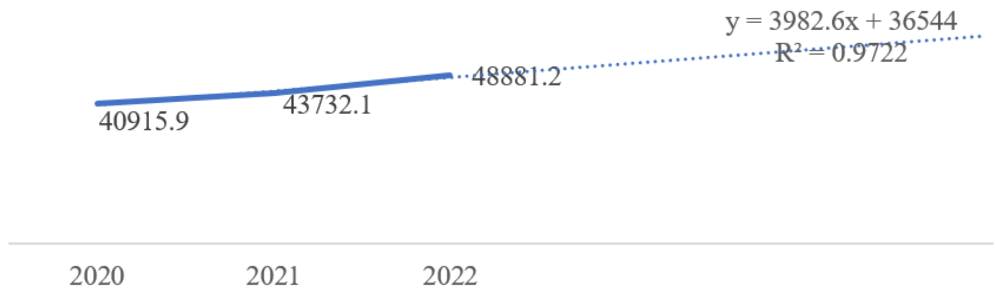

Figure 3. Internal R&D costs, million tenge.

Source: Compiled by the authors: https://www.gov.kz/uploads/2023/11/17/e76d83989b2cae13d8fb1e12cc31e83c_original.3751084.pdf.

In general, Kazakhstan's higher and postgraduate education is growing and has priority for modernizing the higher education system, according to the State Program for Education and Scientific Development 2020–2025 of the Republic of Kazakhstan, are:

- integration of vocational training programmed in higher education as part of the creation of an innovative and socially oriented international education system;
- Ensuring multi-level higher teaching through construction of contemporary college centers;
- Change to a qualitatively new educational perfect (optimization of education approaches, energetic use of exposed educational skills;
- addition and interdisciplinary agendas to deepen advanced education, align the university with the latest high technologies, integrate the university with practice-based educational processes;
- individual methods of organizing the learning process taking into account the individual abilities and needs of the student within the framework of the conditions defined by the university;
- Honesty and rationality of the organizational structure of the university;
- increasing the competitiveness of educational institutions in the market of educational services (for this, the university will develop an effective image policy and a marketing strategy for its implementation);
- Improving university management and building a great business culture based on the values of directness and democratization;
- internationalization of university education finished the process of academic mobility of students and teachers, internationalization of students and advanced learning experiences;
- Increase the status of university science within the framework of process expansion. Commercialization of scientific achievements, integration of university science, business environment and production.

Since there is not enough general information on the graduation of doctoral students in technical specialties, the author examined the indicator data on the graduation of doctoral students in A 2023–2025 trend model was constructed in which the subsequent steps were followed completed:

- Time sequence verification for observational allamandas. To do this, the Irwin criterion was used (**Figure 4**).

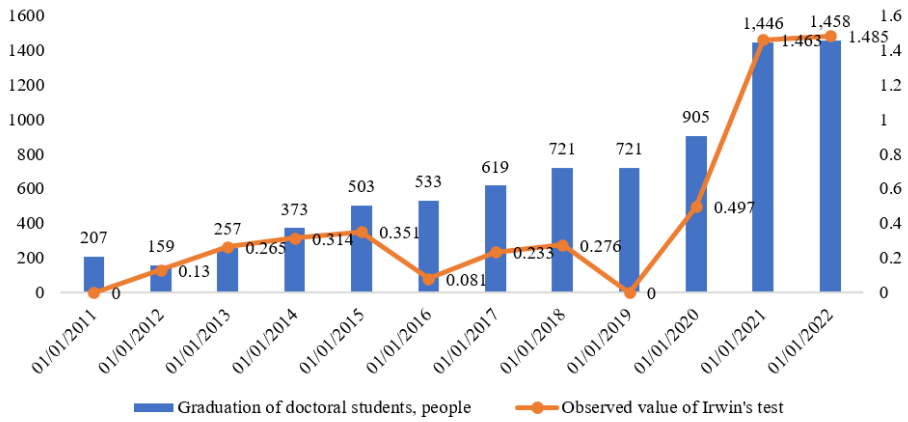

Figure 4. Validation allometric observations in a time series.

Source: Compiled by the authors.

Experiential worth of Irwin's test:

$$\lambda_t = \frac{|y_t - y_{t-1}|}{\sigma_y},\ t = \overline{2.11}$$

Critical value of Irwin's criterion $\lambda_{0,05} = 1.5$

- The 95% probability, the unique time sequence does not comprehend all abnormal explanations, since all Irwin criterion ideals are less than the critical value. Using the criterion of "ascending" and "descending" series, it was originated that the time sequence had a tendency constituent.: $\nu(n) > \left[\frac{2n-1}{3} - 1{,}96\sqrt{\frac{16n-29}{90}}\right]$= 2<4, at the calculated value with a probability of error $0{,}05 < \alpha < 0{,}0975$

$$K[K_0(n)]_{max} = 9 > 5$$

- The source data was approximated using a first-degree polynomial:

$$y_t = a_0 + a_1 t + \varepsilon_t$$

The strictures of the designated growth curves were calculated by the minimum frame method. Consequently, the following trend model was achieved:

$$y_t = -35.07 + 103.48t.$$

- The excellence of the subsequent perfect remained evaluated in dual aspects: examination and evaluating the fit of the classical.

To test the fit of the perfect, several remainders were analyzed, i.e., the difference amid the prototypical and the real observed levels. The most significant possessions of residuals are arithmetic parity awake toward nothing, chance of remainders, and decomposition according to the standard circulation rule. **Table 5** shows the results of the specific residuals study to demonstrate the goodness of fit of the model.

Table 5. Checking the adequacy of the model.

Property being checked	Statistics used		Border	Conclusion
	Name, calculation formula	Received value		
Accident	Criterion for "peaks" (turning points) $p > \left[\frac{2}{3}(n-2) - 1.96\sqrt{\frac{16n-29}{90}}\right]$	4 > 3	3	Adequate
Normality	RS-criterion $RS = \frac{e_{\max} - e_{\min}}{S}$	3.90	2.80–3.91	Adequate
Equality of the mean of residuals to zero	t-Student's t-statistic $t_{observ.} = \frac{\lvert \bar{e} \rvert}{S}\sqrt{n}$	0	2.23	Adequate

Source. Compiled by the authors.

To evaluate the truth of the classical, the comparative mean mistake of the estimate stood intended:

$E = \frac{1}{n}\sum_{i=1}^{n}\frac{|e_t|}{y_t} \cdot 100\% = 16.14\%$,value, which indicates an acceptable close of classical truth. Thus, the prototypical is of high quality and can be used for prediction.

- To analyze the opinion prediction, the standards of the corresponding variables remained relieved into the created perfect. To generate an intermediate prediction, a confidence margin was defined at the meaning level $\alpha = 0.05$. Results of forecasting for 2023–2025. are presented in **Figure 5**.

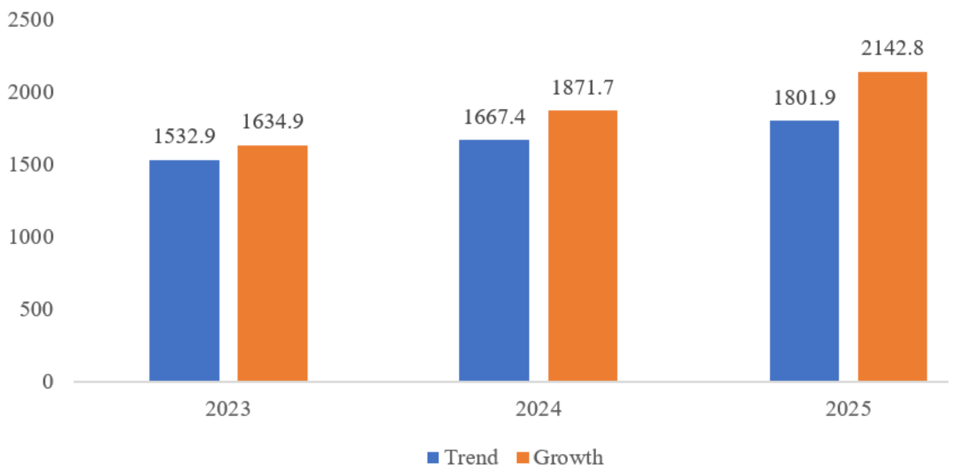

Figure 5. Results of forecasting for 2023–2025.

Source: Compiled by the authors.

5. Conclusion

In conclusion, this study presents a flexible framework for integrating universal competencies and advanced technological tools, such as artificial intelligence, into Kazakhstan's engineering education programs. Academic performance, tolerance, and social skills are now integral components of a student's profile, necessary for fostering effective intercultural cooperation. These competencies not only prepare students for the workforce but also align with the broader goals of sustainable development and technological advancement. Aligning academic training with industry demands, this framework supports Kazakhstan's goal of transforming its universities into innovation-focused institutions that produce graduates who are not only technically proficient but also equipped with essential, adaptable skills for today's dynamic workforce.

Through its recommendations for policy and practical implementation, this study advocates for a proactive approach in aligning educational strategies with labor market needs, ensuring that Kazakhstan's higher education system remains competitive and resilient amid the challenges of globalization and digital transformation.

The findings underscore the importance of a competency-based approach that combines technical knowledge with practical, interdisciplinary skills, such as critical thinking, collaboration, and adaptability, which are essential in today's rapidly evolving technological landscape. The use of AI-driven feedback mechanisms, integrated within the curriculum, enables continuous improvement and responsiveness to industry shifts, making educational practices more dynamic and aligned with real-world demands.

This strategic focus not only enhances individual learning outcomes but also contributes to the broader objective of sustainable socio-economic growth by preparing a skilled, adaptable workforce capable of driving technological advancement. The adaptable framework developed in this research offers a model that can be applied to similar educational contexts globally, contributing to the ongoing modernization of engineering education and supporting national and international goals for economic and technological development.

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