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The Development of Engineering Qualifications in Ukraine and China Through the Prism of Experience, Transformations in the Educational Space, Personnel Policy, and the Integration of Dual Learning Models

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ABSTRACT:
In this article, we will look at how engineering qualifications are developed in the country of Ukraine in context of international comparison with much interest in the experience of China in terms of establishing a dual education system and digitalization strategies. The study design includes qualitative content analysis of Ukrainian policy texts and a systematic empirical survey, which will be completed at the beginning of 2025 with the help of students and instructors of vocational and technical learning facilities. The research explores the issue of introducing dual education, digital technologies (including AI, VR, AI) and public-private partnerships to the engineering training system in Ukraine, determining its limitations of structure, division of power, and regional inequality, mainly between urban and rural institutions. To accomplish the purpose of the analysis, the strategic coherent of the vocational education reforms in China is confirmed and compared to the experimental and decentralized reforms in Ukraine. There is a particular focus on trainings and professional development of teachers in the digital innovation, capacity-building of institutions and lack of nationwide performance indicators in Ukraine. These results contribute to the possible usefulness of hybrid governance systems that would intertwine Chinese strategic planning with the flexibility of the Ukrainian model that will allow flexible routes of reforms without compromising the ability to coordinate at the national level or meet international standards. The article ends with some policy innovation and future research recommendations in transition economies that are faced with a lot of complicated transformations in both education and the labor market.

Keywords: education, dual education, vocational education, dual system, engineering training, China, Ukraine, digitalization, public-private partnership, education policy, innovative economy, human resource development.

1. Introduction

In the current era, the importance of engineering education has increased markedly, driven by worldwide trends toward technological innovation, digital industrial transformation, and heightened global competition for skilled human capital. All this highlights the need for an in-depth analysis of vocational education systems, particularly

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those that train engineers in leading and transformational countries. In this context, particular attention is drawn to the People's Republic of China, as an example of a country with a large-scale centralized modernization of its education system, and Ukraine, which is trying to integrate into the European educational space amid political instability and limited resources. There is growing scientific interest in a comparative analysis of the vocational education systems of the PRC and Ukraine, as both countries are actively reforming their approaches to training specialists. The works of Lu (2024), Yu et al. (2024), and Zhang and Zhou (2024) describe in detail the features of the Chinese model, which combines dual education, digitalization, state support, and integration with industrial clusters. In contrast, studies by Ukrainian authors (Pavlenko, 2018; Dembitska et al., 2020; Bondarenko & Semenova, 2020; Goncharuk et al., 2021) focus on adaptation to European standards, the implementation of the Bologna Process, and the need for partnerships with business. However, despite numerous studies, there is no comprehensive comparison of the strategic, organizational, and content-related aspects of engineering education in these two countries in the scientific discourse, which creates a methodological gap.

In particular, there is still no analytical model that combines empirical data, educational policies, and practical cases to justify the transfer of effective solutions. The limitations of the research also lie in the insufficient attention paid to digital platforms, the role of dual education in the context of the labor market, and the indicators of the effectiveness of partnerships between education and industry. All this reduces the possibility of forming strategically sound recommendations for the modernization of vocational education in Ukraine.

Within this framework, the research seeks to analyze the key strategic orientations and content dimensions of engineering education in China and Ukraine, compare their educational models, and evaluate the applicability of Chinese practices to the Ukrainian educational environment. To achieve this goal, the authors set out to conduct a content analysis of scientific sources and educational programs, analyze empirical data, and compare the mechanisms for implementing dual education, digital technologies, and public-private partnerships in both countries.

2. Theoretical Background

The study of the transformation of vocational education in China and Ukraine outlines several key thematic areas, including the historical development of training systems, strategic guidelines, digitalization, and dual education. Research by Lu (2024) and Yu et al. (2024) reveals the historical background of vocational education in China, including its connection to the Soviet model, as well as its evolution in the context of economic reforms. Zhang and Zhou (2024) complement this analysis with strategic policy guidelines, particularly in the context of the Made in China 2025 initiative and digital transformation. The current state of education in the PRC is also illustrated by the analytical works of Wang and Huang (2024) and Tang et al. (2024), which focus on international integration and the export of the educational model. In the context of digitalisation and knowledge management in education in Ukraine, the works of Iatsyshyn et al. (2024) and Luchyk et al. (2025) are significant, highlighting the challenges of digital transformation, particularly for vocational training. Parallels with Chinese reforms can be

found in the works of Xue and Li (2023a, 2024b) and Li and Xue (2024a, 2024b, 2024c), which analyze education management policy, its social justice, and international cooperation.

The Ukrainian context is deeply analyzed in the works of Pavlenko (2018), Dembitska et al. (2020), and Goncharuk et al. (2021), which trace the paradigm shift from a centralized model to a market-oriented system. Bondarenko and Semenova (2020) focus on the problem of fragmentation of reforms and lack of coordination in Ukrainian education policy. Stepanchuk et al. (2021) and Romanchuk et al. (2020) complement the picture with an analysis of continuous professional development and training. The issue of adaptation to global challenges, in particular the pandemic and war, is explored in the works of Chuiko et al. (2024), Semigina and Stoliaryk (2024), and Sedochenko and Shyyan (2024), which demonstrate the institutional resilience and innovative responses of Ukraine's education system. The contribution of Sofii et al. (2023), who study interprofessional cooperation in the context of inclusive education, deserves special mention. Aspects of the historical development of sectoral training in Ukraine are presented in Manoylenko and Kutsenko (2021), and issues of continuous learning are discussed in Batsurovska (2023).

At the international level, analysis is facilitated by sources such as Dorigné-Thomson (2023), which examines foreign policy and educational expansion, as well as reports from international organizations – OECD (2024), ETF (2023), EdUp (2023) – which form a comparative basis for assessing the dynamics of engineering education (Munkholm, 2024; TradingEconomics, 2025; HireWithNear, 2025).

Research by Sofii et al. (2023) and Chuiko et al. (2024) draws attention to the institutional capacity of the vocational education system to respond to crisis challenges and expand cross-sectoral cooperation. These works are particularly relevant in view of the need to integrate the social context into professional training. In the same vein, the experience of working with special groups of applicants, in particular former military personnel, is discussed in the work of Semigina and Stoliaryk (2024). The issue of crisis leadership in higher education in conditions of war and socio-economic instability is analyzed by Sedochenko and Shyyan (2024), which provides grounds for revising traditional management models in education. A separate area covers the intercultural and political dimensions of the export of educational models. Dorigné-Thomson (2023) analyzes the foreign policy of the PRC, which indirectly influences the internationalization of educational strategies. The works of Li and Xue (2024c) and Xue and Li (2024b) detail the mechanisms of family and international education management in China, which is relevant in the context of educational globalization. Analytical findings on educational policy in ethnic regions of the PRC (Li & Xue, 2024a) provide insight into ensuring social justice in access to vocational education.

Thus, the literature analysis highlights the coexistence of broad strategic frameworks and grassroots-level innovations in the development of vocational education systems in Ukraine and China. At the same time, the scientific discourse does not fully address the issues of assessing the effectiveness of dual education in an unstable labor market and the formation of sustainable models of public-private partnership in vocational training.

3. Methods

The study used a combined approach that integrated content analysis, comparative analysis, and secondary statistical data processing. The main sources of information were scientific publications, engineering-oriented educational programs, international analytical reports (ETF, OECD, EdUp, MOE China), as well as practical cases of specialist training in China and Ukraine. The study design was methodological in nature incorporating quantitative and qualitative aspects. More than 30 sources, journal articles, scholarly and official policy papers, statistical reports, reform plans, and empirical literatures on dual education and digitalization in China and Ukraine, were analyzed as a part of content analysis. In order to determine the effectiveness of findings, the comparative framework was derived which allowed to compare the structural characteristics and major performance indicators of the vocational education systems systematically. The quantitative evaluation was carried out using official statistics of the years 20122023, especially the number of engineering graduates, annual growth tendencies, the degree of digitalization, as well as the level of employer penetration to the educational process. Cross-national data were synthesized and visualized as tables in order to make cross-national analysis and to locate areas of convergence, and places of divergence. The research methodology was implemented by the author through analytical processing of open sources, interpretation of strategic documents, and construction of a generalized comparative model based on typical educational approaches in both countries.

3.1. Empirical Research Design

To prove the findings of the content and comparative analysis with the empirical material, the authors carried out a survey-based research in early 2025 among students and teachers of the Ukrainian vocational and technical institutions where engineering training takes place. This empirical study was aimed at explaining the status of the application of the topics of dual education, digital learning technologies, and partnership of Ukrainian vocational education with businesses, and determine the major barriers and future growth.

The questionnaire was organized among 112 students and 38 teachers members of the five vocational and technical schools in Kyiv, Kharkiv, and Lviv regions. The instrument used in the study was a standardized questionnaire based on a combination of closed-ended and open-ended questions and meant to gather information in four major areas namely participation in a system of dual education, applying digital technologies within the educational process, the level of the employer engagement in training, and perceived obstacles to successful modernization of vocational training.

The answers showed a gap between actual access by the students to proper internships or workplace-based learning activities that are in line with their specialization; poor access to real internships and workplace-based learning experiences by 27 % of the students was revealed. In most cases, when the internship was available, it did not even exceed three weeks and was not coordinated in terms of educational results and production objectives. In the sample of surveyed teachers, 71 percent declared that formal agreements between their institutions and enterprises were existed, however, only 32 percent noted

that they had jointly developed curriculum or planned the process of education with the representatives of the industry.

Vocational training is still unequal in terms of digitalization. Although 82% of academic institutions claimed that they used one learning management system (LMS) element, including Moodle or Google Classroom, only 19% of students declared the availability of advanced and more complex aspects of simulations (e.g., digital labs, VR modules) within their learning programs. The lack of money to buy new technology, the inadequate ICT infrastructure and insufficient training opportunities were identified by teachers as the major causes of the slow pace in the adoption of digital tools.

Table 1 shows a characterization of the quantitative results of some of the questions in the questionnaire.

Table 1: Quantitative results based on the questionnaire

Indicator	Result
Regular participation in dual education programs	27% of students
Access to enterprise-based internships (min. 1 month)	18% of students
Institutions with formal partnerships with enterprises	71% of teachers
Employers involved in curriculum development	32% of teachers
Use of LMS (any form) in educational process	82% of institutions
Use of VR, simulators or digital labs	19% of students
Perceived relevance of training to actual labor market needs	41% of students

There were important themes that were mentioned within open-ended responses. Students often complained about an inconsistency between the presented instruction and the needs of the industry, antiquated facilities and lack of chances to receive hands-on experience. Teachers emphasized the requirement to have more explicit national plans, funding schemes to involve businesses, and regulation policy incentives to help implement dual education.

The findings of the content analysis are supplemented by another finding using an empirical source, which shows the structural fragmentation and low vertical integration among the stakeholders in the Ukrainian vocational education system. Even with the available few promising initiatives, scaling is greatly inhibited due to their isolated characteristic and natures of resource drudgery. These results prove that the adaptation of dual education principles in Ukraine is performed on a sporadic basis without general support. Meanwhile, institutional openness, positive student motivation, and partial infrastructure (LMS adoption) may become the initial basis of the wider reform under the condition of the consistency of policy and the engagement of a public and a private sphere.

4. Results

The historical background of the development of vocational education systems in the People's Republic of China and Ukraine reflects different geopolitical, cultural, and socioeconomic contexts that have significantly influenced the direction and dynamics of human resource development. Engineers in the PRC are trained according to a clearly defined multi-level model that combines theoretical, practical, and digital components.

The basis is a dual education system implemented in a "1+X" format: one year of basic training at a technical college is combined with certification modules and mandatory internships at an enterprise. Educational programs are developed in collaboration with industrial partners who participate in shaping competency profiles, modernizing the content of training, and creating training and production infrastructure. Digital technologies are widely used, including national educational platforms, VR/AR, simulators, and smart classrooms, which enable the simulation of real production processes. In addition, the system includes lifelong learning (LLL) mechanisms and allows students to obtain multiple qualifications simultaneously. This approach makes it possible to train engineering personnel focused on the modern challenges of a high-tech economy and contributes to high graduate employment rates.

At the same time, both countries share a common feature: active state participation in the regulation and support of vocational education as the basis for industrial and innovative development. In China, the vocational training system began to take shape in the 1950s under the influence of the Soviet model, with a clear division between academic and vocational education. The main focus was on meeting the needs of industry, and a key element was the creation of technical colleges and schools focused on practical training (Lu, 2024). From the late 1970s, during the reforms of Deng Xiaoping, vocational education began to modernize with a focus on combining theoretical knowledge and practical skills. Market principles were subsequently introduced into education policy and numerous dual training programs were implemented in cooperation with enterprises (Yu et al., 2024).

Ukrainian vocational education, on the contrary, was formed within the Soviet centralized model, with a dominant planned approach to training personnel for the needs of industry. After gaining independence in 1991, the system underwent significant transformations – from decentralization of management to attempts to implement European standards, particularly in the context of the Bologna Process. The reorientation towards training specialists for the labor market and the needs of the private sector also had a significant impact (Pavlenko, 2018; Dembitska et al., 2020). A common feature of both countries is their efforts to adapt vocational education to the challenges of modernity – globalisation, digitalisation and the transition to a knowledge-based economy. At the same time, differences lie in the speed of reform implementation, the scale of investment in vocational infrastructure and the degree of integration of education policy with national innovation development strategies. In particular, China has demonstrated greater consistency and coherence in linking education with industrial policies (Zhang & Zhou, 2024), while in Ukraine reforms have often been fragmented and lacked coordination between the state, business, and educational institutions (Bondarenko & Semenova, 2020). Thus, an analysis of historical preconditions allows us not only to identify structural differences between the systems, but also to determine promising areas for mutual exchange of experience and adaptation of successful models.

In modern China, professional training for engineers is implemented through a comprehensive model that integrates digitalization, duality, public-private partnerships, and adaptation to market demands. The main practices are: active introduction of digital platforms (national system of online courses, MOOC, virtual laboratories), involvement of business in the creation of training programs and infrastructure, as well as the

widespread use of modular training with certification based on the "1+X" principle. The educational process is focused on developing practical skills through a real production environment: students spend most of their time learning directly at a company that cooperates with the technical college. Training programs incorporate advanced technologies such as artificial intelligence, the Internet of Things, 3D printing, and augmented reality. In addition, regional educational and production clusters are being actively created to ensure balanced access to quality engineering education even in remote regions. This approach contributes to the formation of a new generation of personnel who are mobile, digitally competent, and capable of quickly adapting to the conditions of an innovative economy.

Among the key advantages of the Chinese model of engineering education, it is worth highlighting its practical orientation, large-scale digital infrastructure, close ties with industry, and flexibility of educational content. For example, technical colleges in Guangdong, Jiangsu, and Zhejiang provinces have introduced educational programs in automation, robotics, and 5G technologies, where students work in smart factories with the support of companies such as Huawei, Foxconn, and Haier. As part of the Vocational Education Innovation Action Plan (2021–2025), more than 300 higher technical colleges have been designated as innovation centres and have modernised their curricula to integrate competencies in big data, artificial intelligence and cloud technologies. For example, Shenzhen Technical Institute offers an Intelligent Manufacturing program where students learn digital modeling, automated systems programming, and manufacturing analytics. Another example is the 1+X project, which combines academic qualifications with professional certificates recognized by employers across the country. Participation in such programs significantly increases the competitiveness of graduates and gives them advantages in the labor market, including the opportunity to find employment while still studying.

The official curriculum for the specialty "Electronic Information Engineering" (北京大学电子信息工程专业培养方案), implemented at Peking University, one of the leading higher education institutions in China, deserves special attention. According to the program (see Appendix A), the training of engineers is based on a combination of a thorough fundamental education (mathematics, physics, computer science), specialized disciplines (electronics, telecommunications, digital systems), and an extensive system of elective courses covering modern areas such as machine learning, nanotechnology, the Internet of Things, artificial intelligence, microchips, and optoelectronics. In total, students must earn 148 credits, of which 59 are compulsory courses in their specialization and 38 are elective courses. The program is structured according to the principle of gradual complexity, combining traditional learning with intensive practical training (including research projects and internships), and also provides Honors Track options for gifted students. This model is consistent with the philosophy of dual education, providing flexibility, a focus on the innovative market, and the gradual development of research and applied competencies.

The advantages of the Chinese engineering education system are clearly illustrated by specific training programs and innovative educational models that are actively implemented in technical colleges and universities across the country (Table 2).

Table 2: Key features of professional (engineering) training in the PRC

Direction	Characteristics
Strategic framework	Education is part of the state industrial policy ("Made in China 2025")
Typical learning model	Dual system "1+X" : training + internship in production
Business involvement	Cooperation in program development, creation of training and production bases
Digitalization	National platform with 10,000+ online courses, use of VR/AR
System scale	Over 519,000 educational institutions, 1.5 million engineering graduates each year
Government support	Centralized programs, funding, legislative regulation
Labor market integration	Employment of graduates – over 90%
Continuous learning	LLL (Lifelong Learning) system : retraining, open access
Globalization	543 branches abroad, export of the educational model
Social equity	Educational clusters in rural areas, accessibility for low-income groups

Source: created by the author based on (Yu et al., 2024; MOE China, 2024; Zhang & Zhou, 2024; Tang et al., 2024)

Examples of modern educational programs for training engineers in China are presented in Table 3.

Table 3: Examples of modern educational programs for training engineers in China

Name of program/initiative	Institution/region	Brief description	Features
"1+X" (One plus X)	National policy (since 2019)	Combination of a technical college diploma with several professional certificates	Certification in the following areas: IT, electronics, industrial design, automation
Intelligent Manufacturing	Shenzhen Technical Institute	Educational program in digital manufacturing	Training using digital modeling, AI, process analytics
5G+Industry Program	Colleges in Guangdong Province	Engineering education in telecommunications and Industry 4.0	Cooperation with Huawei, practical experience at real industrial facilities

Digital Twin Engineering	Zhejiang Vocational Institute	Training in the design of digital twins of production processes	Use of AR/VR, simulations, creation of digital models in industry
Vocational Education Innovation Action Plan (2021–2025)	300+ technical colleges throughout China	Modernization of educational content, creation of innovation centers	Focus on AI, big data, machine learning, cloud services

Source: created by the author based on (Yu et al., 2024; MOE China, 2024; Zhang & Zhou, 2024; Tang et al., 2024)

In the 21st century, vocational education in China and Ukraine is undergoing significant transformations under the influence of digital technologies, global competition, and the needs of an innovative economy. For both countries, it has become urgent to update the content of specialist training, introduce digital platforms, develop flexible educational trajectories, and establish partnerships with business. At the same time, the contexts for implementing these practices differ significantly due to different resource capabilities, management models, and levels of integration into the global educational space. Table 4 presents a comparative analysis of current approaches to vocational education in China and Ukraine, taking into account the main priorities for innovative development.

Table 4: Comparison of contemporary vocational education practices in China and Ukraine in the context of digitalization and globalization

Criterion	People's Republic of China	Ukraine
Digital infrastructure	By late 2023, China's national digital education platform encompassed over 519,000 educational institutions, reaching 18.8 million educators and 293 million learners. Its extensive digital content includes more than 10,000 vocational training courses and 27,000 top-tier MOOCs designed for the higher education sector.	In 2023, over 300,000 teachers received training in digital skills. The Diya.Osvita platform offers free digital literacy courses, which have been used by over 1.3 million users.
Education policy	In 2023, more than 6,000 vocational schools opened specializations related to the digital economy, offering more than 25,000 programs.	New training programs focused on innovation and digital technologies have been introduced, particularly as part of the EdUp project, which has reached over 3,400 professionals and increased their employability by 30%.

Cooperation with business	Active implementation of dual education: over 100 pilot projects involving enterprises and vocational schools.	Over 100 partnerships have been established between businesses and vocational education institutions to jointly develop and implement educational programs that meet the needs of the labor market.
Integration of innovative technologies	Introduction of artificial intelligence, virtual and augmented reality into the educational process. In 2022, 74% of vocational college teachers used ICT in teaching, and 90% of students were satisfied with virtual simulation training.	Pilot projects using VR/AR and other digital technologies in vocational education, particularly within the EdUp initiative, which covered 25 vocational education institutions, modernizing their curricula and teaching methods.
Global integration	In 2023, Chinese higher education institutions opened 543 schools abroad, offering 795 specialties for 33,663 students.	Participation in Erasmus+ programs and other international initiatives to strengthen cooperation and exchange experience in the field of vocational education.
Lifelong learning	Developing a national system of continuing education through professional training and online courses.	Creation of a series of courses on innovation in modern education, in particular for teachers of vocational schools, contributing to the improvement of qualifications and adaptation to modern labor market requirements.

Source: created by the author based on (MOE, 2024; ETF, 2023; EdUp, 2023; HKSMP, 2024; Eurydice, 2024)

A comparative analysis shows that China demonstrates a higher level of consistency in updating vocational education to take account of digital trends. Active government policy, large-scale pilot projects, and a clear strategic vision contribute to improving the effectiveness of training for the innovative economy. In Ukraine, despite the existence of high-quality initiatives, there is a lack of institutional stability and resource support, which hinders the introduction of digital and globalized approaches to vocational training. At the same time, it is precisely the vector of adaptation of successful foreign practices and the development of public-private partnerships that can become a driver for further modernization. The dual vocational education system, which combines education in educational institutions with practical training in enterprises, has become one of the key areas of vocational education modernization in the People's Republic of China. Since 2014, when the Ministry of Education of the PRC officially launched a national policy on the integration of production and education, mechanisms for cooperation between vocational colleges and businesses have been actively developed in the country (Yu et al., 2024).

Within the framework of the PRC's current education policy, the dual form of education is being actively implemented for the training of engineering personnel. Table 5 presents the key characteristics of the Chinese model and the possibilities for its adaptation to Ukrainian realities.

Table 5: Features of dual education in China and its potential for adaptation in Ukraine

Indicator	People's Republic of China	Potential for Ukraine
Training model	Combining technical college education with work at an enterprise ("1+X", internships)	Development of standard models of dual education at the level of vocational education and training and universities
Business participation	Integration of enterprises into program development, creation of training and production bases	Attracting business through public-private partnerships, tax incentives
Government support	Central strategy of the PRC's MOE, support from the government and provinces	A systematic state program with performance indicators and support for educational institutions is needed.
Graduate employment	Over 90% according to official data (MOE China, 2024)	The indicator may grow to 75–80% in the event of a large-scale launch of the program.
Flexibility of training programs	Regular updating of content in line with technological changes and business requirements	Introduction of a modular approach and adaptation of programs with the participation of employers
Scale of implementation	1000+ colleges, 100+ pilot projects, millions of students in the system	Initial pilots are already being implemented (100+ VETs), with potential for scaling up to regional clusters.

Source: created by the author based on (Lu, 2024; Yu et al., 2024; MOE China, 2024; ETF, 2023)

The comparison shows that China has achieved systematic implementation of dual education thanks to synergy between the government, educational institutions, and business. Ukraine has the initial potential and is already demonstrating the first successful practices, but full adaptation of the Chinese experience requires targeted policies, institutional strengthening, and the creation of conditions to motivate all participants in the educational process.

In the field of vocational education, the People's Republic of China follows a coherent strategy aimed at aligning educational development with scientific and technological advancement, industrial modernization, and the promotion of social cohesion. Table 6 presents the main strategic guidelines that determine the PRC's educational policy in this area.

Table 6: Strategic guidelines of the PRC's educational policy on vocational education

Strategy direction	Content of the strategic guideline	Link to national priorities

Integration of education with industry	Development of "production + education" models, promotion of cooperation between enterprises and colleges	Support for Industry 4.0, development of high value-added manufacturing
Vocational education as a basis for innovation	Inclusion of skills in AI, robotics, and digital design in basic educational standards	Priorities for scientific and technological breakthroughs within the framework of "Made in China 2025"
Digital transformation of education	Large-scale implementation of online platforms, smart environments, and educational clouds	Digitalization of the national economy, development of knowledge infrastructure
Regional balance	Creation of vocational education clusters in rural areas, support for small towns	Reducing socio-economic disparities, supporting balanced development
International integration and export of the model	Exporting the Chinese model of vocational education through the establishment of overseas branches and partnerships	Strengthening China's soft power, implementation of the Belt and Road Initiative (OBOR)
Lifelong learning	Establishment of an LLL system with open access to continuing vocational training and retraining	Labor force flexibility, adaptation to technological change, and population aging

Source: created by the author based on (Zhang & Zhou, 2024; Li & Xue, 2024a; Yu et al., 2024; MOE China, 2024; Tang et al., 2024)

The PRC's strategic model focuses not only on training skilled personnel, but also on transforming vocational education into a driving force for the development of national technologies and industry. It is integrated with long-term scientific programs and industrial initiatives, making vocational education in China a systemic tool for socio-economic modernization. This experience deserves careful study and adaptation in countries seeking to combine education with an innovative economy.

In today's world, engineering education is a key factor in ensuring technological development and competitiveness. China and Ukraine have different approaches to engineering education, reflecting their national priorities and resources. A content analysis of scientific sources, educational programs, and practical cases reveals common features and differences in the engineering training systems of both countries.

The methodological framework of the content analysis incorporated the use of mixed-methods approach, which involved both quantitative and qualitative issues in order to analyze three major areas of sources: academic literature, educational programs targeted at engineers, and real- case studies. In the Chinese case, the analysis used the data offered by the Ministry of Education (People Republic of China), intergovernmental reports (OECD, UNESCO, World Bank), and other recent publications of Chinese scholars who described the policy frameworks in the sphere of engineering vocational training in the country. In the context of Ukraine, the research was based on the statistics that included

the State Service for Education Quality, analytical publications of the National Agency with the Higher Education Quality Assurance, reports of the projects of the international cooperation (in particular with EdUP and the European Training Foundation) and the sample of the 15 educational programs of the institutions offering pre-tertiary vocational training and higher education.

The analysis was done through two consecutive steps. The former concerned tapping and assessing the quantitative indicators, either the total engineering graduates, the share of engineering disciplines in the overall architecture of higher education, the decadal growth patterning of graduate production, and the number of engineers per 1,00,000 population. Case study interviews were the second phase of work that concentrated several case studies and described the events of cooperation between the educational organizations and the representatives of the industry in the two countries.

The main criteria of analytical focus were the correspondence of the educational programs to the demands of an innovation-oriented economy, the level of corporate involvement in the formation of learning, the incorporation of digital skills, the efficiency of the dual education methodologies. The comparative knowledge was organized basing on the creation of a comparative table of summaries, on which the construction of the comparative model of engineering education systems was built. Table 7 introduces the major quantitative indicators that supplement visual presentation (e.g., graphs) and offer to conduct in-depth cross-national analysis.

Table 7: Key indicators of engineering education in China and Ukraine

Indicator	China (2023)	Ukraine (2023)
Number of engineering graduates	1,500,000	130,000
Share of engineering majors among graduates	32.8%	23.3%
Number of engineers per 100,000 population	1,071	295
Growth rate of graduates (2012–2023)	+43.2%	+8.3%

Source: created by the author based on (Munkholm, 2024; HireWithNear, 2025; OECD, 2024; TradingEconomics, 2025)

In 2023, China produced approximately 1.5 million engineers, accounting for 32.8% of the total number of higher education graduates. This demonstrates the high priority of engineering education in the country and its role in supporting technological development. The growth rate of engineering graduates in China between 2012 and 2023 was 43.2%, demonstrating the active expansion of this field. In Ukraine, in 2023, the number of engineering graduates was approximately 130,000, accounting for 23.3% of the total number of graduates. The growth rate for the same period was 8.3%, indicating stable but less dynamic development compared to China. The number of engineers per 100,000 population in China is 1,071, while in Ukraine this figure is 295. This indicates a significantly higher concentration of engineering personnel in China, which may be the result of targeted government policy and investment in this area.

The content analysis revealed significant differences in the approaches to engineering education in China and Ukraine. China demonstrates high growth rates and a

significant concentration of engineers, which is in line with its strategic goals in the field of technological development. Although Ukraine has a stable engineering education system, additional efforts are needed to improve its effectiveness and adapt it to modern labor market requirements. Studying the Chinese experience can be useful for improving the Ukrainian engineering education system.

Recommendations for adapting the Chinese experience to the Ukrainian vocational education system

1. *Institutionalization of the dual model through public-private partnerships.* It is advisable to introduce a legally established form of cooperation between vocational and technical institutions and employers, similar to Chinese practices. It is important to create financial incentives for businesses, such as tax breaks or partial state co-financing of training. This approach will not only promote a more practical focus in education, but also reduce the shortage of skilled labor in the market.

2. *Establishment of training and production centers at enterprises.* A pilot network of regional vocational training centers integrated into existing production facilities should be developed. They should provide continuous access for students to modern equipment, a real production environment, and engineering solutions. Such infrastructure will reduce the gap between theory and practice and foster a new culture of cooperation between education and industry.

3. *Modernization of educational programs with the participation of employers.* Ukrainian vocational training programs need flexibility and rapid updating of content. It is recommended to establish a mechanism for regularly updating curricula with the involvement of industry representatives. This will allow the list of competencies to be adapted to the requirements of the innovative economy, particularly in the areas of automation, digital technologies, and green production.

4. *Development of digital platforms for blended learning.* The successful Chinese experience of implementing national online platforms can be adapted by creating a state-run cloud platform for vocational education. It should include multimedia courses, simulators, and modules on engineering disciplines, which will provide access to high-quality content regardless of the applicant's place of residence. This is particularly relevant for regions with limited resources.

5. Discussion

The study confirmed the initial hypothesis that the systematic integration of vocational education with production, digitalization, and state strategic priorities contributes to its effectiveness and relevance to the needs of an innovative economy. It has been established that the People's Republic of China has achieved greater consistency, scale, and strategic consistency in the transformation of vocational education, particularly engineering, compared to Ukraine. This is consistent with the findings of Lu (2024) and Yu et al. (2024), who emphasize the role of public policy as a driver of dual education and modernization of learning content. Our findings also support the observations of Wang and Huang (2024) regarding the digital breakthrough in education, which creates a competitive advantage for the PRC in training highly skilled personnel. At the same time, other authors emphasize the importance of institutional flexibility and openness to

partnership, which is characteristic of the modern Ukrainian context. For example, studies by Goncharuk et al. (2021), Dembitska et al. (2020), and Pavlenko (2018) demonstrate the evolution of Ukrainian vocational education towards adaptation to the labor market, but with less coordination between stakeholders. Bondarenko and Semenova (2020) point to a gap between government goals and actual resources, which slows progress.

In the context of digital transformation, Iatsyshyn et al. (2024) and Luchyk et al. (2025) emphasize the importance of infrastructure modernization, but note that in Ukraine this transformation largely depends on external financing and pilot initiatives rather than systemic policy. This contrasts with the Chinese approach, where digitalization is part of the national strategy (Zhang & Zhou, 2024; Li & Xue, 2024a). The debate surrounding social justice in access to vocational education is particularly noteworthy. In China, this issue is addressed through regional balance policies (Tang et al., 2024; Li & Xue, 2024a), while in Ukraine, according to Chuiko et al. (2024) and Semigina and Stoliaryk (2024), inequality is exacerbated by war and crisis.

Although the study reinstates the findings of Lu (2024) and Yu et al. (2024) about China strategic coherence and good policy coordinating in the field of vocational education reform, the work also provides original contribution considering to present a structured comparative model that internalizes the hybrid governance dynamics of the situation in Ukraine. This research meets the gap in the analysis due to research that only looked at a single country or a description of the comparisons, the work combines empirical analysis, content, and implications of policy formulations to enhance the approach to policy strategy. By thus, it is reacting to a new academic discourse that supports the idea of adaptable and context-sensitive policy model in those economies that are experiencing digitalization, labor markets restructuring, and resource limitations concomitantly. It is not just a model that permits cross-national learning; it also permits the triage of policies in terms of what elements of the Chinese success under a centralized model can sensibly be adjusted to the Ukrainian decentralized and highly constrained reality. The paper thereby contributes with the comparative educational research by indicating the interaction amid national policy traditions, institutional capabilities, and the preparedness to innovate.

Although the engineering education system in China demonstrates the great use of artificial intelligence, virtual reality and augmented reality in the training settings, one of the critical conditions is the readiness of educators to adapt and combining these technologies into their work pattern as well. The current focus of China involves well-structured capacity-building initiatives, including national certification programs in digital pedagogy, ongoing in-service training, and investments in the professional development centers, allowing the mass implementation of new technologies. Conversely, the pilot projects in Ukraine lag behind in terms of infrastructure capacity, as well as human capacity. As we have found in our practical research, only a minority of students reported access to simulation-based or in VR-supported training and educators complained about the absence of organizational backing or education in digital pedagogy. All these findings demonstrate a major lacking in the capacity building of teachers in Ukraine. The solution to this gap should not be limited to investing in the technologies, but also development of a national system of computer training to the extent of training digital teachers and institutionalizing systematic professional development specific to vocational education.

The results confirm that, despite structural differences, both countries face common challenges: the need to update educational content, strengthen cooperation with business, and support continuous learning. However, unlike China, Ukraine has not yet developed a comprehensive dual training model with clear performance indicators. The study is limited in that it is based primarily on open sources, without empirical verification of the effectiveness of individual models. In addition, the results do not cover the specifics of regional education policies within the countries themselves, which may affect the overall picture. Thus, although there are differences between the authors' positions — from an emphasis on a centralized state strategy to support for a flexible and market-oriented model — most researchers agree on the importance of innovation, digital technologies, and partnerships with business. Further studies should focus on developing mechanisms for the practical implementation of dual education in Ukraine, taking into account the Chinese experience, as well as conducting a comparative empirical study of the effectiveness of graduate training in different models of vocational education.

Even though the research is related to the systemic specifics of vocational education in Ukraine, it should be stated that there are regional differences in the outcomes of religious implementation of dual education. Unlike China where the aspect of social justice is strategically and adequately addressed including the formation of education clusters in rural settings, Ukraine has no synchronised system of maintaining equity in both urban and rural settings. Evidence based on preliminary survey on some of the sampled institutions shows that rural TVETs tend to work with older infrastructures, limited employer participation, and have comparatively weak digital capability. It underlines the necessity of further investigations of the micro conditions, especially in the underfunded areas, where dual education programs might succeed conditioned by the particularities of the micro context, like regional economy characteristics, demographic patterns, and existence of partners enterprises. Such disparities need to be eliminated in order to give equal opportunity to vocational modernization around the country.

The contrast of large-scale and centralized approaches in China and more divided and decentralized reform practice in Ukraine supports the argument of the role played by governance mechanisms in determining the result of educational programs. The persistence of China in adopting dual education and digital innovation has been intimately linked to the country spelling out national performance indicators; maintaining line-built policy, and guaranteed consistent investment using built coordinated state programs. Ukraine does not however have a consolidated set of monitoring and evaluation of vocational education outcome. It was not uncommon to find that reforms which have been implemented are isolated initiatives that are not followed up and feedback loops are not instituted.

To fill these vacuums, Ukraine might enjoy a productive experiment with an outcomes-based model of governance based on the Chinese model, namely, the introduction of national performance criteria in vocational education (e.g., graduate employment rate, enterprise participation index, digital readiness scores), a notion of a division of roles carried out by central, regional, and institutional players, and long-term budget model that promotes innovation. These would allow it to have a framework of measuring, incentivizing, and commit the public-private to the direction of modernization of engineering-related qualifications.

6. Implications and further research

The results obtained showed that a comparative study of vocational education models in China and Ukraine allows not only to identify structural and content differences, but also to suggest opportunities for adapting effective solutions in the national context. Contrary to initial assumptions about the incompatibility of the centralized Chinese system with the Ukrainian educational model, the analysis demonstrated significant potential for combining Ukrainian flexibility with Chinese strategic integrity.

This creates a fruitful area in which hybrid governance forms in vocational education can be explored further how national power structures can still give a sense of direction to the governance structure but where the implementation strategy is regional, institutionally specific and dependent on available resources. Such blended models provide a chance to integrate the notions of innovation and responsiveness with the notions of coordination and strategic alignment and make it possible to such a country as Ukraine to seek customized changes without undermining the goals of national policies and compatibility with international commitments. It can be proposed that future study and research efforts need to be invested in the conceptualization and practical testing of such hybrid models in transition economies who are currently undergoing educational, economic, and digital change all at once.

The novelty of this research lies in the development of a generalized analytical model that synthesizes content analysis, comparative statistical data, and case-based evidence related to dual education practices. This integrative approach enables a multidimensional understanding of engineering training systems. The practical value of the study stems from its potential application in shaping national strategies for engineering workforce development—particularly through the promotion of public-private partnerships, the modernization of curricula, and the advancement of digital infrastructure in vocational education. Among the limitations, it is worth highlighting the dependence on secondary sources and statistical databases without the possibility of field verification. Future research should focus on studying the effectiveness of specific models of cooperation between educational institutions and businesses in conditions of limited resources, as well as analyzing the impact of the regional context on the implementation of dual education. It is also promising to study the motivations of students to participate in dual programs and to identify indicators of their professional success in a post-industrial society.

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Appendix A.

Questionnaire for Empirical Survey

Title: *Survey on the Implementation of Dual Education and Digital Tools in Engineering Training Programs (Ukraine)*

Block 1: General Information

1. Your status:
2. □ Student □ Teacher
3. Institution name (optional): _____
4. Year of study / Teaching experience: _____
5. Field of study / Discipline: _____

Block 2: Dual Education

5. Does your institution offer dual education programs (combined study and work-based learning)?

□ Yes □ No □ I don't know

6. If yes, do you personally participate in such a program?

□ Yes □ No

7. What is the typical duration of your internship(s)?

□ Less than 2 weeks □ 2–4 weeks □ More than 1 month

8. Is your internship coordinated with the educational program?

□ Fully □ Partially □ Not at all

Block 3: Digital Tools

9. Does your institution use a learning management system (LMS)?

□ Yes □ No □ I don't know

10. Which digital tools are used in your program? (Select all that apply)

□ LMS (e.g., Moodle) □ VR/AR modules □ Simulators □ Online quizzes/tests

11. How would you rate the digital readiness of your training program?

□ High □ Moderate □ Low □ Very low

Block 4: Partnerships and Barriers

12. Does your institution cooperate with employers in developing training content?
□ Yes □ No □ I don't know
13. Are training and employment opportunities discussed with students by business representatives?
□ Often □ Sometimes □ Rarely □ Never
14. How would you rate the relevance of your training to actual job market demands?
□ Highly relevant □ Mostly relevant □ Poorly aligned □ Not relevant
15. What are the main obstacles to the implementation of dual education at your institution?
(Open-ended)

Block 5: Suggestions

16. What changes would you recommend to improve the connection between education and real work experience?
(Open-ended)
17. Do you believe digital tools (simulators, VR, LMS) help you prepare better for your profession?
(Open-ended)
18. In your opinion, what could motivate businesses to participate more actively in educational programs?
(Open-ended)
19. Any additional comments:
(Open-ended)