World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

Preparing schoolchildren for future professions in a digitalizing economy

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World Journal of Advanced Research and Reviews, 2025, 28(01), 051-057

Publication history: Received on 23 August 2025; revised on 28 September 2025; accepted on 01 October 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.28.1.3320

Abstract

This article is dedicated to preparing schoolchildren for the professions of the future within the digital economy of Kazakhstan and comparable jurisdictions. The topic's relevance is driven by the acceleration of automation and the growing demand for ICT competencies. Its novelty lies in integrating international policy guidelines and empirical data from Kazakhstan's school environment into a unified skills model. The paper describes employers' requirements for higher-order thinking and technological literacy, examines policy and administrative decisions on updating standards, developing personnel and infrastructure, and pays attention to extracurricular formats of ICT socialization. The objective is to identify a set of effective mechanisms for the early formation of digital and cross-curricular competencies. To achieve this, comparative analysis, analytical review, thematic coding, and a synthesis of practices were employed. The study examined regulatory documents, reports from international organizations, academic research, and case studies of clubs and Olympiads. The conclusion outlines a package of recommendations for updating programs, supporting teachers, and expanding access to IT practices. This material will be useful for educational policymakers, school administrators, methodologists and informatics teachers, and labor market researchers. A special emphasis is placed on early experience in programming, robotics, and project sprints as predictors of successful academic adaptation and the choice of IT fields, and on mechanisms for reducing the digital divide between urban and rural schools based on international comparison metrics.

Keywords: Digital Economy; School Education; ICT Competencies; Programming; Career Guidance

1. Introduction

The modern digitalization of the economy places new demands on the competencies of future specialists, starting from school age. Amid rapid technological progress, the demand for specialists in the field of information and communication technologies is growing a trend observed both in Kazakhstan and worldwide. Governments and educational policymakers recognize the need to equip students with skills that are in demand in the digital economy. The professions of the future are typically associated with the active implementation of Artificial Intelligence, big data, automation, and other digital technologies. According to OECD estimates, over half of the jobs in Kazakhstan (52%) are at high or significant risk of automation, which is higher than the OECD average (47%) [1]. This means that many traditional professions will be transformed or will disappear, while new roles will emerge—for example, in data analysis, Artificial Intelligence, cloud technologies, etc. [2]. To successfully adapt to these changes, current schoolchildren must acquire 21st-century skills, including digital literacy, complex problem-solving, critical and creative thinking, as well as socio-emotional competencies.

Kazakhstan, striving to join the ranks of developed economies, recognizes the importance of training personnel for the digital economy. Strategic documents have established guidelines for modernizing education and developing human capital. In particular, the state program "Digital Kazakhstan" (2018–2022) was aimed at digitalizing industries and

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improving the basic digital skills of the population. The State Program for the Development of Education until 2025 is also being implemented, which provides for the updating of school curricula, support for science, and the introduction of electronic forms of knowledge assessment (for example, the electronic Unified National Testing). These steps lay the foundation for preparing schoolchildren for future professional activities in the digital economy. Nevertheless, for these initiatives to yield results, it is necessary to understand more deeply which specific skills should be developed in students and how to integrate them into the educational process.

The purpose of this article is to analyze approaches to preparing schoolchildren for the professions of the future in the context of the digitalization of the economy, with an emphasis on Kazakhstan and taking into account international practice. The objectives include

- Systematizing the labor market requirements for the skills of graduates;
- Reviewing educational solutions that have proven effective;
- Assessing implementation bottlenecks in Kazakhstan;
- Formulating practice-oriented recommendations for school and extracurricular environments.

2. Methods and Materials

Normative frameworks, international reports, and academic research were used to construct a comparative picture of school-level preparation for future professions in Kazakhstan and comparable systems. S. Duke [4] demonstrated an upskilling strategy in the context of AI implementation, emphasizing the link between "technological literacy and continuous learning." The World Economic Forum [2, 3] presented an initial map of skill deficits and their update trajectories for the coming years and updated its forecast on the demand for analytical and creative thinking, additionally highlighting the growing importance of technological literacy and data handling. The Organisation for Economic Co-operation and Development (OECD) [1] provided a diagnosis of Kazakhstan's skills system and pointed out the gaps between school graduates and the demands of the knowledge economy. The European Commission [5] set the digital education policy for 2021–2027, describing the architecture of infrastructure, teacher qualifications, and competency assessment. A. Kapysheva [6] examined initiatives for developing the digital skills of youth in Eurasia; from these case studies, techniques for scalable extracurricular formats were extracted. K. Abdrakhmanova [7] described the structure of STEM competencies for future teachers and indicators of skill formation; these provisions were taken into account when designing learning pathways. A. Orymbaeva [8] empirically showed the influence of pre-university programming experience on the academic adaptation of ICT students; this result was used to argue for the early inclusion of schoolchildren in IT practices. O. Pavlova and E. Yanova [9] analyzed informatics Olympiads as a mechanism for selecting and accelerating the growth of ICT talent; their conclusions were applied in describing competitive formats.

To write this article, comparative analysis, analytical review, thematic coding, content analysis, logical-structural systematization, and triangulation of evidence from different types of sources were applied. The final integration of materials and procedures made it possible to build a consistent model for the early formation of digital and cross-curricular competencies, suitable for direct application in school and extracurricular practice.

3. Results

Global studies confirm that digital transformation is radically changing the labor market [2-4]. According to the World Economic Forum (WEF), tens of millions of jobs will disappear under the influence of automation and AI, but at the same time, new job roles will emerge in the green economy, data analysis, AI, content management, cloud technologies, and other high-tech fields [4]. This means that today's schoolchildren will be competing for the professions of the future, which require fundamentally different skills. The WEF notes that analytical thinking and creativity top the list of skills whose importance for employers will only grow. Critical thinking and the ability to solve complex problems have consistently been considered basic competencies since 2016. Meanwhile, new priorities include self-management skills the ability to learn actively, resilience, adaptability, and flexibility [2]. In its more recent "Future of Jobs 2023" report, the WEF confirmed that for the next five years, employers still prioritize analytical and creative thinking, and among the skills rapidly gaining importance are technological literacy (especially understanding AI and big data) and the ability to learn continuously throughout life [3]. It is predicted that the demand for technological literacy will increase by 60% by 2027, and the ability to work with AI systems will become necessary in almost all spheres [3]. Thus, digital skills, innovation, the ability to learn, and adaptability are the cornerstones of the profiles of future specialists (Table 1).

Table 1 Framework of Future Skills for School Education (compiled by the author based on [1–4])

Skill Cluster	Substantive Characteristic	Example Learning Trajectories	Target Educational Goal
Cognitive	Analytical thinking, critical thinking, complex problem-solving.	Research tasks, problem-solving studios, case analysis.	Transition from knowledge reproduction to its productive use.
Technological Literacy	Fundamentals of programming, basic data handling, understanding of AI and cloud services, cybersecurity.	Introduction to Python/Blockly, visual data analytics, no-code/low-code.	Readiness for digital job roles and interaction with AI systems.
Self-Management	Self-learning, resilience, adaptability, flexibility.	Personal learning planning, sprint projects, reflection.	Sustainable acquisition of new competencies and transition between fields.
Socio-Emotional	Communication, collaboration, empathy, leadership.	Team projects, debates, peer-review.	Cooperation in multidisciplinary teams.
Metacognitive	Lifelong learning skills, goal setting, evaluation of one's own strategies.	Portfolio, individual educational pathways.	Meaningful accumulation and transfer of competencies between subjects.

In advanced countries, systemic measures are being taken to restructure school education to meet the needs of the digital age. A key direction is the introduction of 21st-century skills into curricula—programming, robotics, data analysis, as well as the development of so-called soft skills (communication, collaboration, creativity). For example, the European Union is implementing the Digital Education Action Plan for 2021–2027, which proclaims the strategic goal of ensuring high-quality and inclusive digital learning, thereby making education systems "future-proof" [5]. This plan was adopted in 2020 in the wake of the pandemic and involves strengthening cooperation at the EU level to adapt schools to the digital era. Special attention is paid to improving the digital skills of teachers, developing digital infrastructure, and reducing the "digital divide"—currently, less than 40% of European teachers feel confident using digital tools in teaching, and more than 40% of teenagers aged 13–14 in the EU do not yet possess basic digital skills [5]. To solve these problems, significant funds are being invested in Europe to equip schools with technology, create online resources, and conduct training for educators. Similar initiatives are observed in other countries: national strategies for teaching programming from the early grades are being introduced, STEM education centers and robotics clubs are being opened, etc. For example, a number of US states have made computer science a mandatory subject in school, and Singapore is implementing the "Code for Change" program, which covers all schoolchildren with the basics of coding. International experience shows that the integration of digital technologies into education yields results when a comprehensive approach is taken—updating standards, training teachers, and ensuring equal access for all students (Table 2) [1].

Table 2 Policy and Administrative Decisions for a "Digital School" (compiled by the author based on [1,5,6])

Direction of Change	Substantive Measure	Implementation Tools	Expected Effect for the System
Educational Standards	Embedding 21st-century skills into subject areas.	Curriculum revision, cross-cutting digital modules, interdisciplinary projects.	Alignment of school requirements with labor market forecasts.
Teaching Staff	Improving the digital competence of teachers.	Training, micro-credentials, mentoring, communities of practice.	Improved quality of digital teaching and methodological diversity.
Infrastructure	Access to devices, internet, and platforms.	"1 student - 1 device" program, cloud resources, EdTech ecosystems.	Equalization of access and resilience to external disruptions.
Assessment	Formative and authentic assessment of competencies.	Electronic portfolios, project-based evaluation, proctoring.	Transparent tracking of skill progress, not just facts.

Inclusion and Outreach	Reducing the digital divide.	Regional resource centers, online formats, adapted content.	Expanded participation of rural and vulnerable groups.
Partnerships	Links with the world of work and NGOs.	Internships, joint modules, volunteer clubs.	Content relevance and early career guidance.

In Kazakhstan, the modernization of school education content to include new competencies is already underway but requires further deepening. As noted in an OECD analytical review, the youth population in the country is growing, and to fully realize this demographic potential, it is necessary to improve the quality and relevance of the skills young people acquire [1]. This implies restructuring school programs so that graduates are prepared for the demands of the modern economy. Certain steps are being taken in the country: trilingual education has been introduced from the 1st grade, specialized subjects are being implemented in senior classes, and specialized schools (e.g., Intellectual Schools with a STEM focus) are being opened. The state program "Digital Kazakhstan" had among its tasks the development of digital skills among the general population and, in education, the transition to electronic journals, online courses, and platforms like BilimLand. Nevertheless, systemic indicators still point to the need to strengthen these efforts. According to the OECD, Kazakhstani schoolchildren show below-average results in international assessments (e.g., PISA) in complex problem-solving and critical thinking, and many graduates experience difficulties when transitioning from school to university or work [1]. This indicates a gap between the declared goals and the actual level of competency formation. There is also the problem of the practical orientation of education: the traditional model, based on memorization and testing, does little to develop creative abilities. The WEF directly states that outdated models of rote learning and standardized tests are becoming irrelevant, whereas employers value creativity, critical thinking, and the ability to solve non-standard problems [2-4,6]. Kazakhstani education needs to shift its focus from the simple assimilation of knowledge to the development of skills for its application, project work, and teamwork—without this, it is impossible to prepare schoolchildren for a dynamic labor market.

Research shows that prior practical experience in the ICT sphere before entering university significantly increases the chances of subsequent academic success [1-9]. In particular, a Kazakhstani study has statistically confirmed that ICT practice (e.g., participation in programming clubs, independent learning of technologies) during school years has a positive effect on motivation to learn and facilitates the adaptation of students who enroll in IT specialties [8]. Thus, those first-year students who programmed or acquired digital skills before university find it easier to master complex material and show better results. This indicates the critical importance of early exposure of schoolchildren to IT skills—whether through the school curriculum or through additional education. There are examples of such initiatives in Kazakhstan: robotics clubs are active, national informatics Olympiads are held regularly, and in 2017, the introduction of programming fundamentals into the school informatics course from earlier grades began. However, the coverage of such practices is still limited, especially outside major cities. International experience—for example, the Code Club movement (volunteer-led coding clubs for children) or competitions like FIRST Robotics—confirms that an informal environment where children can experiment with technology sharply increases their interest and competence in IT. Informatics and robotics Olympiads also serve as a strong incentive: they create a competitive environment that inspires teenagers to study programming in-depth out of passion and excitement. Students participating in such competitions note an increase in motivation and a desire to improve their skills, spending many hours solving problems. As researchers note, the concentration of talented peers at Olympiads has a positive impact on the development of all participants and fosters in them a mindset geared toward achieving high results [9]. Thus, involving schoolchildren in extracurricular IT activities from clubs and hackathons to competitions is an effective mechanism for preparing personnel for the digital economy (Table 3).

A comparison of the forms of early ICT socialization demonstrates their complementarity: clubs solidify the basics and a portfolio, robotics and STEM centers develop engineering thinking and interdisciplinary connections, hackathons train for deadlines and client communication, Olympiads accelerate the growth of algorithmic mastery, online courses support personalized competency building, and internships provide experience in industrial cooperation. The combined use of these forms increases the likelihood of a successful transition from school to specialized university programs and facilitates a start in the labor market. The priority is to expand the reach of these practices in regions with a deficit of infrastructure and mentorship.

Table 3 Forms of Early ICT Socialization and Their Intended Educational Effects (compiled by the author based on [6, 8, 9])

Format	**Target Skill Focus**	**Motivation Mechanism**	**Effect on Transition to University and Market**
Programming Clubs	Algorithmics, basic coding, logic.	Interest in creating products, quick successes.	A solid basic portfolio and readiness for specialized courses.
Robotics and STEM Centers	Engineering thinking, sensors, prototyping.	Tangible results, team assembly.	Understanding of the "idea-prototype-test" cycle and interdisciplinary connections.
Hackathons/Project Sprints	Problem-solving, design thinking, presentation.	Competitiveness, deadlines, practical case studies.	Skills in working to deadlines, communication with clients.
Informatics Olympiads	Algorithms, optimization, competitive training.	Environment of strong peers, rankings.	Accelerated development of ICT talent and entry into IT fields.
Independent Online Learning	Self-management, digital literacy, specializations.	Individual pace, choice of pathways.	Personalized preparation and validated micro-credentials.
Internships in IT Companies	Applied ICT processes, team development.	Mentorship, practical utility.	Early professional socialization and informed choice of specialty.

4. Discussion

The analysis shows that Kazakhstan is moving in line with global trends to reorient education toward the skills of the future, but these changes need to be accelerated and deepened. International practice provides valuable benchmarks. First, curricula should be adapted to new competencies. By 2025, approximately 44% of the core skills of workers will require updating, and the school curriculum should proactively provide for teaching what will become a basic requirement in the near future [3]. This involves introducing courses on the fundamentals of programming, data analysis, and cybersecurity, with an emphasis not on narrow technological proficiency but on the development of computational thinking the ability to formulate algorithms, solve problems, and use data. At the same time, soft skills should not be underestimated: the ability to communicate, work in a team, and be creative must be cultivated through project work, research, and creative assignments in lessons. Education in Kazakhstan has historically been strong in subject knowledge but relatively weak in the skills of applying it in practice; bridging this gap is key to successfully preparing personnel.

Second, a critical factor is the professional development of teachers. Without educators who are proficient in modern technologies and methods, it is impossible to implement future skills in schools. Research notes that a significant portion of Kazakhstani teachers are not sufficiently familiar with the concept of STEM education and new digital tools [7]. This is a legacy of the previous system, where there was no choice of courses and creativity, as well as a result of the rapid emergence of new technologies that educators cannot keep up with. Large-scale teacher training is necessary: courses on using digital resources, methods for developing critical thinking, and integrating interdisciplinary projects. The state is already taking steps in this direction in 2020, the status of the teacher was legally elevated, and centers of pedagogical excellence are in operation. It is important to motivate teachers themselves to master new approaches, encouraging those who incorporate elements of project-based activities, robotics, and research into their lessons. International experience (e.g., Singapore, Finland) shows that the teacher of the future is more of a mentor and facilitator of the learning process than a transmitter of knowledge, and the Kazakhstani school must gradually move toward this model.

Third, it is necessary to ensure equal access to modern education for all students. There is currently a gap between urban schools, especially advanced ones, and rural schools. Rural students have fewer opportunities to acquire digital skills a lack of equipment, internet, and qualified personnel takes its toll. The government recognizes this problem: the "Digital Kazakhstan" strategy paid attention to connecting rural schools to the internet and creating resource centers to support rural teachers. An important step was also the introduction of the concept of non-formal education into legislation in 2017 this made it possible to recognize learning outcomes obtained outside of school (for example, in online courses) and to support various forms of supplementary education. The network of free clubs and sections for programming and other tech areas in small towns and villages should be expanded, possibly using an online format. It is also promising to develop the "1 student - 1 computer" model (providing all schoolchildren with devices) and to create publicly accessible platforms with interactive courses on future skills.

Finally, a close link between education and employers and the forecasting of future professions are needed. The world is experiencing a "double disruption" in the labor market due to the pandemic and automation, and the personnel training system must react flexibly to these shocks. In Kazakhstan, IT companies could be more actively involved in educational initiatives for example, mentorship programs, internships for high school students in technology firms, and joint development of educational modules. This would give schoolchildren an idea of the real skills needed in the industry and allow for the adjustment of curricula in line with future professions (such as AI solutions developer, big data analyst, digital marketer, etc.).

Overall, despite the existing challenges, Kazakhstan has a solid foundation for progress. The population is young and receptive to technology, the state has declared a course toward innovation, and there is access to international practices. The main thing is to consistently implement the planned reforms, invest in human capital, and not be afraid to introduce new learning formats in schools.

5. Conclusion

The digital economy is shaping a new landscape of professions, and preparation for them must begin at school. The analysis conducted shows that for successful adaptation to the professions of the future, students need a wide range of competencies: from digital and technical literacy to critical thinking, creativity, and self-management skills. Kazakhstan, like other countries, faces the task of transforming its education system according to these requirements. International experience (EU, WEF, OECD, McKinsey, etc.) provides clear benchmarks: education must become more flexible, interdisciplinary, and focused on developing skills that machines cannot replace—creativity, communication, and emotional intelligence.

Important steps have been taken in Kazakhstan—strategic programs have been adopted, standards are being updated, and additional education in the IT sphere is being supported. However, to achieve the goal, further efforts are required: modernizing curricula with an emphasis on practical skills, mass professional development for teachers, eliminating inequality in access to quality education, and strengthening partnerships between schools and the IT sector. It is equally important to encourage extracurricular activities for students—clubs, Olympiads, projects—which, as research has shown, significantly increase the level of ICT competencies among young people.

Preparing schoolchildren for the professions of the future is an investment in the sustainable development of the country. Young personnel, armed with relevant digital skills and capable of constantly learning new things, will become the engine of growth for the knowledge economy. Thus, by investing today in reforming education and developing skills among schoolchildren, Kazakhstan is creating a solid foundation for its successful future in the global digital economy.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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