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Evolution of curricula in technical colleges: Compliance with modern technological requirements

Abstract. The study aimed to identify the key factors of modernisation of educational technology programmes to improve vocational education in the context of the modern labour market. The methodological basis of the study was a comparative analysis of curricula in technical colleges in Ukraine and leading foreign countries such as the United States, Sweden and Germany. This method was used to analyse the vocational education system of Ukraine in the context of global trends and determine the relationship between international educational practices and changes in the Ukrainian system. The main results of the study demonstrated that the introduction of international approaches, such as the dual system of education and the use of the latest technologies, significantly improves the quality of training and increases their adaptability to the conditions of the modern labour market. The study determined that cultural and socio-economic differences can complicate the effective implementation of foreign experience, emphasising the importance of adapting these models to national conditions. The study has made significant progress in identifying effective strategies for integrating international educational practices, which will ensure the sustainable development of vocational education in Ukraine and increase the competitiveness of Ukrainian specialists in the global market. The results also highlighted the need for further study and improvement of the adaptation of international models to national realities. The study highlighted the importance of close cooperation between educational institutions, government agencies, and the private sector for the successful modernisation of vocational education. The findings can be useful for educational institutions in improving curricula, for government agencies in developing educational reforms, and for the private sector in actively engaging employers in training

Keywords: technological education; innovations; standards; scientific progress; trends

INTRODUCTION

Studying the problem of curriculum evolution in technical colleges in Ukraine is becoming increasingly necessary due to the rapid development of technology, which requires constant updating of students' knowledge and skills. The technical field is constantly changing, so curricula must meet modern labour market requirements, ensuring that graduates are competitive and highly sought after. Changes in the technological environment, such as automation, digitalisation and the integration of artificial intelligence, create new requirements for professional skills and knowledge. Therefore, curricula should meet the current needs of the labour market and provide graduates with the necessary

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competencies. Many Ukrainian technical colleges use outdated methods and curricula that do not meet international standards, which limits students' opportunities and affects the quality of their professional training.

An important challenge is the study of international experience in the field of vocational education, which can identify effective models and approaches that can be adapted to Ukrainian conditions. For instance, the dual system of education, which has been successfully applied in many European countries, can significantly improve the quality of training in Ukraine. There are also specific challenges, such as cultural and socio-economic differences, that can affect the effectiveness of international practices. Researching these aspects helps to develop recommendations for the successful adaptation and implementation of new educational strategies. This will help to increase the competitiveness of Ukrainian specialists in the global labour market and to develop an educational policy that meets modern requirements and ensures the training of highly qualified personnel.

More and more researchers address the issue. Each of them has highlighted important aspects of the evolution of technical college curricula. M. Kamal *et al*. (2023) analysed the elements of cooperative learning in the development of curricula for subjects related to construction drawing in vocational colleges. The study revealed how the integration of cooperative learning can improve students' technical training. A contemporary study by R. Kossmann (2022) examined individual education plans in the context of technical education, focusing on their impact on adaptation to curricula and on reducing parental criticism. The findings demonstrated how individualising curricula can affect learning outcomes. J. Künstler-Sment *et al*. (2024) developed a standardised data management plan for educational research that can be applied to curriculum optimisation in technical colleges to effectively manage data for curriculum improvement. Q. Liu (2024) investigated the evaluation of the effectiveness of the training platform for technical professionals and how curriculum changes can affect the training of technical professionals. X. Ma (2024) examined the reform of the curriculum assessment system in the context of the needs of professional positions and how curriculum modernisation can meet the current requirements of technical specialities.

S. McGrath & S. Yamada (2023) reviewed current and emerging trends in skills development in vocational education and training. This helps to understand how the evolution of curricula meets the changing demands of the labour market. A. Meshel *et al*. (2023) investigated the implementation of the Plan-Do-Study-Act plan in emergency training curricula. The results show the effectiveness of integrating new methods into technical curricula to improve practical skills. R. Powell *et al*. (2024) created a repository of robotics lesson plans that can be useful for improving curricula in technical colleges. This highlights the importance of updating and expanding learning resources to improve student learning.

Y. Ma *et al.* (2022) and D. Silva Costa *et al.* (2023) studied the impact of individualised education plans on the inclusion of students with autism in teamwork. This study demonstrates how curriculum adaptation can affect the effectiveness of learning in technical specialities. Despite the important contributions of these researchers, the long-term impact of the integration of new technological technologies in vocational education on curricula and their evolution in technical colleges remains under-researched. The study aimed to identify a model for the development of technical education programmes in Ukraine, addressing international experience, to improve its compliance with modern labour market requirements.

The objectives of the study were:

- To study the negative educational factors affecting the quality of curricula in Ukraine in Ukraine.
- To analyse international educational models of educational programmes that have been successfully implemented in the United States of America, Sweden and Germany and determine their potential for adaptation in Ukrainian technical colleges.
- To assess the impact of new technologies on vocational training and develop recommendations for their integration into curricula in Ukraine.

MATERIALS AND METHODS

This study included two main stages. The first stage of the study included a systematic analysis, which was a comprehensive process of studying and evaluating the existing curricula of the Ministry of Education and Science of Ukraine (2024). At this stage, a detailed review of the current curricula used in technical colleges in the country was carried out. An important part of this process was to study the structure of the curricula, their content and their relevance to modern labour market requirements. In particular, the extent to which the curricula integrate the latest technologies and teaching methods was addressed, which is critical for training competitive specialists. Percentage feedback was collected from teachers and students to determine their needs and expectations of the curriculum. The study involved 50 teachers and 100 students representing vocational education institutions. The teachers' ages ranged from 30 to 60 years, and the students from 18 to 25 years. There were 20 men and 30 women among the teachers, and 80 men and 20 women among the students. This included gathering feedback on the effectiveness of existing programmes, as well as suggestions for improvement. The analysis of this data identified weaknesses in the current curricula and determined what changes are needed to improve the quality of education. The first phase demonstrated the current state of curricula in technical colleges in Ukraine and laid the groundwork for the next phase.

The second stage involved a comparative analysis of the curricula of technical colleges in Ukraine and foreign countries such as the United States of America, Germany and Sweden. This demonstrated the results of the comparative analysis, including recommendations for further

improvement of curricula based on the data obtained. Four technical colleges representing each country were selected for this purpose. In the second stage of the study, a comparative analysis of technical college curricula in Ukraine and abroad, in the United States of America, Germany, and Sweden, was used. For this purpose, four technical colleges were selected, one from each country, representing different aspects of technical education and having a significant impact in their regions. Georgia Tech is known for its innovative education and best practices in technical education. To compare the curricula in Germany, the Technische Hochschule Neubrandenburg was selected, which represented the integration of the dual system in educational programmes, the Chalmers University of Technology, known for its innovations in technical disciplines and international cooperation, and the College of Technology of Lviv Polytechnic National University, which is one of the leading technical universities in Ukraine. The research was conducted in compliance with all ethical standards set out in the Declaration of Helsinki (2013).

The curricula at the above-mentioned educational institutions were compared based on the following criteria: relevance and compliance with modern requirements, structure of educational modules, analysis of course organisation, including the number and types of disciplines, teaching and assessment methods, practical training, integration of new technologies, international standards and accreditation. The selected criteria comprehensively assessed the effectiveness and relevance of curricula in technical colleges and their compliance with modern educational and labour market requirements. In addition, considerable attention was paid to developing recommendations for adapting these international models to Ukrainian conditions. This included developing plans for implementing new teaching approaches, identifying the necessary resources and training teaching staff.

RESULTS

Curricula at technical universities are documented programmes of study that define the structure, content and sequence of academic disciplines, as well as the methods of teaching them. These curricula are designed to provide students with the necessary knowledge and skills in line with the requirements of the modern labour market and technological innovations. The curriculum usually includes an extensive list of subjects, the number of academic hours, assessment methods and success criteria.

Adherence to curricula in technical colleges is critical to ensuring quality standards in education. Curricula should be strictly adhered to, providing structured and consistent training for students. However, in practice, deviations may occur, often due to the need to adapt to rapidly changing technologies or the specific needs of students and the labour market. Deviations can be manifested in a change of emphasis in teaching, the introduction of new courses without revising existing plans, or failure to follow recommended methods. In particular, the study of the evolution of curricula in technical colleges in Ukraine highlighted both the pros and the significant cons of introducing technological innovations. The positive aspects of adhering to curricula include providing a structured approach to education that helps students achieve clearly defined educational and professional goals. Standardised curricula also facilitate accreditation and quality assessment. However, the downside may be a lack of flexibility to respond quickly to new trends and technologies, which may limit the relevance of the programme. Some colleges may be lagging modern requirements due to outdated curricula or insufficient adaptation to specific industry needs. A systematic analysis of curricula is important to identify both the strengths and weaknesses of existing programmes and to develop recommendations for improvement to enhance the quality of education in technical colleges in Ukraine.

The evolution of curricula in technical colleges in Ukraine has undergone numerous changes and adaptations, driven by both the internal needs of the educational system and external labour market demands and global educational trends. In the early 2000s, these programmes were largely focused on traditional disciplines with an emphasis on theoretical knowledge. The curricula of that time were characterised by rigid standardisation, which limited the flexibility to introduce new technologies and relevant changes in the respective industries. Technical education in this period favoured basic technical and engineering disciplines that were mandatory for training specialists in classical industries and manufacturing. However, with the development of technology and changes in labour market requirements, there was a need to update the curriculum. Gradually, the process of introducing new topics and teaching methods focused on practical skills and the integration of modern technologies began. This contributed to greater flexibility in the programmes, allowing them to be adapted to modern needs. Over time, the curricula of technical colleges began to include courses in information technology, automation, robotics and other innovative areas, reflecting the new challenges and opportunities faced by modern education.

In the 2000s, the educational system began to reform, including updating curricula to reflect new technologies and labour market needs. The concept of integrating practical skills into the learning process was introduced, and computer and information technologies were started to be integrated into the curriculum. New courses were introduced in project management, computer science, and production process automation. This period saw significant changes in the direction of adaptation to European education standards. Reforms included the introduction of a credit-module system, which allowed for greater flexibility in educational programmes and the possibility of personalising learning. New courses were gradually introduced to reflect the needs of the modern economy, such as robotics, renewable energy and digital technologies. Practical training, internships and cooperation with industry were prioritised.

In recent years, Ukrainian technical colleges focused on the intensive integration of modern technologies into their curricula. The updated curricula incorporated the requirements of Industry 4.0, including automation, artificial intelligence and big data. These changes are a response to the growing labour market demand for specialists capable of working with advanced technologies. In this regard, new initiatives have emerged in education policy aimed at introducing distance learning programmes and hybrid learning models that combine traditional and digital forms of education. According to the Ministry of Education and Science of Ukraine, as of 2023, 65% of technical colleges have implemented modular study programmes, which allow for a more flexible approach to shaping students' educational trajectories. These modular programmes also contribute to updating the content of education in line with modern technologies and trends. In addition, 40% of technical colleges have introduced courses on the latest technologies, such as artificial intelligence, big data analysis and robotics. This has helped to improve the quality of education, as evidenced by more than 75% of technical college students who reported improved learning due to these innovations (Ministry of Education and Science of Ukraine, 2024).

As of 2023, 80% of technical colleges in Ukraine have updated their curricula to include modern technologies such as IoT and Big Data (Ivanov *et al.*, 2023). This study confirms that 60% of students report a significant positive impact of the new courses on their preparation for professional activities. However, 30% of educational institutions still face challenges in implementing the new standards due to insufficient material resources and staffing constraints. Thus, the volition of curricula in technical colleges in Ukraine demonstrates a tendency to adapt and integrate modern technologies, which is necessary to maintain the competitiveness of education in the face of rapid changes in the labour market.

In this study, teachers and students provided feedback on the effectiveness of curricula in technical colleges. Among the teachers, 70% expressed concern about the lack of relevance of teaching materials. Many of them noted that curricula are often not updated in line with modern technological advances and labour market needs. In addition, 64% of teachers said that the existing curricula do not always consider an interdisciplinary approach, which is important for the development of students' practical skills in today's environment. Regarding administrative aspects, 50% of teachers pointed out the need to improve the organisation of the educational process, including revising the format and frequency of practical classes. In particular, 80% of students expressed their dissatisfaction with the insufficient integration of practical tasks into the curriculum. They emphasised that real projects and internships, which improve real-world work condition training, should be prioritised. 75% of students also noted that the curricula are not sufficiently focused on the needs of the labour market, which leads to irrelevance of the knowledge gained during study. Another 60% of students pointed to the need to update teaching materials and incorporate new technologies that are relevant to their professional field.

The feedback collected revealed a significant gap between the requirements of the modern labour market and the existing curricula in technical colleges in Ukraine. This gap indicates the need for a thorough review and modernisation of the curricula to ensure that they meet the current requirements and expectations of both teachers and students. The identified shortcomings indicate that many programmes are still not sufficiently adapted to the realities of Industry 4.0 and do not fully prepare students for the challenges posed by the modern labour market. The feedback collected was an important basis for further analysis of specific technical colleges, as shown in Table 1. The analysis identified weaknesses in existing programmes and determined which aspects need to be updated or improved. Based on the data obtained, recommendations were developed to modernise the curricula, including the integration of the latest technologies, increasing the practical component and increasing the flexibility of educational pathways. These measures will help improve the quality of training and increase the competitiveness of specialists in the labour market.

Table 1. Analysis of the activities of vocational education institutions following key criteria

Criteria	Vocational education institutions			
	Technische Hochschule Neubrandenburg	Chalmers University of Technology	Georgia College of Technology	College of Technology of Lviv Polytechnic National University
Curricula	Integration of interdisciplinary courses	Focused on practical skills	Balanced theoretical and practical courses	Needs to be updated, and more balance between theory and practice
Internship programmes	Developed internship system	Internships are compulsory in the educational process	Internships at industrial enterprises	Limited internship opportunities
Cooperation with industry	Close cooperation through a dual system	Active partnership with companies	Active cooperation with enterprises	Fewer partnerships with industry
Employment of new technologies	High level of innovation and modern laboratories and equipment	Integration of the latest technologies in education	Modern laboratories and equipment	Limited and gradual increase in the use of innovation
Support for students	Support system through consultations and mentoring	Support through academic advisors	Strong support through additional courses	Developed support system

Source: compiled by the authors

The data in Table 1 reveals significant differences in approaches to technical education. The benchmarking criteria determined that Ukraine lags the other three countries in several key areas, such as integration of the latest technologies, level of practical training, cooperation with industry, international experience and access to modern equipment. The integration of the latest technologies into the curriculum is one of the main differences. In the US, Georgia Tech is actively implementing innovations such as artificial intelligence, big data and other modern technologies in its curriculum. This provides students with access to the relevant knowledge and skills needed to work in advanced industries. Sweden's Chalmers University of Technology also focuses on the latest technologies but additionally offers opportunities for international cooperation and interdisciplinary research. In contrast, in Ukraine, particularly at Lviv Polytechnic National University, although the latest technologies are gradually being integrated into the curriculum, this is happening more slowly due to limited access to modern equipment and resources.

The level of practical training of students in Ukraine lags far behind that of other countries. Germany's Technische Hochschule Neubrandenburg uses a dual education system that combines theoretical classes with practical experience in real-world settings, providing students with a deeper understanding of their specialities. In the United States, Georgia Tech also provides students with numerous internship and practical work opportunities through close cooperation with industry. Sweden, through Chalmers, offers students participation in international projects and internships. In Ukraine, practical training is part of the educational process, but the level of integration with industry is less pronounced, which reduces the effectiveness of student training compared to international standards.

Collaboration with industry and access to modern equipment also points to Ukraine's lagging. Georgia Tech actively cooperates with industry, providing students with the opportunity to collaborate on real-world projects and gain experience in leading companies. Neubrandeburg uses a dual system that includes close cooperation with local companies. Chalmers provides international cooperation and access to global research networks. In Ukraine, although Lviv Polytechnic has some initiatives with industrial cooperation, in general, access to modern equipment and integration with industry is limited, which negatively affects the quality of education. The above aspects indicate the need for significant changes in the curricula of technical colleges in Ukraine. To catch up with international standards, Ukraine needs to focus on integrating the latest technologies, improving practical training for students, expanding cooperation with industry, and providing access to modern equipment. These measures will help to increase the competitiveness of Ukrainian technical education institutions in the international arena and prepare students for the challenges of the modern labour market.

Curricula must meet modern technological requirements, as technology is constantly changing and improving, which challenges educational institutions to adapt their training to new realities. Modern labour market requirements dictate that graduates must have not only theoretical knowledge but also practical skills that allow them to effectively cope with new technologies. Timely updating of curricula helps to ensure high-quality education and improve students' professional readiness. The technology requirements cover various aspects that include the integration of the latest technologies such as artificial intelligence, big data, the Internet of Things (IoT) and automation. Artificial intelligence (AI) is being actively used to solve complex tasks such as forecasting, pattern recognition and automation of routine processes. Educational programmes should include training in the basics of AI, as well as its application in various industries. Big Data has become critical for modern business as it allows collecting, storing and analysing huge amounts of information to make informed decisions. Training programmes should provide knowledge in data analysis, statistics and database management. Process automation and robotics are also important aspects that require integration into the curriculum. Understanding the principles of automation, robot programming and control systems are critical to training professionals who can use modern technologies.

Modern curricula must also consider rapid changes in industries that require constant updating of content and teaching methods. The use of interactive technologies, online resources and simulations helps students to better absorb the material and adapt to changing conditions. The compliance of curricula with technological requirements ensures the training of highly qualified specialists who can use the latest technologies and meet the requirements of the modern labour market. This contributes to the development of innovations, increases the competitiveness of graduates and maintains high standards of education.

In Ukraine, there is often a mismatch between the curricula of technical colleges and modern technological requirements, which seriously affects the quality of training. Curricula that were developed several decades ago often fail to keep up with the rapid pace of new technologies. This leads to students being taught using old methods that do not include the modern tools and technologies needed for successful professional activities. Many technical colleges still use outdated courses and laboratories that do not meet current industry requirements. For example, the curriculum may lack courses on new software platforms, data management systems, or the latest design methods. This creates a gap between the knowledge that students receive and what the modern labour market expects from them.

It is also important to note that curricula in Ukraine are often not adapted to the specific needs of the changing labour market. In many cases, educational institutions are not able to quickly update curricula or integrate new technologies into the learning process due to a lack of resources or administrative obstacles. These challenges highlight the need to reform curricula to ensure that they meet modern technological requirements. Existing curricula need to be reviewed, updated to reflect the latest advances in technology,

and teachers need to be continuously trained to keep education up to date. Otherwise, the gap between the theoretical knowledge students receives and the practical skills required in the labour market will only grow, which will negatively affect the competitiveness of graduates on a global level.

To ensure that the curricula of technical colleges in Ukraine meet modern technological requirements and become more effective, several key recommendations need to be implemented to facilitate their evolution and adaptation to the rapidly changing labour market. The first important step is to regularly update curricula based on the latest technological advances and trends. To do this, a mechanism that allows for ongoing review and adjustment of programmes, and introducing new courses that meet current industry requirements is required. This can be achieved through the creation of special commissions with the participation of industry representatives to assess the relevance and effectiveness of the curricula.

The next step is the active implementation of dual education, where theoretical knowledge is combined with practical experience at enterprises. With this approach, students can gain real-world experience while studying, ensuring that they are ready for the demands of the modern labour market. The dual education system has already been successfully implemented in many European countries and can be an effective tool for improving the quality of technical education in Ukraine. Partnerships with industry and enterprises to create practical internships and projects allow students to work on real-world tasks, which contributes to their professional development.

In addition, regular professional development should be provided to keep teachers up to date with the latest developments in their field. Teachers need to have access to the latest technologies and methodologies to enable them to teach students effectively. Organising trainings, seminars and refresher courses for teaching staff will help ensure that they are competent and prepared to teach new subjects. Another necessary aspect is the integration of new technologies into the learning process. Technical colleges should provide students with access to modern equipment and software used in industry. This includes updating laboratories, equipment and software to allow students to work with the real tools and technologies they will encounter in their professional lives. It is also necessary to develop an interdisciplinary approach to learning, allowing students to gain knowledge from different areas of science and technology. This will help to develop universal skills and abilities that can be applied in various fields of activity. Interdisciplinary programmes can include the integration of courses in project management, business analytics and other related disciplines, which will help to create a comprehensive approach to solving technical problems.

To ensure continuous monitoring of the effectiveness of curricula, it is important to organise feedback from graduates and employers. Regular surveys among graduates and analysis of feedback from employers will help identify weaknesses in educational programmes and promptly make the necessary changes. Such a mechanism will help create a dynamic educational system that will be able to respond quickly to new challenges and changes in technology and the labour market. This will not only improve the quality of education but also ensure that students' training meets modern requirements, making them competitive in the labour market.

Implementation of recommendations for improving curricula in technical colleges in Ukraine is an important step towards modernising education, but the process is complex and requires systematic efforts. Implementation requires a comprehensive approach, including updating teaching materials, professional development of teachers and the introduction of modern technologies. Table 2 shows the percentage of opportunities for implementing these recommendations in practice by Ukrainian technical colleges, which can be used to assess the level of readiness of educational institutions for change and identify key challenges in this process.

Table 2. Characteristics of the correlations between the possibilities of implementing the recommendation in practice by Ukrainian technical colleges

Recommendation	Realism of execution	Characteristic
Regularly updating the curriculum	60%	Will require resources to set up commissions and collect data, but there is scope for gradual implementation
Implementation of dual education	50%	Integration with enterprises and additional funding is required, which can be difficult to implement at the national level
Professional development of teachers	70%	Most colleges can organise training, but budget constraints may affect their regularity
Integration of new technologies into the educational process	55%	The cost of the latest hardware and software can be significant, but there are support programmes available
Interdisciplinary approach to learning	65%	Can be implemented through retraining and revision of programmes, but requires time to adapt
Feedback from graduates and employers	75%	Implementation through regular surveys and meetings is achievable but will require a systematic approach.

Source: compiled by the authors

Recommendations such as regular updating of curricula, introduction of dual education, professional development of teachers, integration of new technologies and feedback from graduates are critical to ensure that education meets

modern technological requirements. These changes will not only improve the quality of training but will also contribute to better integration of graduates into the labour market. For example, regular updating of curricula will help to keep the knowledge and skills acquired by students up-to-date with rapidly changing technological trends. The introduction of dual education will provide students with practical experience while they are still studying, which will significantly improve their professional skills and readiness for real-world assignments.

However, the implementation of these recommendations is a difficult task for Ukraine. It requires not only financial expenditures but also significant organisational efforts. For instance, the integration of new technologies requires the purchase of modern equipment and software, which can be expensive. Professional development of teachers requires the organisation of trainings and courses, which also requires resources and time. Implementation of dual education requires close cooperation with industry, which can be difficult if partnerships are not well developed.

Despite these challenges, Ukraine has the potential to successfully implement the recommendations. Technical colleges in Ukraine have an established infrastructure and experience in training specialists. Many of them have modern laboratories, qualified teachers and a good academic reputation. There are government programmes and grants aimed at modernising education that can help finance the necessary changes. Ukraine is actively developing cooperation with international educational institutions, which opens opportunities for the exchange of experience and resources. Another important factor is the growing interest in technological innovation among Ukrainian students and young professionals. This interest can be used to stimulate changes in the curriculum, adapting it to new technologies and methodologies. In addition, there is an existing human resource potential, including young, ambitious teachers, who are ready to introduce new approaches and technologies into the learning process.

DISCUSSION

The results of the study showed that the modern world is characterised by rapid technological development, which necessitates changes in educational programmes, especially in technical colleges. In response to these transformations, curricula must constantly evolve to ensure that they meet the current requirements of the labour market. The study determined that technical college curricula have undergone a significant transformation in recent decades. In the beginning, technical education was focused on training skilled workers capable of performing routine tasks in plants and factories. Over time, curricula began to include more complex technical disciplines such as engineering and computer science, reflecting the growing role of technology in the economy. Later, however, radical changes to the curriculum became necessary. This is due to the emergence of new technologies such as artificial intelligence, big data, and the Internet of Things, as well as the requirements for interdisciplinary knowledge and skills. These findings are in line with N. Rudhumbu (2021) and A. Pereira *et al*. (2023), who noted that the labour market now requires technical college graduates to have not only knowledge of specific technologies, but also critical thinking skills, creative problem-solving, and the ability to continuously learn throughout their lives.

The survey results showed that the curricula of technical colleges have changed significantly in recent years, towards greater integration of modern technologies and teaching methods. For example, the study of programming and data analysis has become mandatory in most technical specialities. This is confirmed by J. Rossmann *et al*. (2020) and J.I. Venegas-Muggli (2020), who noted that technical colleges in many countries have already adapted their programmes to include courses in big data, machine learning, and cybersecurity. Such changes demonstrate the readiness of educational institutions to meet the challenges of our time. Another important issue raised in this study is the interdisciplinary approach to education. According to a study by A. Venatius *et al*. (2023), modern employers expect graduates of technical colleges to have not only highly specialised knowledge but also skills in related fields. For instance, engineers are now expected to have a basic knowledge of economics and project management, as well as an understanding of the social sciences for effective communication and teamwork. R. Salhab (2024) and J. Albrecht *et al*. (2024) also confirmed this trend, noting that technical colleges are increasingly introducing courses to develop soft skills such as teamwork, communication, and time management. Changes in curricula are accompanied by the introduction of new teaching methods. As noted by X. Li *et al*. (2019), modern technical colleges are increasingly using innovative teaching approaches, such as project-based learning, problem-based learning, and simulations. This allows students not only to acquire theoretical knowledge but also to apply it in practice. These results are consistent with this study, which showed that higher education students who study using such methods are better prepared for the real world, which is positively noted by employers.

The results of the study showed that one of the key aspects is the importance of adaptability and flexibility of curricula in technical colleges. This correlates with the work of Y. Ma *et al*. (2022), who identified that given the rapid development of technology, educational institutions need to be able to change and adapt their programmes quickly. They added that traditional curricula that are updated only every few years can no longer meet the demands of the modern world. Therefore, they recommend the introduction of modular learning systems, where individual courses and units can be easily adapted to new technological trends. Studies by C. Winberg & S. Hollis-Turner (2023), P. Themba (2023), and M. Razi-ur-Rahim *et al*. (2024) also confirmed that technical colleges that use flexible modular programmes are better able to respond to labour market changes and provide their students with relevant knowledge and skills. For example, some colleges have already

introduced a system where students are offered several course options to choose from, allowing them to specialise in specific areas of technology, such as cybersecurity, robotics or artificial intelligence. This concurs with the findings of this study that the flexibility of training allows graduates to be competitive in the labour market and quickly adapt to new conditions.

In recent years, the concept of lifelong learning has been receiving more and more attention in the educational environment. This is especially true for technical specialities where technology is rapidly becoming outdated. As noted by A. Bejan *et al*. (2020), C. Saneewongnaayuttaya *et al*. (2021), technical colleges should not only provide students with current knowledge but also teach them independent learning and critical thinking skills that will allow them to constantly update their knowledge after completing formal education. This is supported by this study, as curricula must include elements that promote the development of such skills, such as courses on knowledge management, self-management and analysis of new technologies. Another important aspect considered in this study is the involvement of industry in curriculum development. The study by Y. Xu *et al*. (2023) noted that technical colleges are increasingly collaborating with enterprises to ensure the relevance of their programmes. For example, companies provide information on current knowledge and skill requirements, participate in the creation of teaching materials, and offer internships for students. Such interactions help to ensure that technical college graduates are better adapted to the needs of the labour market. This is supported by research by L. White *et al*. (2023) and J. Albrecht *et al*. (2024), which shows that students who complete internships during their studies have a higher chance of successful employment after graduation.

Despite the positive developments, this study also highlights some of the challenges faced by technical colleges in adapting their curricula to modern requirements. As noted by researchers A. Bopegedera (2021), C. Willis *et al*. (2024), one of these challenges is the constant need to update material and technical facilities and training equipment. This requires significant financial resources, which are not always available, especially in public colleges. This is consistent with this study. It was determined that there is a problem of insufficient qualification of teachers who do not always have time to master new technologies and teaching methods. It was added that there is a need to further improve the relevance of curricula to current requirements. To do this, it is necessary to ensure that curricula are constantly updated in line with current technological trends and labour market requirements. This implies regular updating of teaching materials and expanding cooperation with industry. More time should be devoted to the development of interdisciplinary programmes and the integration of soft skills courses into technical specialities. This will help graduates be more competitive in the labour market. These thoughts were confirmed by N. Siyam & S. Abdallah (2022), and M. Byrnes *et al*. (2024). They found that there is a need to invest in teacher training and access to modern teaching materials and equipment. This will allow teachers to better respond to the challenges of the modern world and ensure a high level of student learning. It is equally important to increase the use of innovative teaching methods, such as project-based learning, simulations and distance learning, which will help students develop practical skills and increase their readiness to work in the real world.

Based on the analysis of the research results, it can be concluded that the curricula of technical colleges are evolving in response to modern technological challenges. They are increasingly focused on the integration of new technologies, the development of interdisciplinary knowledge, the use of innovative teaching methods and close cooperation with industry. Nevertheless, this process is accompanied by certain challenges, such as the need to constantly upgrade the material and technical base and improve the qualifications of teachers. Therefore, the evolution of curricula in technical colleges is necessary to ensure that they meet modern requirements. Various studies confirm that colleges that actively adapt their programmes, integrate new technologies and teaching methods, and collaborate with industry are better able to prepare their students for the challenges of the modern labour market. However, for further success, it is necessary to continue to invest in curriculum flexibility, interdisciplinary knowledge and self-learning skills, which will allow graduates to be prepared for the constant changes in the world of technology.

CONCLUSIONS

A comparative analysis of the curricula of technical colleges in Ukraine and leading foreign countries, such as the United States of America, Sweden and Germany, has shown that the integration of international approaches, such as the dual system of education and the introduction of the latest technologies, has a positive impact on the quality of training and increases their adaptability to the labour market. However, the study also revealed certain challenges. Cultural and socio-economic differences between countries can make it difficult to effectively implement foreign experience in the Ukrainian context. This underscores the need to adapt international models to national conditions, which requires additional research and in-depth analysis of the specifics of the Ukrainian labour market and education system. Despite the progress made in identifying effective strategies for integrating international educational practices, questions remain about the scale and sustainability of such changes. Particular attention should be paid to the development of partnerships between educational institutions, government agencies and the private sector, which will facilitate the exchange of experience and support the sustainable development of the educational system in Ukraine.

In addition, the survey results showed that teachers and students have different expectations and needs that need to be addressed when developing and modernising educational programmes. Teachers stressed the need for continuous professional development and access to

modern teaching materials, which would allow them to meet the high standards of education implemented in international practice. Students also pointed out the importance of practical orientation of training and the possibility of applying the acquired knowledge in practice during their studies. The feedback also revealed the need to update the technical support of educational institutions, which is an important component for the successful implementation of the latest educational technologies. In addition, the importance of support from employers was emphasised, who could become active partners in curriculum development by providing their recommendations and providing students with internship opportunities. The analysis of the findings identified specific steps to improve curricula, including the development of flexible educational pathways that would consider the individual needs of students and ensure their readiness for the challenges of the labour market.

Prospects for further research include a deeper analysis of the mechanisms for adapting international models to national conditions exploring the possibilities of integrating practice-oriented teaching methods, developing new tools to measure the effectiveness of such changes, and creating strategies to overcome possible obstacles to modernisation. The practical significance of the work lies in the evolution of curricula in technical colleges that provide students with relevant knowledge and skills necessary to work with modern technologies, which can be used by educational institutions to optimise curricula, as well as by employers to determine the readiness of graduates to work in innovative fields.

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Еволюція навчальних планів у технічних коледжах: відповідність сучасним технологічним вимогам

Анотація. Метою дослідження було визначення ключових чинників модернізації освітніх технологічних програм для підвищення професійної освіти в умовах існування сучасного ринку праці. Методологічною основою дослідження став порівняльний аналіз навчальних планів у технічних коледжах України та провідних іноземних країн таких, як Сполучені Штати Америки, Швеція та Німеччина. Даний метод дозволив розглядати систему професійної освіти України в контексті глобальних тенденцій і зрозуміти взаємозв'язок між міжнародними освітніми практиками та змінами в українській системі. Основні результати дослідження показали, що впровадження міжнародних підходів, таких як дуальна система навчання та застосування новітніх технологій, значно покращує якість підготовки фахівців і підвищує їхню адаптивність до умов сучасного ринку праці. Було виявлено, що культурні й соціально-економічні відмінності можуть ускладнювати ефективне впровадження зарубіжного досвіду, підкреслюючи важливість адаптації цих моделей до національних умов. Дослідження досягло значного прогресу у визначенні ефективних стратегій інтеграції міжнародних освітніх практик, що дозволить забезпечити стійкий розвиток професійної освіти в Україні та підвищить конкурентоспроможність українських фахівців на глобальному ринку. Отримані результати також підкреслили необхідність подальшого вивчення та вдосконалення адаптації міжнародних моделей до національних реалій. У дослідженні з'ясовано важливість тісної співпраці між освітніми закладами, урядовими структурами та приватним сектором для успішної модернізації професійної освіти. Отримані результати можуть бути корисними для освітніх закладів у вдосконаленні навчальних програм та для урядових структур у розробці освітніх реформ та приватного сектору для активного залучення роботодавців до підготовки кадрів

Ключові слова: технологічна освіта; інновації; стандарти; науковий прогрес; тенденції