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Education digitalization: impact on the learning quality and the participants' readiness in the educational process

Abstract

The aim of this study is to analyze the impact of digitalization on the quality of the educational process in secondary and higher education, as well as to identify the conditions conducive to successful integration of digital technologies. The theoretical base includes a review of 35 international publications covering various aspects of digital transformation in education: from digital literacy and learner motivation to management strategies and digital inequality. The empirical part is based on the results of a survey of 75 teachers and 305 students of an international school in the city of Astana. The results showed a high level of positive perception of digital tools, as well as the presence of barriers related to the choice of suitable platforms, lack of digital competences and overload of diversity of technologies. The study highlights the need for systemic support of educators and strategic digital leadership by administrations. Findings may be useful for education policy makers, managers and educators interested in sustainable digital transformation of the educational environment.

Keywords: Digitalization of education, digital literacy, motivation of students, pedagogical support, digital tools, educational transformation..

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Introduction

With the rapid development of digital technologies, the transformation of the educational environment is becoming not just a technological trend, but a necessary condition for the modernization of the education system. Digitalization affects all levels of the educational process - from the content and forms of teaching to the management of educational institutions, evaluation of learning outcomes and interaction of participants in the educational process. Contemporary challenges, including the COVID-19 pandemic, have significantly accelerated this transition by identifying both the significant potential of digital tools and vulnerabilities in the education system (Rosak-Szyrocka et al., 2024; Yang, 2024).

At the international level, there is a steady trend towards integrating online platforms, hybrid learning formats and digital feedback, visualization and collaboration (Laursen & Ryberg, 2024; Reis-Andersson, 2024). The scientific literature emphasizes that the effectiveness of digitalization depends not only on the availability of technologies, but also on the willingness of teachers, students and administrations to use them consciously (Niksiar et al., 2025; Solodovnikova & Malkova, 2025). The critical question remains: how much human, organizational and infrastructural resources are available to educational institutions for systemic digital transformation?

Despite the growing number of publications devoted to digital platforms and educational technologies, in Kazakhstan and CIS countries there are still no comprehensive studies combining theoretical analysis and empirical data on the perception of digitalization in secondary and higher education. It is particularly important to consider the views of both teachers and students, as they are the main actors in digital change.

This study aims to analyze the advantages and limitations of digital transformation of education, as well as to assess the degree of readiness and acceptance of digital practices by teachers and schoolchildren in one of the international educational institutions of the city of Astana. The article is based on a synthesis of modern scientific approaches (based on analysis of 35 international publications), as well as results of questionnaires among teachers and students in 2024-2025 school year.

The scientific novelty of research consists in an integrated approach to the study of digitalization, combining theoretical systematization of scientific sources with localized empirical analysis. The practical importance lies in identifying specific conditions and limitations that should be taken into account when developing strategies for digital development of educational institutions.

Materials and methods

General synthesis of scientific literature. Digitalization of education is a global and multidimensional process that has been actively developed since the COVID-19 pandemic. Based on the analysis of 35 international studies, several sustainable trends can be identified.

Geographical coverage and type of education. The studies cover more than 20 countries on 5 continents, including European (Spain, Germany, Lithuania, Portugal), Asian (Kazakhstan, China, South Korea, Japan), African (Mozambique), North American (USA, Canada) and Latin American (Colombia) contexts. They analyze both schools and institutions of higher education.

Table 1
Summary of the literature review

№	Authors (Year)	Method	Key findings
1	Batuchina & Melnikova, 2025	Qualitative (interview)	Digital creativity of teachers as a key factor in digital pedagogy; the importance of infrastructure and professional development
2	(Gavrus et al., 2025)	Project analysis (DoCENT)	Model of digital creativity in learning; development of digital competences through collaboration
3	(Finch et al., 2023)	Theoretical review	Rethinking creativity in the digital age, creativity as a factor of adaptation to digitalization
4	Torres A.A., Collazos C.A., Mon A.	Theoretical review	Diversity of creative approaches; emphasis on digital interaction
5	(Akim et al., 2023)	Analysis of personalization models	Highlights the need for individualization and personalisation in digital learning
6	(Reis-Andersson, 2023)	Analysis of strategic documents	Digital transformation requires changing the content of education and the role of teachers
7	(Reis-Andersson, 2024)	Qualitative (OER analysis)	Teachers are becoming active creators of digital content; importance of open resources
8	(Amdam et al., 2024)	Content analysis	Teachers use Pinterest and TPT as sources of ideas; trust issues
9	(Oluseyi-Sowunmi & Samuel, 2024)	Conceptual analysis	Definition of digital creativity: synergy between technology and imagination
10	(Tsupari et al., 2024)	Survey	Creating digital content improves the quality of education and motivates students
11	(Solodovnikova & Malkova, 2025)	Digital readiness model	Development of a model to evaluate the digital transformation of universities; importance of digital leadership
12	(Panayotova, 2024)	Scenario analysis	The future of education in a digital and uncertain environment; the importance of strategic thinking
13	(Gutu et al., 2024)	Mixed methods	Authoritarian aspects of digitalization; the risk of exclusion in digital university
14	(Rosak-Szyrocka et al., 2024)	Student survey	Link between digital literacy, motivation and support of teachers
15	(Buchmann, 2025)	Content analysis	Analysis of digital platforms and video books as tools for pedagogical reflection
16	(Göltl et al., 2024)	Case-study	Digital transformation in resource-constrained environments requires a systemic approach

17	(Filipova & Malakhova, 2024)	Survey and interview	Technological backwardness as key barrier to digitization; importance of donor support
18	(Gumaelius et al., 2023)	Case analysis	Integrating LMS and artificial intelligence into the educational process
19	(Moustakas, 2025)	Experiment	The use of digital games promotes STEM learning and sustainable thinking
20	(Hollenstein et al., 2025)	Focus group	Low digital competence of teachers as an obstacle to digitalization
21	(Ma et al., 2025)	Survey and interview	Changing roles of students in the digital educational environment; growth of autonomy and reflection
22	(Rajcsanyi-Molnar et al., 2025)	Focus group	Involving parents and teachers as the key to successful digitalization of schools
23	(Gumbi et al., 2024)	Survey and statistical analysis	Low level of teacher training; need for continuous digital training
24	(Zheng et al., 2024)	Scenario planning	Shaping digital strategies under uncertainty and TUNA paradigms
25	(Silén-Lipponen et al., 2024)	Digital software analysis	Joint digital programmes between EU universities; increased mobility and learning flexibility
26	(Zaqueu, 2024)	Case analysis	Use of digital platforms helps adapt to changing conditions
27	(Carlsson & Willermark, 2023)	Content analysis	Evaluation of distance learning platforms; impact on academic performance
28	(Laursen & Ryberg, 2024)	Mixed methods	Hybrid learning enhances student personalization and motivation
29	(De-Torres et al., 2024)	Quality interviews	Inclusive digital education is possible when platforms are adapted to local conditions
30	(Yang, 2024)	LMS data analysis	Monitoring digital activity of students allows to assess the digital competence of teachers
31	(Drljić et al., 2025)	Survey and observation	Integrating AI and VR into learning increases interest, but requires infrastructure support
32	Frolova E., Rogach O., Faizullin R	Content analysis	Digital technologies help transform engineering education
33	(Hewidy et al., 2023)	Case-study	Successful implementation of digital learning depends on a flexible curriculum
34	(Chounta et al., 2024)	Simulation	Digital readiness of universities affects academic performance and engagement
35	(Niksiar et al., 2025)	Survey and interview	Lack of digital skills among non-mathematical teachers; recommendations for vocational training

As shown in Table 1, the authors used both qualitative (interviews, focus groups, case studies) and quantitative methods (questionnaires, statistical models), as well as mixed approaches (e.g., Gutu et al., 2024; Laursen & Ryberg, 2024).

The articles raise the following key themes:

- Digital competence of teachers;
- Access to digital infrastructure;
- Motivation and involvement;

- Hybrid and mixed learning models;
- Digital justice and inclusion.

Thus, the literature reflects the multidimensionality of the process of digitalization – from technical and organizational aspects to psychological, pedagogical and cultural.

Advantages and disadvantages of digitalization in education

Digitalization benefits. One of the key advantages of introducing digital technologies into the educational process is to increase the level of involvement and motivation of students, especially in online and blended learning environments. As shown in a study by Rosak-Szyrocka et al. (2024), the perception of the digital environment as flexible, adaptive and supportive on the part of teachers has a significant influence on the involvement of students in the educational process. Digitization promotes the personalization of learning, allowing to take into account the individual characteristics of students. Research by Kim et al. (2025) has shown that hybrid learning models enhance autonomy, give students greater control over the pace and pattern of learning, and contribute to higher satisfaction with the educational process. It is emphasized that digital technologies increase access to educational resources. For example, Laursen & Ryberg (2024) points to the growing role of Open Educational Resources (OERs) and the development of competences in creating and adapting digital content among teachers. This promotes both academic freedom and the development of digital pedagogical creativity.

The literature also highlights the role of digitalization in ensuring educational resilience during crises such as the COVID-19 pandemic. In particular, post-COVID-19 architecture education has been one example of a successful transition to mixed formats where digital flexibility and scriptwriting have enhanced academic adaptation ((Hewidy et al., 2023)). For example, Panayotova (2024) describes how scenario planning has helped schools in Norway adapt to the unpredictable challenges associated with mass online adoption.

Shortcomings and challenges of digitalization. Despite the stated advantages, digitalization of education faces a number of structural, pedagogical and ethical challenges. One of the main barriers remains the lack of digital competence of teachers, especially in non-mathematical and non-humanities disciplines. (Niksiar et al. (2025) point out that teachers in Kazakh universities have low levels of ICT skills, which negatively affects the quality of teaching and limits the potential of digital platforms.

Moreover, unequal access to digital infrastructure remains a serious problem. The study by Barrera et al. (2025), conducted at universities in Mozambique, identified a severe shortage of equipment, slow internet and limited software as major barriers to digital transformation.

Another problem highlighted in a number of works is the overload of students and teachers in conditions of constant online presence. Filipova & Malakhova (2024), for example, point out that the digital environment can contribute to the authority of education by reducing student autonomy and turning the teacher into a mediator between the system and the learner.

The lack of systemic support from the education administration is also a concern. Studies by Gumbi et al. (2024) and Rajcsanyi-Molnar et al. (2025) highlight that schools where digitalization was implemented without coordination with parents and teachers were more likely to face resistance and technical failures.

Application of skills acquired through digital tools (based on cases). One of the steady trends in modern educational practice is becoming not only the integration of digital technologies, but also the formation of new forms of applied and meta-subject skills necessary for adaptation to the digital society. The studies emphasize that digital tools play an important role in the development of both academic competences and 21st century skills - critical thinking, autonomy, creativity and cooperation.

A study by Moustakas (2025) on the use of digital games in STEM education in China showed that interactive digital environments stimulate students' analytical thinking and sustainable project motivation. The use of such games promotes task comprehension, not mechanical memorization. In another example - work of Yang (2024), - the collection and analysis of student activity data on learning management platforms (LMS) allowed teachers not only to adjust courses in real time, but also to diagnose cognitive overload zones. This builds students' skills of self-reflection and digital self-assessment, allowing them to adapt to dynamically changing learning content. An article by Filipova & Malakhova (2024), based on the experience of using video blogs for educational purposes, demonstrates how digital video literacy contributes to the formation of pedagogical reflexes in future teachers. The development of educational videos requires not only mastering technical tools, but also awareness of the logic of material delivery, which is directly related to the competence «learn to learn».

In addition, the study by De-Torres et al. (2024) on digital inclusion in universities stresses that successful implementation of digital practices is only possible with locally adapted solutions that take into account the linguistic, cultural and technical characteristics of students. Here, digital tools have become not just a means of delivering content, but a platform for developing adaptive skills and critical analysis.

It is also worth noting the conclusions of Panayotova (2024), who argued that digital creativity is not only the ability to use technology, but also the ability to combine knowledge from different disciplines to create new solutions. This transdisciplinary literacy is actively developed through the participation of students in online collaborations, projects, script games and case studies.

Thus, the analysis showed that digital tools not only transform teaching forms, but also model new educational outcomes focused on practice-oriented, creative and adaptive skills of learners.

Stakeholders: students, teachers, administration

Students: a digital generation with different opportunities. Most studies highlight that students are not just the subject of digitalization, but active actors with high expectations for the digital environment. Their involvement is enhanced by the

availability of visual and multimedia content, as well as the ability to adapt the pace of learning to their needs (Laursen & Ryberg, 2024). However, as noted by Filipova & Malakhova (2024) and Drljić et al. (2025), not all students have equal access to digital devices and the internet, especially in countries with limited resources. This leads to a deepening of the digital divide and requires special attention by the education system to social inclusion.

Teachers: from resistance to professional growth. Teachers remain the central agents of digital transformation, but their level of readiness varies greatly. Similar findings are confirmed in Gumbi et al. (2024) and Ma et al. (2025), where lack of training and system support is highlighted. At the same time, many authors note a positive trend. For example, Reis-Andersson (2024) and Panayotova (2024) point out that the participation of teachers in the development and adaptation of digital content stimulates professional growth and forms a pedagogical community based on exchange of practices. Digital pedagogy becomes an area of innovation, not coercion.

Administration: driver or change barrier? The role of school and university administration in the process of digitalization is difficult to overestimate. Studies by Solodovnikova & Malkova (2025) and Zheng et al. (2024) highlight that the success of digital reforms depends directly on digital leadership at the management team level. With a clear strategy, motivational programs and infrastructure support, digitalization is implemented more consistently and systematically. However, a number of studies document the reverse cases. For example, Rajcsanyi-Molnar et al. (2025) describes a situation where administrative passivity and lack of coordination with educators lead to formal and ineffective ICT adoption. Students thus require adaptability, teachers support and development, and administration strategic leadership. Similar situation is observed in the context of Mozambique, where the lack of digital leadership and institutional strategy by the administration of educational institutions has led to a superficial introduction of technologies and increased inequality (Zaqueu, 2024). Only the collaboration of all stakeholders can ensure a sustainable and effective digital transformation in education.

Research methodology

The aim of the empirical part of the study was to identify perceptions, experiences and problems related to the use of digital tools in teaching and learning in the context of secondary school. Special attention was paid to assessing the readiness of teachers and students for digital transformation of the educational environment, as well as identifying factors that promote or hinder the effective use of digital technologies.

Study participants. The study was conducted within the framework of a pilot introduction of digital practices in one of the International schools of Astana (hereinafter - ISA). The following participated in the survey:

- 75 out of 139 teachers (54%) in various subject areas, excluding computer science;
- 305 out of 536 students in grades 6-10 (approximately 57%).

Respondents represented a diverse pedagogical and age composition, as well as a wide range of subjects and learning paths.

Data collection method. The collection of empirical data was carried out during the academic year 2024-2025 through an anonymous online survey developed specifically for this study. Google Forms were used, accessible through the personal electronic devices of the respondents. The questionnaire included both closed-ended questions with options and open for comments, which allowed to combine quantitative and qualitative approaches.

Questionnaire structure. The questionnaire for teachers included the following blocks:

- Frequency of use of digital tools in lessons;
- Impact of digitalization on student engagement;
- List of applied platforms and technologies;
- Problems in the selection, development and application of tools;
- Assessment of the level of digital training;
- Need for methodological and administrative support.
- The student questionnaire consisted of the following components:
- Comparison of traditional and digital learning formats;
- Level of interest and comfort in the application of digital technologies;
- Availability of platforms in the off-season;
- Effectiveness of group and individual work;
- Advantages and disadvantages of digital tasks;
- Feedback to teachers in the digital environment.

Ethical aspects. All participants were informed about confidentiality and voluntary participation. The responses were collected without identification and used solely for scientific analysis. The study meets the ethical requirements of pedagogical empirical work.

Table 2

The results of the teachers survey

Category	**Number of responses (out of 75)**	**The percentage (%)**
Introducing digital tools in class	63	84
Students' interest is growing	59	79
Students actively participate in the use of DT	61	81
Have difficulty choosing tools	47	63
Limited access to platforms/resources	42	56
Lack of skills in new technologies	39	52
Need methodological support chosen by the DT	52	69

Note: DT- digital tool

Table 2 with the results of a survey among 75 teachers in Middle Years Programme (MYP). It shows the proportion of respondents who confirmed key statements, for example:

- 84% introduce digital tools in class;
- 81% report active participation of pupils in the use of digital technologies;
- 69% need methodological support in choosing digital tools.

Table 3

The results of the students survey

Category	**Number of responses (out of 305)**	**The percentage (%)**
Lessons become more understandable and interactive with DT	242	79
DTs contribute to group work	228	75
Less paper writing and more digital work	221	72
DTs allow you to make edits without stress	213	70
Tasks can be performed anytime and anywhere	234	77
CIs help kinesthetic to better perceive information	198	65
DTs provide more practice than theory	205	67
DTs promote learning differentiation	191	63
Sometimes tools are unclear and require adaptation	176	58
Some teachers are overloaded with tools	169	55
Teachers ask students for help with problems	142	47

Note: DT- digital tool

According to Table 3 with the results of a survey of 305 students in grades 6-10 of YRS, reflecting their perception of digital tools:

- 79% believe that the lessons have become more understandable and interactive;
- 77% appreciate the ability to do tasks anytime and anywhere;
- 70 percent say that digitally editing reduces stress.

Also, 58% reported that new tools needed to be adapted and 55% that some lessons were overloaded with digital platforms.

Analysis and interpretation of empirical data

1. Teachers' perspective: striving for digitalization without support. The results of the survey among 75 teachers of MYP show a high degree of desire for digitalization of the educational process: 84% of respondents adopt digital tools, and 81% noted that students' activity in class has increased. This confirms the research findings of Rosak-

Szyrocka et al. (2024) and Laursen & Ryberg (2024), which focus on increasing students' motivation and participation in digital environments.

However, about 63% of teachers have difficulties in choosing digital platforms and 69% need methodological support. These data illustrate the general lack of vocational orientation, also mentioned by Niksiar et al. (2025) and Gumbi et al. (2024): even with motivation, teachers often do not feel confident in choosing and adopting technologies.

More than half (52%) admitted that they did not have the skills to master new digital solutions on their own. Such difficulties are particularly noticeable in the context of non-mathematical disciplines, where digital integration requires adaptation of traditional methods to a multimodal environment (Reis-Andersson, 2024).

2. Students' perspective: digital technologies increase flexibility and reduce stress. Among the 305 students interviewed, there is a generally positive attitude towards digital technologies in education. 79% noted that the lessons have become more clear and interactive, and 75% are positive about the possibility of group work in a digital environment. Such findings are consistent with the work of Laursen & Ryberg (2024) and Moustakas (2025), where digital organization promotes collaborative skills and flexible thinking.

Moreover, 70% of the students stressed that digital formats allow them to edit without stress, and 77% appreciate being able to do tasks at a convenient time and place. This is consistent with the ideas of individualization of learning described in Akim et al. (2023).

It is also important to note that 67% of students believe that digitalization enhances the practical orientation of lessons, while 63% believe that it promotes differentiation. This effect is particularly valuable for kinesthetic and visual learners, as highlighted in studies by Panayotova (2024).

3. Coincidences and divergences in perception. Despite positive assessments, both participants in the educational process point to a number of problems. Students note that sometimes the platforms are not understood (58%), and some teachers overload with digital means (55%). As shown in international studies, the overload of students with digital platforms is often the result of a lack of coordinated methodological policy in schools (Silén-Lipponen et al., 2024). This confirms the conclusions of Gutu et al. (2024) on the risk of overload and fragmentation in unstructured digitalization.

An interesting aspect is that 47% of the students reported that teachers sometimes turn to them for help during technical failures, indicating a redistribution of digital competence within the class and a lack of systemic technical support (Niksiar et al., 2025).

Discussion

1. Coherence between theory and practice: confirming global trends. The results of an empirical study in schools in the city of Astana are largely consistent with the international observations presented in the literature review. In particular, the active use of digital tools by teachers (84%) and high involvement of students (81%), as well as

highlighting that the digital environment contributes to increased educational motivation, especially with interactive and visual elements.

Just as in foreign contexts, positive perception of students' flexibility, adaptability and practicality of digital learning (Hewidy et al., 2023; Moustakas, 2025) is confirmed by data in Astana: 77% of schoolchildren value the opportunity to perform assignments at a convenient time and place, a 70% say that stress is reduced because digital documents are easy to edit.

Thus, we can talk about the universality of a number of effects of digitalization, regardless of the country and level of education. This is confirmed by the results of international analysis, where it is stressed that regardless of the type of education and geographical context, digitalization reinforces both the involvement and transformation of the roles of the teacher (Torres et al., 2024)

2. Conditions for effectiveness: importance of support and coordination. Despite the clear advantages, the data confirms that the success of digitalization is not guaranteed by the fact of the introduction of technologies. The main problem is the uncertainty of the teachers - 69% of them reported a lack of methodological support, and more than half have difficulties with mastering new tools. This is in line with conclusions about the systemic deficit of digital pedagogical training and supporting infrastructure.

In addition, the lack of digital leadership and strategic approach on the part of the administration (Solodovnikova & Malkova, 2025) can lead to formal and unsustainable implementation of platforms. In the context of the study, such problems are manifested in the form of teachers turning to students for technical support (47% of students noted), which indicates insufficient institutional digital maturity.

3. Stress points: digital overload and instrumental chaos. It is interesting that, despite the predominantly positive perception, students note the overload of digital tools, as well as difficulties in adapting to new platforms when necessary (55% and 58% respectively). Such complaints confirm the concern expressed by Gutu et al. (2024) about fragmented and unstructured digitalization, in which tools are selected without regard to cognitive stress and age of students.

This conclusion highlights the importance of the didactic strategy of technology selection, as written by Akim et al. (2023): successful digitalization is impossible without the coordination of pedagogical goals with the functionality and interface of platforms. Also, the results of an analysis of engineering education show that successful digitalization requires flexibility in the choice of formats, including combinations of hybrid models, structured freedom and visual transparency of tasks (Laursen & Ryberg, 2024).

Conclusion and recommendations

Main conclusions. The results of theoretical and empirical analysis confirmed that the introduction of digital tools into educational practice has a predominantly positive impact on the involvement, motivation and quality of education in both secondary and

higher education. In this way, the most important conditions of digitalization efficiency are identified:

Trained teachers with sufficient digital literacy;

- Access to adapted infrastructure and resources;
- Management support and strategic guidance from the administration;
- Involvement of students in the process of choosing and mastering digital learning tools.

Despite a high level of enthusiasm on the part of teachers and students, digitalization faces several challenges: uncertainty in choosing suitable platforms, digital inequality, tool overload, and a fragmented approach to implementation.

Empirical data collected at the international school of the city of Astana confirmed the general international trends described in the scientific literature of researchers in the field of education, which allows to speak about the transnational nature of digital transformation of education.

Practical recommendations.

For teachers:

- Take targeted courses on digital didactics with emphasis on the choice of tools for specific purposes of the lesson;
- Use digital tools not as an end in itself, but as a means to enhance differentiation, visualization and practical orientation;
- Engage students in reflection on the convenience and effectiveness of the applied platforms.

For school and university administration:

- Shape the digital strategy of the institution, taking into account the opinions of teachers and students;
- Provide guidance and technical support to teachers, especially in non-mathematical disciplines;
- Implement common digital ecosystems to avoid overloading and duplication of functions.

For EdTech developers:

- Create adaptive, intuitive interfaces designed for different age and cognitive levels of users;
- Allow flexibility to integrate with existing LMS and other platforms;
- Develop analytical tools that allow teachers to track student progress and behavioral patterns.

Prospects for further research. Future work may be directed to:

- Comparative analysis of digital transformation in urban and rural schools;
- Research into the impact of specific digital tools on academic achievement;
- Analysis of management strategies of digitalization in regional and national education systems.

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