

FROM CHALKBOARDS TO TABLETS: THE DIGITALIZATION PROCESS IN BULGARIAN EDUCATIONAL SYSTEM

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Abstract. The article examines the degree of digitalization in Bulgarian kindergartens and schools, with the aim of assessing the influence of technical infrastructure and institutional ownership on the implementation of digital technologies. Two hypotheses are formulated: 1) better infrastructure leads to a higher level of digitalization; 2) private educational institutions are better prepared for technology integration than public ones. The methodology is based on a quantitative approach through a survey among 4206 institutions (January-October 2024), analyzed with descriptive and inferential statistics. The study fills the lack of large-scale, representative empirical data on digitalization in Bulgarian preschool and school education, providing a basis for formulating policies for equal access, human capital development and sustainable integration of technologies.

Keywords: digitalization; Bulgarian education; STEM projects; digital readiness; digitalization index

Introduction

The successful development of a socio-economic system is dependent on multiple factors that have a different impact both in terms of direction, strength, and intensity. However, it is remarkably easy and almost intuitive to point to the individuals in this socio-economic system as the cornerstone of its evolution. And the reason is rooted in the dual role of individuals – simultaneously as creators of goods, and as consumers of goods, in other words: as a cause (factor) for the development of the system and as a consequence (result) of its development (Manov, 2001). In this sense, the formation of the qualitative characteristics of individuals in a country appears to be of key importance for future success. And at the basis of these qualitative characteristics is the educational system and its functioning in the conditions of digitalization.

Digitalization of the education system worldwide is gaining more and more importance, being perceived as a key factor for the modernization and adaptation of

learning processes to the needs of modern students. In Bulgaria, the pace of this process varies among individual schools and kindergartens, and the integration of digital technologies often depends on factors such as financial security, technical infrastructure and the readiness of teachers to use new technologies in education. The COVID-19 pandemic has accelerated the implementation of distance learning, but it has also revealed several challenges related to the lack of preparation and uneven distribution of resources in the education system.

Conceptualizing digitalization in education is a necessary step in order to analytically distinguish between its different dimensions and mechanisms. In the present study, digitalization in preschool and school education is understood as a multidimensional process encompassing: a) the availability of digital infrastructure and technological tools; b) institutional and organizational readiness to integrate these tools into everyday educational activities; and c) the capacity to sustain their use through support mechanisms, training opportunities and the management of technical challenges. While pedagogical digital transformation also implies deeper changes in teaching methods, learning design and assessment practices, the current research deliberately focuses on the infrastructural and organizational dimension of digitalization, which represents a necessary, though not sufficient, precondition for effective technology-enhanced education.

Beyond the availability of infrastructure and funding, the effectiveness of digitalization largely depends on teachers' digital competences, workload, institutional support and openness to pedagogical change. Insufficient training opportunities, limited time for professional development and growing administrative pressure often restrict the pedagogical impact of digital technologies, even in institutions where technical resources are formally available. Conceptually, the assumed mechanism underlying the digitalization process is that better technical infrastructure and higher organizational readiness reduce barriers to technology adoption and enable more frequent and systematic use of digital tools in educational practice. At the same time, institutional ownership and governance arrangements may influence the flexibility of resource allocation, decision-making speed and openness to innovation, thereby shaping the overall level of digitalization achieved.

In this context, the digitalization of school and preschool education in Bulgaria is a basic prerequisite for the development of quality education that meets the modern requirements of society and the labor market. This study provides valuable information about the level of readiness of educational institutions to integrate new technologies, the factors that influence this process, as well as guidelines for the content of national strategic documents in the field. At the same time, digitalization processes may unintentionally reinforce existing inequalities within the education system, particularly between regions, types of settlements and socio-economic groups, when access to digital technologies is not accompanied by targeted support mechanisms and capacity-building.

The main goal of the study is to assess the degree of digitalization of the educational system in Bulgaria by analyzing the factors that determine it. Identifying the level of use of digital technologies, and the obstacles to their implementation, provide an opportunity to formulate specific recommendations for improving the technological infrastructure and the training of teachers. Also important is the possibility to use the generated information during the formation of long-term and short-term strategies and policies in the field of education. **The object** of the study are kindergartens and schools (pre-school, primary and secondary) in Bulgaria, considering both private and public educational institutions. **The subject** of the study is the degree of use of digital technologies in the learning process, as well as the factors that influence their integration.

The study applies a cross-sectional quantitative research design based on institution-level self-reported data. The research is built on a quantitative method, with the main tool for data collection being a survey conducted among kindergartens and schools in Bulgaria in the period January – October 2024. The survey contains questions related to the use of digital technologies, the degree of readiness of schools for the integration of new technologies and the challenges faced by teachers and students. The collected data is analyzed using SPSS statistical software. Based on the goal of the study, the following **main hypothesis** are formulated:

1 hypothesis: The educational institutions with better technical and organizational readiness for digitalization demonstrate a higher level of digitalization compared to those with limited access to technology.

2 hypothesis: Private schools and kindergartens are better prepared for the integration of digital technologies compared to public educational institutions.

1. Literature review

The digitalization of education has become a key factor in the modernization of education systems globally in recent years. It is no longer seen solely as a process of implementing new technologies, but as a profound transformation that affects the content, methods and organizational models of teaching. As the European Commission¹ notes, digitalization requires an integrated approach that combines infrastructure investments, human capital development and a change in the culture of learning and management. In this sense, digital transformation should be understood as a systemic process that reshapes technological environments, pedagogical practices, institutional governance, and professional roles within education systems. This understanding implies that digitalization is a complex construct composed of interrelated technological, organizational and human components.

International literature² shows that the COVID-19 pandemic has been a catalyst for the accelerated introduction of distance and hybrid learning. Within a few months, educational institutions around the world were forced to switch to online platforms, such as Google Classroom, Microsoft Teams, and Moodle (Zawacki-Richter, Altur-

ki, & Aldraiweesh, 2017) (Zawacki-Richter & Bozkurt, 2023). This transition has demonstrated the capabilities of digital tools and highlighted long-standing problems: uneven distribution of resources, disparities in digital literacy, and the need for new pedagogical approaches. A World Bank report highlights that effective use of technology is not limited to its availability. A key factor is the ability of teachers to integrate digital resources into the lesson in a way that increases student engagement and stimulates critical thinking. As a result, teacher readiness, digital competences, workload and access to continuous professional development emerge as critical determinants of successful digitalization, often outweighing the mere presence of technological infrastructure. These findings suggest that infrastructure represents a necessary enabling condition, while human and organizational factors determine the actual depth and quality of digitalization. Therefore, many countries are introducing programs to enhance teachers' digital skills and adapt curricula to new realities.

Teacher-related challenges have increasingly been recognized as a central explanatory mechanism for uneven digitalization. Empirical and policy-oriented studies converge on the view that teachers' digital competence, perceived self-efficacy, workload, and resistance to change shape both adoption and the pedagogical depth of technology use. In practice, insufficient time for training, pressure to produce digital content, and growing administrative demands may lead to surface-level implementation, even when devices and platforms are formally available. This highlights that sustainable digitalization requires training opportunities, but also organizational arrangements that protect teachers' time, provide on-site support, and reduce implementation stress.

Attention is paid to STEM education, which has been identified as a driver of innovation and competitiveness³ (Tytler, 2020) (Bybee, 2013). Countries such as Finland, Estonia and Singapore are integrating virtual labs, 3D modelling and project-based learning to link theoretical knowledge with practical skills. STEM-oriented digital environments are often associated with higher levels of institutional innovation and stronger alignment between technology use and pedagogical objectives. In this sense, STEM initiatives can be interpreted as a qualitative expression of digitalization, reflecting the capacity to embed it meaningfully within the educational process. Similar approaches are being transferred to other educational contexts through international partnerships and the transfer of good practices.

The European Union, through the Digital Education Action Plan 2021 – 2027, has formulated two main strategic objectives: 1) Creating a highly effective digital education ecosystem; 2) Developing digital skills and competences⁴. Within these policies, frameworks such as DigCompEdu are also being developed, which define levels and areas of digital competence for teaching staff. Eurydice report shows that sustainable digitalisation requires long-term support – regular training, mentoring programmes and sharing of innovative practices between schools⁵. This reinforces

the view that digitalization outcomes depend on institutional capacity and governance arrangements rather than on technological investments alone. This highlights the importance of institutional support structures and leadership in reducing resistance to change and ensuring the effective pedagogical use of digital technologies.

In Bulgaria, the digital transformation in education is embedded in several key documents: i) Strategic Framework for Development of Education, Training, and Studying in the Republic of Bulgaria (2021 – 2030)⁶; ii) National Program “Digital Bulgaria 2025”⁷; iii) National Program “Education” ver. 2.0⁸; iv) Digital Education Action Plan (2021 – 2027)⁹; v) Investment Project “STEM Centers and Innovations in Education”¹⁰.

According to the National Reports on the Status and Development of Preschool and School Education (Hristova, Baev, Petrova, & Tosheva, 2019), the pandemic has led to a rapid adaptation of electronic platforms, but has revealed serious regional differences. While schools in large cities are more easily provided with devices and the Internet, in small settlements they often work with outdated equipment and unstable connectivity. These differences illustrate the risk that digitalization processes may reinforce existing territorial and socio-economic inequalities if targeted compensatory measures are not implemented. Thus, regional and institutional disparities emerge as an important contextual factor.

Beyond territorial gaps, the digital divide is also driven by socio-economic differences that shape learners’ and families’ ability to access and benefit from digital learning. Disparities in household connectivity, device availability, parental digital skills, and socio-economic vulnerability can translate into unequal learning opportunities even when schools provide basic infrastructure. In this sense, institutional digitalization may interact with broader social inequalities, making “equal access” dependent on compensatory policies (e.g., device provision, connectivity support, targeted training, and community-level digital inclusion measures). These socio-economic mechanisms remain critical for interpreting digitalization outcomes and for designing effective policy responses.

Empirical research (Mishkova-Yotova, 2024) (Parijkova & Simeonov, 2023) shows that schools that successfully integrate digital tools report higher student motivation, more active parental involvement, and more flexible organization of the learning process. At the same time, the lack of systematic teacher training and limited time for developing quality digital materials remain serious challenges. These findings further confirm that the human factor plays a central role in determining the real impact of digital technologies on educational outcomes, supporting the distinction between formal access to technologies and their effective institutional use.

In recent years, Bulgaria has invested significantly in building STEM centres equipped with modern equipment for experimental learning. Stoyanov et al. notes that these centers have the potential to change the way of teaching, but their sustainability depends on support, open programs and exchange of experience between

schools (Stoyanov, et al., 2022). Authors emphasize that the integration of STEM should be supported by cross-curricular connections and project-based tasks that stimulate creative thinking (Zhelyazkova, 2023) (Raycheva, 2024). This suggests that the presence of STEM initiatives may serve as an indicator of higher organizational digital readiness.

The literature identifies several groups of problems that hinder the full realization of digital potential: i) *Unequal access to technology*¹¹; ii) *Limited digital competences of teachers*¹²; iii) *Outdated infrastructure*¹³; iv) *Resistance to change* (Fullan, 2015). For students, the digital environment offers a wide range of resources, opportunities for personalized learning, and the development of key skills for the future labor market. However, challenges also arise – decreased concentration, increased screen time, and risks of digital addiction. Teachers, in turn, gain opportunities to apply more flexible teaching methods, experiment with new forms of assessment and enhance student engagement through interactive tools. At the same time, the constant need to adapt to technological change, combined with insufficient institutional support, may lead to professional overload and burnout.

Based on the reviewed literature, digitalization in education can be structured along several interrelated dimensions: infrastructural technological readiness (availability and reliability), organizational and institutional capacity (governance, leadership, flexibility, support mechanisms), and human capital factors. While these dimensions jointly shape digital transformation, empirical evidence suggests that infrastructural and organizational readiness constitute a foundational layer enabling further pedagogical change. The literature review clearly shows that the digitalization of education is a multidimensional process, in which technology is only one of the components. Key factors for success are equitable access, human capital development, strategic management and the cultural readiness of the educational community. In the Bulgarian context, significant progress has been achieved, particularly after 2020, yet sustainable digital transformation will depend on the ability to integrate infrastructure investments with long-term pedagogical, organizational and social support mechanisms. These theoretical insights provide the basis for the operationalization of digitalization and the formulation of the empirical hypotheses tested in the present study.

2. Methodological framework of the study

The study is based on quantitative methods of analysis, which allow the objective measurement and subsequent evaluation of data related to the use of digital technologies in Bulgarian kindergartens and schools. A cross-sectional quantitative research design is applied for identifying structural patterns and institutional differences in digitalization at a given point in time. The main method of data collection is a *questionnaire survey*, which provides a rich database for quantitative analysis. The selection of the participants was carried out through a *stratified random*

sample, and schools and kindergartens from all administrative regions of Bulgaria participate in it. The sampling frame included all registered preschool and school educational institutions in Bulgaria, and stratification was applied by region and type of institution (kindergarten, primary, secondary; public and private) to ensure broad territorial and institutional coverage. This approach ensures representativeness of the results and allows comparative analysis by region and type of educational institution. The unit of analysis is the educational institution, with responses provided by school principals or designated staff members responsible for digital coordination or management.

The survey was administered online via MS Forms and disseminated through institutional and professional channels to reach educational organizations across all administrative regions. Distribution was carried out through official contact lists and intermediary institutional networks with periodic reminders sent during the fieldwork period to increase coverage and reduce non-response. Participation was voluntary, and institutions were invited to provide one consolidated response representing their organization (completed by the principal or a designated staff member). The survey contains *closed and semi-closed* questions that allow quantitative measurement of various aspects of digitalization. The questions are divided into several main sections:

- *Level of digitalization in the organization and the learning process*: In this section, participants assess the availability and use of digital technologies in their institutions, including hardware and software resources;
- *Type of technologies used*: This section contains questions about the type of digital technology used in the learning process, such as computers, laptops, tablets, interactive whiteboards and educational software.
- *Conducting STEM-based learning*: Participants answer questions about the availability of STEM programs in schools, as well as the use of modern technology in these programs.
- *Obstacles to digitalization*: This section identifies the main difficulties in using digital technologies, such as lack of resources, technical problems, lack of appropriate training and others.
- *Frequency of use of digital technologies*: Participants rate how often they use digital technologies in their daily teaching work, as well as how they deal with technical problems that may arise.
- *Participants profile*: It includes demographic questions about the participants' work experience, their position in the organization, and the type and ownership of the educational institution.

In line with transparency and replicability requirements, the complete questionnaire (all closed, semi-closed and open-ended items, including response scales and coding rules) is provided by link to an external repository. To ensure the reliability and validity of the results, the survey questionnaire was *pilot tested* (through 63

respondents) to ensure that the questions were clearly worded and understandable to the respondents. After the pilot stage, the questionnaire was revised to remove potential ambiguities and increase the accuracy of the data collected. Construct validity of the key composite measure was further examined through exploratory factor analysis.

The collected data were processed and analyzed using the statistical software SPSS. Prior to analysis, the dataset was screened for completeness and consistency. Records with substantial missing information on core analytical variables were excluded from specific analyses using listwise deletion, while descriptive statistics were computed on all available valid responses. Variable coding followed a pre-defined codebook aligned with the questionnaire structure; semi-closed “Other (specify)” answers were reviewed and, where appropriate, recoded into existing categories or retained for qualitative content analysis.

The analysis includes both descriptive statistics, which will provide information about the distribution of responses, and more in-depth statistical methods for hypothesis testing. The main analysis methods used include: i) **descriptive analysis** to identify the main trends in the degree of digitalization in different educational institutions; ii) **hypothesis testing**: a t-test for independent samples to compare the level of digitalization between private and public schools; iii) **regression analysis** to investigate the relationship between technical problems and frequency of technology use; iv) **correlation analysis** to measure the relationship between different factors. In addition to bivariate analyses, multivariate linear regression models were estimated to assess whether the observed relationships remain robust when controlling for key institutional characteristics, such as type of institution, ownership and region. Specifically, the dependent variable in the multivariate models is the self-assessed level of digitalization (Q1), while key predictors include the Digitalization Index and ownership type; control variables include institution type and region.

The first hypothesis examines the **relationship between technical infrastructure and the degree of digitalization**. For this purpose, information from questions 3, 4 and 5 is used, through which the availability and diversity of hardware and software resources, the implementation of STEM-based training and the absence or presence of technical difficulties are assessed. The data obtained will be compared with the calculated **Digitalization Index**, formed by four questions.

The first indicator measures the number of digital technologies used (Q3), calculated as the total number of technologies reported by each organization. The second indicator reflects the presence of STEM fields or programs (Q4), coded binary (Yes = 1; No = 0). The third indicator considers the number of infrastructure barriers (Q5), with only elements related to internet connectivity, hardware, software and technical equipment included in the calculations. The fourth indicator measures the frequency of technical problems (Q8) on a four-point ordinal scale from 0 (never) to 3 (often). The classification of indicators in the index is based on their expected direction of

influence: *number of technologies* and *availability of STEM programs* are included in the index with a positive sign, as they are assumed to contribute to improving the technical infrastructure. Conversely, *number of obstacles* and *frequency of problems* are included with a negative sign, as they represent limitations or deficits.

To ensure comparability between indicators measured at different scales, all variables are standardized using a z-transformation, defined as: $z_x = \frac{x - \bar{x}}{SD_x}$, where: x is the individual score; $\bar{x}$ is the sample mean; SD_x is the standard deviation of the corresponding indicator.

The Digitalization index for an organization i is calculated using the formula: $DI_i = z_{Technologies_i} + z_{STEM_i} - z_{Barriers_i} - z_{Problems_i}$, where: $z_{Technologies_i}$ is standardized number of technologies used; z_{STEM_i} – standardized binary indicator for the presence of STEM; $z_{Barriers_i}$ – standardized number of infrastructure barriers; $z_{Problems_i}$ – standardized frequency of technical problems.

The constructed Digitalization Index is used as a proxy measure of technical and organizational readiness for digitalization, rather than as a comprehensive measure of pedagogical digital maturity. As such, it captures the structural and infrastructural conditions for digital transformation, while acknowledging that deeper pedagogical integration depends on additional qualitative and human factors beyond the scope of the present index. Given its composite nature, the index is intended for comparative and analytical purposes rather than for absolute measurement of digital maturity.

To assess the construct validity of the index, an exploratory factor analysis (EFA) was conducted on its four components. Sampling adequacy was evaluated using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. Internal consistency of the index was assessed using Cronbach's alpha. As a linear combination of standardized variables, the index has a mean close to zero; its standard deviation depends on the intercorrelations between the components. A further analysis is carried out through correlation analysis and linear regression to determine the strength and direction of the dependency. A statistically significant positive coefficient is interpreted as empirical support for the hypothesized relationship.

To examine territorial disparities in digitalization, regional differences were analyzed using analysis of variance (ANOVA) and region-specific dummy variables included in regression models. To explore potential mechanisms underlying digitalization processes, additional analyses considered the role of STEM initiatives and the frequency of technology use as intermediate factors linking infrastructural readiness and perceived digitalization. The qualitative procedure followed an inductive coding approach: responses were cleaned, anonymized, coded independently into preliminary categories, merged into broader themes, and used to contextualize quantitative findings.

The second hypothesis tests whether private schools and kindergartens are more prepared for the integration of digital technologies compared to public ones. Q12 (type of ownership) and the Digitalization Index are used for its research. The comparison between the two groups will be carried out using a t-test for independent samples. Welch's correction is applied where necessary to account for potential inequality of variances between groups. The hypothesis will be confirmed if the average values of the index for private institutions are significantly higher than those for public ones.

The study relies on self-reported institutional data and applies a cross-sectional design, which does not allow for causal inference or observation of dynamic changes over time. Furthermore, the analysis focuses on quantitative indicators and does not include qualitative insights into classroom-level pedagogical practices. These limitations are partially mitigated by the large sample size, the national coverage of the survey and the institution-level focus of the analysis. Ethical considerations were observed throughout the study: participation was voluntary, no sensitive personal data were collected, and responses were analyzed in aggregated form for scientific purposes.

3. Results and Discussion

Hypothesis 1 assumes that organizations with better technical infrastructure demonstrate a higher level of digitalization. The first component of the Digitalization Index that measure the number of digital technologies used is with a mean value of 1.59 technologies per organization. Regarding the integration of STEM projects, 40.2% of organizations declaring a positive answer. The third component is the number of reported infrastructure barriers (Q5), with mean of 0.47 barriers per organization and a standard deviation of 0.69. The frequency of technical problems (the fourth component) is with a mean of 1.51 and a standard deviation of 0.88.

The dependent variable is the self-assessed level of digitalization, measured by Q1 on a scale from 1 to 5, with the mean value of 2.96 in the full sample of 4,206 valid observations. To establish the relationship between technical infrastructure and the level of digitalization, an analysis using Pearson's correlation coefficient and one-way linear regression (OLS) was applied. The results show a statistically significant positive relationship: the correlation coefficient is $r = 0.149$ at $p < 0.001$, which corresponds to a low strength but stable relationship. The linear regression model gives a coefficient $b = 0.094$ ($SE = 0.0096$) at $R^2 = 0.022$ and $p < 0.001$, which means that the technical infrastructure index explains about 2.2% of the variation in the level of digitalization between organizations. The relatively low explanatory power of the regression model suggests that digitalization is influenced by additional factors that are beyond the scope of the present index.

A detailed review of the individual components of the index reveals that the strongest direct relationship with digitalization is the presence of STEM, for which

a correlation coefficient of $r = 0.282$ at $p < 0.001$ was calculated. The number of technologies used shows a very weak effect ($r = 0.016$, $p = 0.279$), while infrastructure barriers ($r \approx 0.002$) and the frequency of technical problems ($r \approx 0.006$) practically do not have a statistically significant impact on their own. These results emphasize that the qualitative characteristics of the infrastructure (presence of STEM programs that develop human capital and technological culture) are more important for the digital transformation than the simple presence of technical means or the absence of problems.

The relationship between the technical infrastructure index and the level of digitalization presented in Figure 1 clearly illustrates the positive trend, despite the moderate slope of the regression line. The statistical significance of the model and the stability of the effect within a large and diverse sample allow us to assume that Hypothesis 1 is not rejected. This supports the conclusion that improving technical infrastructure is associated with higher levels of digitalization.

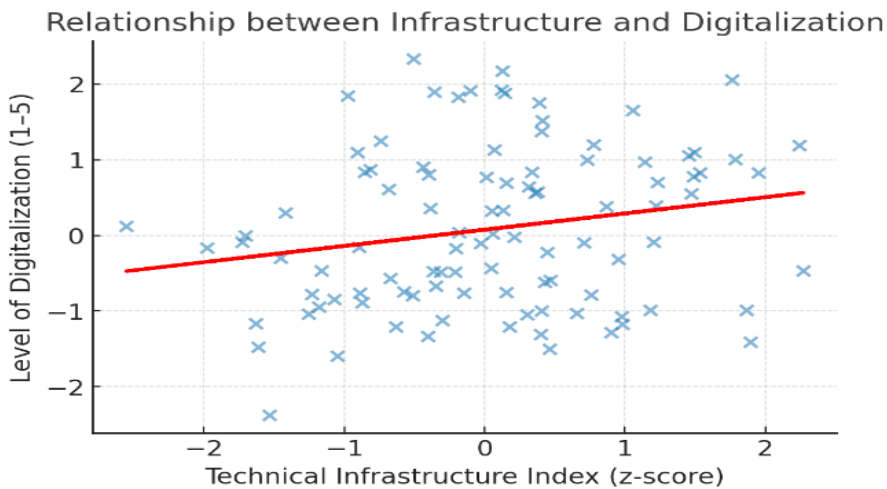


Figure 1

Source: Own figure.

Exploratory factor analysis (EFA) on the four index components indicated that the data are suitable for factor extraction (KMO = 0.63, Bartlett's test $\chi^2 = 2146.7$, $df = 6$, $p < 0.001$). The exploratory factor analysis was conducted using Principal Axis Factoring with oblimin rotation, given the expected correlations between indicators. The EFA results supported a one-factor structure, explaining 52.4% of the total variance. Factor loadings were: 0.12 – Technologies, 0.78 – STEM, -0.64 – Barriers, -0.66 – Problems, indicating that STEM loads most strongly on the latent

readiness dimension, while barriers and technical problems load in the expected inverse direction. Internal consistency reliability was assessed using Cronbach's alpha ($\alpha = 0.82$), which indicates acceptable reliability given the small number of components and the deliberately composite nature of the index. These results provide empirical evidence for the construct validity of the index as a proxy for infrastructural and organizational readiness.

To test whether the relationship between infrastructural/organizational readiness and perceived digitalization remains robust when accounting for institutional characteristics, multivariate linear regression models were estimated. Model 1 replicates the bivariate association between the Digitalization Index and self-assessed digitalization (Q1). Model 2 introduces ownership, institution type, and region (dummy-coded). The Digitalization Index remains a statistically significant predictor ($\beta = 0.12$, $p < 0.001$) in the full model, while ownership retains an independent association ($\beta = 0.18$, $p < 0.001$). The model's explanatory power increases from $R^2 = 0.022$ in the bivariate case to $R^2 = 0.093$ in the multivariate specification, suggesting that institutional characteristics and territorial context explain an additional share of variance.

To assess territorial disparities, an ANOVA comparing mean digitalization levels across regions indicates statistically significant differences $F = (27, 4178) = 18.6$, $p < 0.001$. Post-hoc comparisons reveal that districts Sofia (city), Plovdiv, Varna, Burgas demonstrate significantly higher average digitalization than districts Kardzhali, Razgrad, Montana, Vidin. This confirms that digitalization in Bulgaria is unevenly distributed geographically, consistent with the literature on digital divide dynamics. Region-specific effects are also reflected in the multivariate regression model, where several regional dummy coefficients are statistically significant ($p < 0.05$), indicating that location matters even when controlling for ownership and institution type.

Hypothesis 2 tests whether private schools and kindergartens are more prepared for the integration of digital technologies compared to public ones. The information from Q12 (type of ownership), as well as the constructed Digitalization Index is used. The sample includes 4,206 valid observations, of which 2,076 (49.36%) are private institutions, and 2,130 (50.64%) are public. Private institutions are intentionally over-represented in the sample compared to their actual share in the national system. This ensures sufficient statistical power for public-private comparisons but requires caution when generalizing institutional proportions to the national level. The data show that the average value of the index for private organizations is 0.2818 ($SD = 0.8461$), while for public ones it is -0.2826 ($SD = 1.0361$).

The Digitalization Index values show a significant difference between private and public institutions. The results obtained for the average value characterizing private organizations are positive (0.2818). It shows that within the standardized scale, these organizations are positioned above the average level. Conversely, the average value

for public institutions is negative (-0.2826), which shows that they lag the general average level. Beyond differing in direction (positive versus negative), the groups vary in dispersion, with private institutions showing a smaller standard deviation ($SD = 0.8461$) than public ones ($SD = 1.0361$). This means that in private organizations the level of digitalization is more evenly distributed around the average value, while in public ones there are larger fluctuations – from highly digitalized to significantly lagging. The results obtained provide grounds for formulating a conclusion that the group of private kindergartens and schools demonstrate a higher degree of readiness for the integration of digital technologies, as well as higher resilience. At the same time, public ones show greater heterogeneity and lower average capacity.

To assess the statistical significance of the difference between the two groups, an independent-samples t-test with Welch's correction was conducted to account for unequal variances. The result Welch's t (≈ 4090) = 14.98, $p < 0.001$, Hedges' $g = 0.584$, indicating a highly significant difference with a medium effect size. This suggests that the difference between private and public institutions is of practical relevance. The results clearly show that private educational institutions demonstrate a higher degree of digitalization compared to public ones. This can be explained by greater flexibility in resource management, freer access to funding from various sources and the ability to introduce new technologies more quickly. Therefore, the available data does not reject Hypothesis 2.

In the multivariate regression model, the ownership effect remains statistically significant after controlling for institution type and region ($\beta = 0.18$, $p < 0.001$), indicating that the public-private gap is not solely a reflection of territorial structure or the distribution of institution types. This finding supports the interpretation that governance flexibility and resource allocation capacity may constitute mechanisms contributing to higher institutional readiness among private organizations.

To complement the quantitative findings and to better understand mechanisms underlying digitalization, semi-closed responses ("Other, specify") were analyzed using inductive qualitative coding. The most frequent themes include: 1) insufficient or unstable Internet connectivity, 2) shortage of functioning devices or outdated equipment, 3) lack of time and workload pressure limiting teachers' ability to use technology meaningfully, 4) need for targeted training and on-site technical support, and 5) administrative and procurement barriers, particularly in public institutions. These qualitative patterns help explain why similar levels of basic infrastructure may produce different perceived digitalization levels: organizational capacity, teacher support structures, and administrative constraints shape whether technology becomes routine practice or remains underutilized.

Conclusions

The study of digitalization processes in the Bulgarian education system, covering 4,206 respondents from kindergartens and schools across the country, shows that the degree of implementation and effective use of digital technologies depends on both the technical infrastructure and the way it is integrated into educational practices. The results do not reject the first hypothesis, according to which the presence of a better technical infrastructure is associated with a higher level of digitalization, although the relationship is weak. Of particular importance are qualitative characteristics, such as the presence of STEM projects, which have a stronger impact on digital transformation than simply the number of available technologies or the absence of technical problems. The results obtained from the analysis also do not provide grounds for rejecting the second research hypothesis. The conclusions are that private kindergartens and schools demonstrate a significantly higher degree of digitalization compared to public ones, with the difference being statistically significant and with a medium strength of effect. This phenomenon can be explained by greater flexibility in resource management in private organizations, faster access to financing and less administrative inertia, which lead to increased efficiency of digitalization processes.

The research conducted and the results obtained during it are an objective basis for outlining several main conclusions and recommendations. First, to achieve a sustainable digitalization process, it is necessary to make investments to achieve systematic development of human capital through training, mentoring programs and stimulating innovations in teaching. Second, policies in the field of education should be aimed at overcoming regional and institutional differences, so that access to quality digital education is equal. And third, the integration of STEM approaches and project-based learning should be considered as a strategic priority that strengthens technological culture and prepares students for the challenges of the modern labour market.

In conclusion, the digitalization of the education system in Bulgaria is at an advanced but uneven stage, and sustainable progress will depend on a balanced combination of infrastructure investments, innovations in the pedagogical process, and the application of the strategic planning process in managing processes and formulating strategies and policies for the future development of the sector.

Finally, the combined evidence from multivariate models, regional comparisons, and qualitative coding suggests that infrastructural readiness is a necessary enabling condition, but differences in institutional capacity, teacher support, and administrative constraints play a decisive role in explaining the uneven distribution of digitalization outcomes across Bulgarian education.

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NOTES

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