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Managing Digital Transformation in Public Education within a Centralized School System: Evidence from Greece

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Abstract

This study examined the management of digital transformation in Greek primary education, focusing on the interplay of leadership, digital competencies, and strategic investment. Conducted within a highly centralized system, it investigates how these factors, as perceived by teachers, shape schools' capacity to adopt and sustain digital change. A quantitative design was applied with 323 public primary school teachers, who completed a structured questionnaire on leadership practices, digital competencies, and infrastructure investment. Results show that while all three factors were positively related to digital transformation, leadership practices and strategic investment were the strongest predictors, whereas digital competencies played a supportive role. Regarding principal gender, teachers in schools led by male principals reported higher self-assessments of their own digital competencies, though no differences were observed in leadership or investment. Age differences were clearer: older teachers evaluated leadership and investment more positively, while younger teachers reported stronger digital skills. Overall digital transformation was rated as moderate, with particularly low scores for strategic investment, which highlighted structural barriers. By situating these results within a centralized governance context, the study demonstrates how leadership and resource allocation jointly shape digital change at the school level. The study concludes that sustainable digital education in Greek primary schools requires strong leadership, long-term investment, and continuous professional development. These implications are relevant to other centralized public education systems in the broader region.

Keywords: *digital transformation; centralized governance; digital competencies; leadership; strategic investment*

Introduction

Digital transformation involves the integration of processes, people, and technology to enhance organizational operations in education. It goes beyond simply adopting digital technologies, representing a wider and more integrated process of change. The purpose of digital transformation in education is to foster continuous innovation in teaching and learning while optimizing administrative processes to improve efficiency for all stakeholders (Vičič Krabonja et al., 2024; Yıldırım et al., 2024).

Primary education plays a critical role in preparing future citizens and building a digitally literate and socially cohesive generation. There is a need for educational approaches to change so that students acquire the essential knowledge and abilities to contribute to a more united, inclusive, and adaptable society (Cerna et al., 2021). Digital technologies expand access to information and foster innovation in the school context, serving as mechanisms for improving educational equity and efficiency (Khin & Ho, 2019; Liu, 2024; Mastrothanasis et al., 2025; Vizjak et al., 2023).

The potential of digital transformation in education is widely recognized. Managing digital transformation goes beyond the implementation of technological solutions; it also requires the targeted development of digital competencies, strategic investment in infrastructure, and effective leadership (Raptis et al., 2024; Zhang et al., 2023). According to Heavin and Power (2018), effective leadership, strategic investment, and the systematic integration of digital technologies into the school context are prerequisites for the successful digital transformation of educational institutions. To strengthen schools in a rapidly changing digital context, clear priorities must be set within and beyond the organization, many of which are implemented by the school leader (Navaridas-Nalda et al., 2020).

In the post-COVID-19 context, the systematic development of teachers' digital competencies is essential for ensuring quality education (Suphakicco, 2022). Investment in teachers' digital capacity and the continuous upgrading of school infrastructure form the cornerstone of effective digital transformation (Timotheou et al., 2023). Digital transitions inevitably influence both economic and social structures. They not only generate new demands for modern skills but also produce mismatches and instabilities between competencies and the constantly shifting labour market (Hippe & Jakubowski, 2022).

Driven by economic changes and unforeseen disruptions such as COVID-19, new digital working models, including hybrid and remote arrangements, are emerging (Janković et al., 2025; Wontorczyk & Rożnowski, 2022). Such conditions have underscored the existence of a digital divide, highlighted the limited digital competencies of teachers, and exposed the inadequacy of technological infrastructure within educational institutions (Li, 2025; Miljković Krečar & Pavlin-Bernardić, 2025; Novković Cvetković et al., 2024; Soomro et al., 2020).

Building on prior work on digital leadership and capacity-building, this article makes explicit its conceptual move by treating leadership, digital competencies, and strategic

investment as a single, school-level triad that links human capability, organizational direction, and technical resources within a centralized structure. In Greece, the education system´s high level of centralization provides an insightful context for exploring how digital governance can drive inclusion and strengthen social resilience. In this regard, Greece offers a useful case for understanding what an equitable digital transformation within public institutions might look like. Importantly, in centralized public systems, the feasibility of school-level innovation often depends on external resource allocation, which may amplify the role of strategic investment relative to individual capacity.

Conceptual framework of the study

The conceptual model of this study rests on the triad of digital competencies, strategic investment, and leadership as prerequisites for managing digital transformation in public education (Figure 1; adapted from Brunetti et al., 2020; Heavin & Power, 2018; Navaridas-Nalda et al., 2020). Conceptually, the triad is anchored in sociotechnical systems thinking. Leadership expresses the organizational and cultural subsystem, strategic investment the technical-structural substrate, and digital competencies the human capabilities that connect the two (e.g., Mumford, 2006; Trist & Bamforth, 1951).

Drawing on transformational leadership theory (Bass, 1999), the model assumes that leadership acts as the primary behavioural and cultural catalyst that enables investment decisions and competence development. From a resource dependence perspective (Pfeffer & Salancik, 2015), strategic investment represents the capacity of schools to secure and allocate scarce resources to support innovation. The digital capability framework (Kane, 2019) further positions digital competencies as the micro-level enablers that translate leadership vision and investment into effective transformation outcomes.

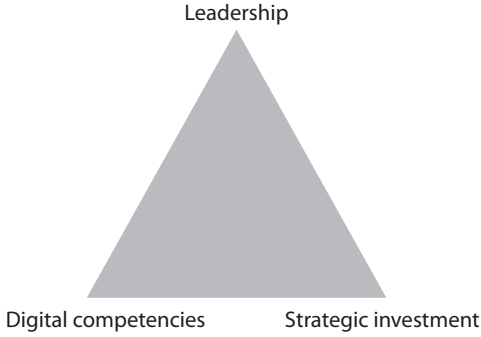

Figure 1. The triad of prerequisites for digital transformation

The digital transformation in primary education does not merely involve the adoption of digital tools but represents a complex and multidimensional process, founded on three fundamental prerequisites, as illustrated in Figure 1. In the absence of interplay among these three dimensions, digital transformation remains partial and lacks the foundations to be sustainably embedded within the educational context.

The existing literature indicates that school principals are central to addressing these demands, acting as key leaders in driving and managing the digital transformation of education (Navaridas-Nalda et al., 2020; Okunlola & Naicker, 2025; Ruloff & Petko, 2025). They must balance the expectations of teachers, students, families, and communities with system-level requirements and the unique context of their schools.

Secondly, digital competencies are considered a fundamental prerequisite for the successful implementation of digital transformation in education (Schlegel & Kraus, 2023; Tóth et al., 2022; Županić Benić & Kajm Ferčec, 2025). Beyond basic technical skills, they encompass a broad set of knowledge, attitudes, and abilities that allow teachers to effectively integrate digital technologies into learning and teaching processes (Falloon, 2020). Similarly, Basilotta-Gómez-Pablos et al. (2022) highlighted that the development of teachers' digital competencies is essential for fostering innovative pedagogies and supporting students' digital literacy.

Third, strategic investment is widely recognized as a requisite for the effective realization of digital transformation in education (Brunetti et al., 2020; Mohamed Hashim et al., 2022). It goes beyond the mere provision of technological tools and infrastructure, encompassing long-term planning, sustainable funding, and the alignment of resources with pedagogical goals (Liu, 2024). Strategic investment ensures that schools are equipped not only with the necessary technologies but also with the capacity to integrate them effectively, thereby enabling systemic and lasting change in teaching and learning (Nhung et al., 2025).

Leadership, investment, and competencies are treated as interrelated predictors, while the overall digital transformation of schools constitutes the systemic outcome that emerges from their interaction. In practical terms, the triad refers to three closely connected dimensions that support digital transformation at the school level. Leadership relates to the ability of school principals to guide change and create a supportive environment for the use of digital technologies. Digital competencies describe teachers' capacity to integrate digital tools into their daily teaching practices. Strategic investment concerns the provision of technological infrastructure, equipment, and opportunities for professional development that allow schools to make effective use of digital resources. In this context, these three dimensions are examined as interconnected factors that shape the overall process of digital transformation within the centralized governance structure of Greek primary education.

Digital transformation in Greek primary education

Digital transformation has emerged as a pressing priority for education systems worldwide, reshaping pedagogical practices, leadership models, and institutional capacities. Yet, in the Greek context, the academic literature remains relatively limited, particularly when it comes to primary education. Most existing studies focus either on higher education or on the public sector, leaving the specific challenges and opportunities within public primary schools underexplored. This gap highlights the

importance of situating research in Greek primary education and contributing to the development of a fertile academic dialogue that addresses both theory and practice. From an institutional perspective, the high degree of centralization sets the rules and resource flows within which schools configure the three levers of the triad.

Several contemporary studies have illustrated the emerging interest in this field but also underscored the need for more targeted investigation. For instance, Kokkonos et al. (2025) examined digital technologies and leadership practices in Greek elementary schools, focusing on how demographic characteristics shape perceptions of digital leadership and revealing significant differences based on age, education level, teaching experience, and the role within the school. Similarly, research on the knowledge and skills of digital transformation in the Greek public school system in the post-COVID era has emphasized the pressing need to build teachers' digital competencies while acknowledging persistent shortcomings in infrastructure and training (Kalogeratos & Pierrakeas, 2022).

At the level of higher education, digital transformation has been framed as a strategic policy priority, highlighting the necessity of long-term planning and alignment with institutional goals (Exarchou et al., 2024). Beyond education, research on the Greek public administration has also offered useful insights. Xanthopoulou et al. (2023) showed that factors such as technology quality, leadership, staff training, evaluation, and a strong digital culture are crucial for successful transformation. They also found that the Covid-19 pandemic acted as a catalyst for change, seen by many public servants as an opportunity rather than a threat.

This perspective is relevant for schools as well, since leadership and strategy can either support or hold back digital change. Overall, these studies have shown growing interest in digital transformation in Greece but also revealed a clear gap: little attention has been given to primary education. This research focuses on Greek primary education as a means of addressing this evident gap in the literature. It investigates how leadership, digital competencies, and strategic investment intersect within this context, positioning primary schools as a crucial setting for examining broader processes of digital change. The Greek case is also positioned as a policy-relevant example for other centralized public systems in the region.

Research purpose and questions

The present research investigated the interplay of leadership, digital competencies, and strategic investment as prerequisites for managing digital transformation in Greek primary schools. It focused on capturing the perceptions and experiences of teachers in public primary education, aiming to assess the extent of their digital competencies, the quality of leadership practices, and the level of strategic investment in technological infrastructure.

Particular emphasis was placed on examining the degree to which principals' gender and teachers′ age groups affect perceptions of leadership practices, digital competencies, strategic investment, and overall participation in the digital transformation of schools.

The goal was to identify the structural and human factors that enable meaningful and sustainable digital transformation within a centralized education system. Within this framework, the study sought to respond to the following research questions:

What is the relationship between digital competencies, strategic investment, and leadership, and how do these dimensions act as critical drivers of digital transformation?

What is the current state of digital competence among primary education teachers in Greece?

(1) → To what extent is strategic investment in infrastructure and technological resources being implemented to support digital transformation?

(2) → What is the impact of school leadership practices on enabling and maintaining digital transformation in public primary schools?

(3) → What differences, if any, exist between male and female school principals in their leadership practices, digital competencies, strategic investment, and overall engagement in managing digital transformation?

(4) → How do teachers' perceptions of leadership, competencies, investment, and digital transformation vary across different age groups?

Methodology

Research design

This study followed a quantitative research design using a structured questionnaire composed of closed-ended questions. Its aim was to demonstrate that leadership practices, teachers′ digital competencies, and strategic investment operate as key prerequisites for managing and integrating digital transformation in schools. The design enables the systematic collection of comparable data from a large number of teachers, capturing correlations and trends across the educational context.

The use of closed-ended questions provided clarity and consistency in responses, facilitating statistical analysis that led to valid and reliable conclusions (Aithal & Aithal, 2020). Although the study focused on Greek primary education, its findings may also inform policy in other centralized contexts.

Participants

The sample consisted of 323 public primary school teachers during the 2024-2025 academic year. Women represented 70.6% and men 29.4% of the sample. Most participants were 30–39 (43.3%) years of age, followed by those over 50 (32.8%). Over half held a master′s degree (53.6%), and the majority were permanent staff (76.5%). Among their schools, 125 were led by male principals and 198 by female principals. Table 1 provides a detailed overview of the demographic characteristics of the sample, summarizing the distribution of participants across gender, age groups, years of service, employment status, and educational level.

A purposive sampling approach was employed due to the structural constraints of the Greek education system and the absence of a comprehensive teacher registry.

Participation was voluntary via an online questionnaire distributed through educator networks and social media. While this approach may have introduce self-selection bias, it allowed for demographic diversity in gender, age, and experience (Campbell et al., 2020; Andrade, 2021).

Table 1

Descriptive statistics of the sample

Demographic variables		N
Gender	Male	95
	Female	228
School principals' gender	Male	125
	Female	198
Age group	<29 years old	24
	30-39	140
	40-49	53
	>50	106
	<5 years	66
	6-10	54
Years in service	11-15	70
	16-20	34
	>21	99
Employment status	Permanent	247
	Substitute	76
Education	Bachelor	133
	Second bachelor	12
	Master	173
	PhD	5

Power analysis (G*Power 3.1.9.6) confirmed that a minimum of 77 participants would suffice for medium effects (power = 0.80, $\alpha = .05$, $f^2 = 0.15$). The actual sample of 323 therefore ensured strong statistical power.

Instrument

A structured online questionnaire was developed to reveal teachers' perceptions of leadership practices, digital competencies, strategic investment, and overall digital transformation. It included 29 items: six demographic questions and 23 on the four core dimensions.

Specifically, leadership practices were assessed with eight items, strategic investment with five items, digital competencies with six items, and digital transformation with four items. Responses were given on a five-point Likert scale (1 = not at all, 5 = very much).

Instrument development followed a multi-stage validation process. A pilot test verified reliability, while three experts confirmed content validity. Cronbach's α values across scales exceeded 0.70, which confirmed internal consistency. Representative items for each dimension are presented in Table 2, while the full questionnaire is provided in the Appendix.

Table 2
Example items for each dimension of the questionnaire

Dimension	Number of Items	Example Item
Leadership practices	8	The principal promotes collaborative actions with the teaching staff of the school unit.
Strategic investment	5	Digital devices are available at the school for students to use when needed.
Digital competencies	6	To what extent can you produce digital material for your students in different formats (e.g., video, images, audio, text)?
Digital transformation	4	The principal collaborates with teachers in developing the school's digital organization (e.g., digital classrooms, blogs, online libraries, repositories with digital content).

Procedure

The study was approved by the University of the Aegean Deontology Committee (Approval No. 2, 19 October 2024). Participation was voluntary and based on informed consent. The questionnaire was distributed online through professional networks and social media platforms used by Greek primary teachers. Data were collected securely and anonymously. Teachers could complete the survey at their convenience. The online format minimized disruption of work duties while ensuring accessibility and data protection.

Analysis

Data was analyzed using descriptive and inferential statistics in SPSS (v25.0). Descriptive statistics (means, SDs, frequencies) provided an overview of teacher perceptions. Cronbach's alpha assessed internal consistency, while inferential tests included:

- Pearson correlations – to explore associations between leadership, competencies, investment, and transformation.
- Independent samples t-tests – to examine gender-related differences based on principals' gender.
- One-way ANOVA (with Bonferroni post-hoc tests) – to identify differences across teacher age groups.
- Hierarchical multiple regression – to determine the predictive power of each factor on digital transformation.

Bonferroni correction was applied ($\alpha = 0.0125$) to control the family-wise error rate. Common method bias was tested with Harman's single-factor test; results confirmed it was not significant (Fuller et al., 2016). Assumptions of regression were verified (normality, multicollinearity, independence of errors). The model was statistically significant ($F(3,319) = 122.59$, $p < .001$), which supported the reliability of the analyses.

Results

To facilitate interpretation, results are presented according to the research questions. Each subsection corresponds to one or more questions and summarizes how the findings address them.

Leadership, competencies, and strategic investment as critical drivers of digital transformation

Pearson's r correlations were computed (Table 3). The variables were measured on continuous scales, and all reliability coefficients were satisfactory (α = 0.726 – 0.878).

Table 3

Pearson correlations among the digital transformation variables

	Leadership practices	Digital competencies	Strategic investment
Leadership practices	-		
Digital competencies	.033	-	
Strategic investment	.550***	.100	-
Digital transformation	.537***	.131*	.702***

Note. *$p < .05$, **$p < .01$, ***$p < .001$. Two-tailed significance tests.

Leadership correlated strongly with digital transformation ($r = 0.537$, $p < .001$); strategic investment showed an even stronger link ($r = 0.702$, $p < .001$). Digital competencies were weaker but significant ($r = 0.131$, $p < .05$). Overall, leadership and strategic investment show the strongest associations with digital transformation, while digital competencies indicate a weaker relationship. Hierarchical multiple regression determined their predictive power (Table 4).

Table 4

Hierarchical multiple regression analysis of the drivers of digital transformation

Model	Model 1			Model 2			Model 3		
Predictors	B	SE B	β	B	SE B	β	B	SE B	β
Constant	.35	.25		-.11	.31		-.14	.25	
Leadership practices	.70	.06	.54***	.69	.06	.53***	.28	.06	.22***
Digital competencies				.13	.05	.11*	.08	.04	.07
Strategic investment							.67	.05	.58***
R^2		.29			.30			.53	
ΔR^2		.29			.01			.23	

Note. *$p < .05$, **$p < .01$, ***$p < .001$. Two-tailed significance tests

Leadership alone explained 29 % of the variance ($\beta = 0.54$, $p < .001$). Adding competencies raised R^2 by 0.01 ($\beta = 0.11$, $p < .05$). When strategic investment entered, R^2 rose to 0.53 ($\beta = 0.58$, $p < .001$). Thus, leadership and investment were proven as the dominant predictors, whereas competencies had a supportive effect. Detailed diagnostics (VIF < 2; Durbin–Watson = 1.98; normal residuals) confirmed model adequacy and absence of multicollinearity.

Overview of digital transformation in primary education: descriptive results

Descriptive statistics for the four dimensions are presented in Table 5.

Table 5

Descriptive statistics of the digital transformation variables

Variables	N	Min	Max	M	SD
Leadership practices	323	1.00	5.00	3.98	.70
Strategic investment	323	1.00	4.83	2.78	.78
Digital competencies	323	1.50	5.00	3.67	.79
Digital transformation	323	1.00	5.00	3.14	.91

Leadership received the highest mean score, followed by digital competencies, while strategic investment was lowest. Teachers perceived supportive leadership and adequate digital readiness but insufficient infrastructure and resources. The overall digital transformation level was moderate (M = 3.14), which reflected both progress and systemic barriers. Repetition of mean-score commentary and restatement of correlation findings were removed for brevity.

Comparison of digital transformation variables by principals' gender

Independent samples t-tests were conducted to compare perceptions between schools led by male and female principals (Table 6).

Table 6

Independent samples t-test of principals' gender

Variables	Male		Female		t	df	p	Cohen's d
	M	SD	M	SD				
Leadership practices	3.92	.78	4.01	.66	-1.013	321	.312	-.124
Digital competencies	3.94	.81	3.56	.75	4.070	321	<.001	.497
Strategic investment	2.90	.75	2.73	.78	1.743	321	.082	.213
Digital transformation	3.24	.85	3.10	.93	1.277	321	.203	.156

Note. Family-wise error across the four t-tests was controlled using the Bonferroni correction (α = 0.0125). Two-tailed tests

Only digital competencies differed significantly: teachers under male principals rated themselves higher ($p < .001$, $d = .50$). This difference reflects self-reported competence and should be interpreted cautiously. No gender differences emerged for leadership, investment, or transformation. After Bonferroni correction ($\alpha = 0.0125$), the result for competencies remained significant. Extended discussion of self-assessment bias and repetition of non-significant results is omitted for conciseness.

Teachers' age group differences in key dimensions of digital transformation

ANOVA tested differences across four age groups (≤29, 30–39, 40–49, ≥50).

Table 7.
ANOVA results by teachers' age group

Variable	Source	SS	df	MS	F	*p*
Leadership practices	Between Groups	6.20	3	2.07	4.37	.005**
	Within Groups	150.91	319	.47		
	Total	157.11	322			
Digital competencies	Between Groups	22.53	3	7.51	13.40	<.001***
	Within Groups	178.84	319	.56		
	Total	201.38	322			
Strategic investment	Between Groups	11.29	3	3.76	6.57	<.001***
	Within Groups	182.78	319	.57		
	Total	194.07	322			
Digital transformation	Between Groups	10.55	3	3.52	4.40	.005**
	Within Groups	255.07	319	0.80		
	Total	265.63	322			

Note. *$p < .05$, **$p < .01$, ***$p < .001$. Two-tailed significance tests. Family-wise error rate across the four ANOVAs was controlled using the Bonferroni correction ($\alpha = 0.0125$)

Post-hoc comparisons provided further insight into group differences. Teachers aged ≥ 50 reported significantly higher leadership practices (M=4.17, SD=0.64) compared to those aged 30-39 (M=3.86, SD=0.73; $p < .01$). For digital competencies, teachers aged ≥ 50 (M=3.31, SD=0.83) reported markedly lower levels compared to younger groups, including those aged 20-29 (M=4.00, SD=0.57; p<.001), 30-39 (M=3.88, SD=0.68; p<.001), and 40-49 (M=3.71, SD=0.80; p<.050).

A similar pattern was observed for strategic investment, where teachers aged ≥ 50 (M=3.00, SD=0.69) reported higher scores than those aged 30-39 (M=2.58, SD=0.77; p<.001). Finally, teachers aged ≥ 50 also reported higher levels of overall digital transformation (M=3.38, SD=0.85) compared to those aged 30-39 (M=2.97, SD=0.94; p<.01).

These findings indicate an age-related divide: older teachers reported more positive evaluations of leadership and strategic investment, while younger teachers had higher levels of self-assessed digital competencies.

Summary of key findings

The findings of this study provide a comprehensive picture of the factors driving digital transformation in Greek primary schools. Leadership practices, teachers' digital competencies, and strategic investment were all positively related to digital transformation, which confirmed their complementary roles. Among them, leadership and strategic investment emerged as the strongest predictors, which jointly explained more than one half of the variance in digital transformation outcomes ($R^2 = .53$). Digital competencies, although statistically significant, exerted only a secondary influence once the effects of leadership and investment were considered, which suggests that technological readiness supports but does not by itself drive systemic change.

Teachers working in schools led by male principals reported higher self-assessments of digital competencies, while no significant differences were observed in perceptions of leadership, investment, or overall transformation. This pattern implies that principals' gender may shape teachers' self-perceptions but has limited impact on the organizational dimensions of digital transformation. Age-related differences were more evident. Older teachers tended to evaluate leadership, investment, and overall digital transformation more positively, whereas younger teachers reported higher self-assessed digital competencies.

Overall, digital transformation in Greek primary schools was rated as moderate. Progress is constrained mainly by limited strategic investment and structural barriers that restrict the full realization of digital change in the educational sector.

Discussion

This study examined how leadership practices, digital competencies, and strategic investment interact as key factors that support digital transformation in Greek primary schools. Teachers' perceptions point to important areas of strength, but they also reveal continuing challenges that slow down the progress of digital change in public education. The findings indicate that leadership practices and strategic investment constitute the strongest predictors of digital transformation in schools. This relationship resonates with broader evidence linking leadership, governance, and sustainable investment practices as key enablers of organizational transformation (Alkaraan et al., 2023; Alqatan et al., 2025). This result also supports the conceptual framework of the study, which approaches digital transformation as the result of the interaction between leadership, digital competencies, and strategic investment within the school environment (Heavin & Power, 2018; Navaridas-Nalda et al., 2020).

This result is consistent with the literature that emphasizes that digital transformation cannot be understood solely as a cultural or pedagogical process but requires the synergy of visionary leadership and systematic allocation of resources (Xafakos et al., 2020). The predominance of strategic investment in this model may reflect the material constraints of centralized systems, where leadership capacity and competence development remain dependent on the steady flow of resources and institutional support. This interdependence suggests a mediating pathway, in which leadership functions as a behavioural mechanism that translates investment into digital transformation outcomes. This finding suggests that the Ministry of Education should prioritize policies that support school leaders with both resources and training, ensuring that visionary leadership is matched by adequate long-term investment. More broadly, this pattern shows how centralized systems can constrain digital change. Schools may be ready to act, but progress depends on externally controlled infrastructure and funding.

At the leadership level, Heavin and Power (2018) and Zervoudakis et al. (2024) emphasize that leaders with the capacity for adaptability and the strategic alignment of technological innovations with organizational goals are crucial for successfully

navigating change. Similarly, in education, Navaridas-Nalda et al. (2020) demonstrated that principals' perceptions of the usefulness of educational digital resources (EDRs), together with factors such as technical support and the school's digital culture, play a decisive role in shaping the trajectory of digital transformation.

Regarding strategic investment, numerous studies have highlighted its importance as a fundamental prerequisite for digital transformation. Fernández et al. (2023) showed that institutions adopting a clear strategy and investing in resources achieve better outcomes than those relying on fragmented initiatives. Singun's (2025) review indicated that the lack of digital resources and infrastructure is one of the most significant barriers. The World Bank study (Rodriguez-Segura, 2022) documented that stable funding, adequate infrastructure, and teacher training are critical for improving learning outcomes; without them, EdTech initiatives remain ineffective. Finally, Brunetti et al. (2020) argued that addressing digital transformation requires coordination among stakeholders and emphasis on investment not only in technology but also in training and sustainable tool use. Comparable OECD data indicate that Nordic education systems, where digital funding is decentralized and autonomy is more pronounced, display stronger competence-driven outcomes, whereas in Southern Europe and Asia-Pacific contexts, resource concentration determines digital maturity (OECD, 2023).

In terms of digital competencies, the findings reveal that although they are positively correlated with digital transformation, they do not constitute an independent predictive factor once leadership and strategic investment are considered. This suggests that competencies operate primarily as a complementary factor, strengthening the influence of leadership and resources rather than serving as an independent driver. Similar conclusions have been reported in previous studies showing that teachers' digital competencies become more effective when they are supported by strong leadership and adequate institutional resources (Kudek Mirošević et al., 2024; Raptis et al., 2025a; Schmitz et al., 2023; Timotheou et al., 2023). Consistent evidence was reported by Antonopoulou et al. (2025), who found that teachers' competencies gained significance only when combined with supportive leadership and organizational structures that ensure adequate resources and professional development.

The OECD (2023) reported highlights that, despite formal frameworks for developing teachers' digital competences, these competences are insufficient without accompanying support policies and coordinated school-level action. Likewise, Schmitz et al. (2023) demonstrated that transformational leadership is critical, as the mere presence of competencies does not automatically lead to successful technology adoption without clear strategies and sustained investment. Consequently, competence development needs to be integrated within broader leadership strategies and supportive policies so that it functions as a medium for change rather than an isolated factor.

The gender-based analysis revealed only limited differences. Teachers in schools with male principals indicated higher self-assessments of digital competencies compared to those in schools with female principals; however, no substantial variations were

identified in leadership practices, strategic investment, or overall transformation. This finding suggests that gender primarily shapes teachers' self-perceptions of digital competence but does not alter the structural factors that drive educational change. Similar conclusions appear in global leadership literature, where gender differences relate more to social and professional perceptions of competence than to organizational effectiveness (Tamar et al., 2023). In line with this, Okunlola and Naicker (2025) in Nigeria found that teachers working with female principals perceived them as displaying slightly stronger digital competencies, although gender was not a decisive factor. Likewise, research in Jordan (Alqudah, 2023) found that teachers supervised by female principals rated their digital leadership more positively, while differences also emerged in favour of those with greater professional experience. These findings contrast with the present study, where teachers in schools with male principals indicated higher self-assessments of digital competencies. This discrepancy highlights that the relationship between principals' gender and teachers' perceptions is context-dependent, that is, shaped by cultural and systemic factors.

Age emerged as a decisive factor. Older teachers evaluated leadership, strategic investment, and overall engagement in transformation more positively, while perceiving lower levels of digital competencies compared with younger colleagues. This reflects a dual digital divide: younger teachers display stronger technological competencies, whereas older teachers benefit from greater organizational experience and strategic vision. These findings are consistent with global research which highlighted the complex role of age, offering both advantages and limitations in the digital era (Hippe & Jakubowski, 2022). Research in India (Rawal, 2024) stressed that the divide extends beyond generations and includes systemic inequalities in access to infrastructure and training. Grigorescu et al. (2025) found that self-perceived digital competence declines with age, while Zervas and Stiakakis (2024) showed that younger employees adapt more quickly, whereas older staff require additional support. Jameson et al. (2022) further confirmed that older teachers often demonstrate reduced digital flexibility. Taken together, these findings suggest that age has a dual influence on digital transformation in education: it may constrain digital competencies, yet it also enhances leadership capacity, strategic orientation, and institutional coherence.

These findings resonate with international research which emphasizes that digital transformation must be understood not only as a technological process but also as one with social, cultural, and organizational dimensions. Espina-Romero (2025) stressed that sustainable digital change requires openness, ethical responsibility, and application of knowledge that creates tangible social value, aligning with this study's view that leadership and investment must be treated as more than managerial functions. Similarly, Sánchez (2025) argued that perception and adoption of technology differ by cultural and economic context, which helps to explain the diversity of competence levels reported here. Overall, these perspectives reinforce that leadership and strategic investment are decisive drivers, while competencies operate within

social and organizational frameworks that ultimately shape their effectiveness. This interpretation is also consistent with sociotechnical perspectives, which emphasize that technological change in organizations depends on the interaction between human capabilities, organizational structures, and technological resources (Mumford, 2006; Trist & Bamforth, 1951).

While consistent with the broader evidence base, the findings should be considered in relation to the Greek educational context. Public primary schools in Greece operate within a highly centralized system, where policy directions, funding, and major decisions are determined at the ministerial level. This structure constrains school autonomy, particularly in areas such as strategic investment and digital infrastructure. In this context, school leaders are called to integrate digital tools into teaching while facing limitations in resources and fragmented access to technology (Antonopoulou et al., 2025). Yet, persistent challenges such as unequal access to digital tools, limited professional development, and the slow pace of systemic reform continue to shape the trajectory of digital transformation (Giavrimis, 2023). These realities highlight that strengthening teachers' digital competencies, providing continuous training, and securing long-term investment are not just desirable but essential conditions for advancing digital education in Greece in a meaningful and sustainable way (Raptis et al., 2025b). This observation also reflects findings from research on centralized education systems, where institutional structures and policy-level decisions often shape the pace of digital transformation at the school level (Perifanou et al., 2022; Ventista et al., 2024). Such actions also foster social equity, digital citizenship, and community resilience, which links school-level transformation with broader societal development.

Implications

The findings of this study have important implications for both educational policy and everyday school practice. They show that the digital transformation of Greek primary schools cannot be achieved simply by strengthening teachers' digital competencies. What is needed is a combination of supportive leadership and carefully planned strategic investment (Navaridas-Nalda et al., 2020; Timotheou et al., 2023). Policymakers should recognize the dual role that teachers attribute to principals: on the one hand, as pedagogical leaders who inspire and support the teaching staff, and on the other, as strategic managers who ensure that resources and infrastructure are aligned with school needs.

The results also highlight the importance of stable, long-term funding, essential to guarantee access to modern technological tools, reliable infrastructure, and continuous professional development, while reducing inequalities between schools. Equally critical is a culture of collaboration and innovation, where digital skills are part of a broader framework of institutional support. In highly centralized public education systems, where school autonomy is limited, such long-term investment decisions become a decisive lever for enabling or constraining school-level digital transformation.

Finally, the differences identified in teachers' self-assessments of digital competencies in relation to the gender of their principals and their own age groups point to the need for targeted professional development initiatives which address different age groups, building on their strengths and supporting areas where further development is required. Beyond the Greek context, these implications are transferable to other centralized education systems, where leadership capacity and digital change are similarly shaped by centralized governance and system-level investment priorities. Taken together, the study suggests that a sustainable digital transformation in Greek primary education requires a strategic reconfiguration that brings together investment, leadership, and human capital. In centralized systems like the Greek one, digital transformation may be easier to sustain when leadership decisions remain connected to everyday classroom practice. Regular dialogue between school leaders and teachers can help ensure that digital priorities reflect actual teaching needs.

Limitations and future research

This study has several limitations that should be considered. First, the study follows a cross-sectional research design, which means that the data were collected at a single point in time. As a result, causal relationships between leadership, digital competencies, strategic investment, and digital transformation cannot be firmly established. Second, the research relied exclusively on quantitative data collected through a questionnaire, which restricts the depth of qualitative insight. Third, the sample included only teachers from public primary schools in Greece, which limits generalizability to other educational levels or private schools. Fourth, the data were based on teachers' self-reports, which may be influenced by subjective perceptions or socially desirable responses. As a result, the findings reflect participants' perceptions of digital transformation rather than objective measures of school practices.

Another limitation stems from the purposive sampling strategy, necessary due to the absence of comprehensive registries of active teachers in Greece. While this approach allowed inclusion of diverse backgrounds, the voluntary nature of participation means findings may reflect self-selection bias, as more digitally confident teachers may have been more inclined to participate. Although the sample covered a wide geographical range and included participants from different age groups and school sizes, it cannot be considered statistically representative of all Greek primary school teachers. Results should therefore be interpreted as indicative rather than fully generalizable. In methodological terms, the reliance on convenience participation constrains external validity, since the absence of randomization reduces the degree to which findings can be generalized to all teachers in the system.

It should also be noted that the findings concerning principals' gender capture differences in teachers' self-assessed digital competencies. Likewise, the findings on age differences refer specifically to teachers' own age groups and how they shape their views of digital transformation. Moreover, a longitudinal examination was not

possible, as the study followed a cross-sectional design. Finally, the analysis focused on leadership, digital competencies, and strategic investment, leaving aside other factors such as collaboration culture, psychological readiness, and parental involvement.

Future research could complement these findings by using longitudinal designs and multiple sources of data, such as school-level indicators or interviews with school leaders.

Further studies may benefit from mixed-methods and comparative designs that examine digital transformation across different educational levels and centralized systems, while also addressing sampling limitations where possible. Qualitative approaches could further illuminate how teachers and school leaders reflect on digital needs and experience digital change in everyday practice.

Conclusions

Leadership and strategic investment are the main forces that shape digital transformation in Greek primary schools, whereas digital skills act as a supporting element. Teachers' perspectives indicate that strong leadership and sufficient investment are decisive for meaningful and sustainable progress, whereas digital competencies alone cannot generate transformation without institutional support. Gender-related variations appeared mainly in teachers' self-assessed digital skills, while age differences reflected a generational pattern in how teachers perceive technology, leadership, and strategic orientation.

In practical terms, advancing digital transformation requires coherent and long-term strategies that link leadership development, targeted investment in infrastructure, and continuous professional learning. Policies should ensure equitable access to digital tools and promote collaboration, viewing leadership not merely as pedagogical guidance but as a driver of digital governance that connects education with societal innovation. Building strong digital schools also strengthens local communities, which helps to reduce inequalities and increase participation in the digital economy. When schools become digitally confident, they help shape a more open, inclusive, and resilient society. Ultimately, digital transformation in education is not only a technological process but also a driver of social cohesion and sustainable development. Although grounded in the Greek context, the study offers insights that are analytically relevant to other highly centralized public education systems, where leadership capacity and strategic investment similarly shape paths of digital transformation.

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Appendix

Structured online questionnaire

Leadership practices

1 The principal involves teachers in the decision-making process during council meetings.

2 The principal encourages staff to take initiative in addressing problems within and beyond the school environment.

3 The principal promotes collaborative actions with the teaching staff of the school unit.

4 The principal uses email to communicate with staff on administrative and organizational matters.

5 The principal uses digital technologies to inform staff about training seminars related to technological innovation in the educational process.

6 Communication between the principal and parents is facilitated through digital media.

7 The principal encourages the use of digital tools to strengthen collaboration between teachers and parents.

8 The principal ensures that parents are informed about upcoming events and activities through the school's website.

Strategic investment

1 The principal collaborates with teachers in shaping the school's digital strategy.

2 The school organizes seminars to strengthen parents' digital skills in collaboration with the municipality and local stakeholders.

3 Digital devices are available at the school for students to use when needed.

4 Portable devices are available for students to borrow and take home when needed.

5 The principal encourages teachers to participate in training programs on digital skills and the use of new technologies.

Digital competencies

1 To what extent can you produce digital material for your students in different formats (e.g., video, images, audio, text)?

2 To what extent can you effectively filter information when conducting internet searches?

3 To what extent do you use digital media on a daily basis for communication?

4 To what extent do you take measures to protect your digital devices?

5 To what extent can you identify and resolve technical problems on your device?

6 To what extent do you seek opportunities to enhance your digital skills?

Digital transformation

1 The principal collaborates with teachers in developing the school's digital organization (e.g., digital classrooms, blogs, online libraries, repositories with digital content).

2. At school, the potential of new technologies (e.g., interactive whiteboards, laptops, 3D printers, computers, drones) is utilized in teaching.

3 The principal uses digital technologies to network and collaborate with other schools.

4 The principal utilizes digital technologies to connect with local informal education stakeholders and promote school-related events (e.g., digital museums, concerts, tours).

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Upravljanje digitalnom transformacijom u javnome osnovnom obrazovanju u centraliziranome školskom sustavu: dokazi iz Grčke

Sažetak

Ovim istraživanjem ispituje se upravljanje digitalnom transformacijom u grčkom osnovnoškolskom obrazovanju, s naglaskom na međudjelovanje vodstva, digitalnih kompetencija i strateških ulaganja. Provedeno u visoko centraliziranom sustavu, istraživanje analizira kako ovi čimbenici, prema percepciji učitelja, oblikuju sposobnost škola za usvajanje i održavanje digitalnih promjena. Primijenjen je kvantitativni istraživački pristup na uzorku od 323 učitelja u javnim osnovnim školama, koji su ispunili strukturirani upitnik o praksama vodstva, digitalnim kompetencijama i ulaganjima u infrastrukturu. Rezultati pokazuju da su sva tri čimbenika pozitivno povezana s digitalnom transformacijom, pri čemu su prakse vodstva i strateška ulaganja najjači prediktori, dok digitalne kompetencije imaju potpornu ulogu. S obzirom na spol ravnatelja, učitelji u školama kojima upravljaju muški ravnatelji iskazali su više procjene vlastitih digitalnih kompetencija, dok nisu uočene razlike u procjeni vodstva ili ulaganja. Dobne razlike bile su izraženije: stariji učitelji pozitivnije su vrednovali vodstvo i ulaganja, dok su mlađi učitelji izvijestili o razvijenijim digitalnim kompetencijama. Ukupna razina digitalne transformacije procijenjena je kao umjerena, pri čemu su osobito niske ocjene zabilježene za strateška ulaganja, što upućuje na postojanje strukturnih prepreka. Smještanjem ovih nalaza u kontekst centraliziranoga upravljanja, istraživanje pokazuje kako vodstvo i raspodjela resursa zajednički oblikuju digitalne promjene na razini škole. Zaključno, održiva digitalna transformacija u grčkim osnovnim školama zahtijeva snažno vodstvo, dugoročna ulaganja i kontinuirani profesionalni razvoj. Ovi su nalazi relevantni i za druge centralizirane sustave javnoga obrazovanja u širem regionalnom kontekstu.

Ključne riječi: *centralizirano upravljanje; digitalne kompetencije; digitalna transformacija; strateška ulaganja; vodstvo*

Uvod

Digitalna transformacija podrazumijeva integraciju procesa, ljudi i tehnologije s ciljem unaprjeđenja organizacijskih aktivnosti u obrazovanju. Ona nadilazi jednostavno uvođenje digitalnih tehnologija te predstavlja širi i integriraniji proces promjene. Svrha digitalne transformacije u obrazovanju jest poticanje kontinuiranih inovacija u poučavanju i učenju, uz istodobnu optimizaciju administrativnih procesa kako bi se povećala učinkovitost za sve dionike (Vičič Krabonja i sur., 2024; Yıldırım i sur., 2024).

Osnovno obrazovanje ima ključnu ulogu u pripremi budućih građana te u izgradnji digitalno pismene i društveno kohezivne generacije. Postoji potreba za promjenom obrazovnih pristupa kako bi učenici stekli temeljna znanja i vještine potrebne za doprinos ujedinjenijem, uključivijem i prilagodljivijem društvu (Cerna i sur., 2021). Digitalne tehnologije proširuju pristup informacijama i potiču inovacije u školskom okružju te djeluju kao mehanizmi za unaprjeđenje obrazovne jednakosti i učinkovitosti (Khin i Ho, 2019; Liu, 2024; Mastrothanasis i sur., 2025; Vizjak i sur., 2023).

Potencijal digitalne transformacije u obrazovanju široko je prepoznat. Upravljanje digitalnom transformacijom ne odnosi se samo na implementaciju tehnoloških rješenja, nego zahtijeva i ciljano razvijanje digitalnih kompetencija, strateška ulaganja u infrastrukturu te učinkovito vodstvo (Raptis i sur., 2024; Zhang i sur., 2023). Prema Heavin i Power (2018), učinkovito vodstvo, strateška ulaganja i sustavna integracija digitalnih tehnologija u školski kontekst preduvjeti su uspješne digitalne transformacije obrazovnih ustanova. Kako bi se škole osnažile u brzo promjenjivom digitalnom okružju, potrebno je jasno odrediti prioritete unutar i izvan organizacije, pri čemu mnoge od tih aktivnosti provodi školski ravnatelj (Navaridas-Nalda i sur., 2020).

U postpandemijskom kontekstu bolesti COVID-19 sustavno razvijanje digitalnih kompetencija učitelja ključno je za osiguravanje kvalitete obrazovanja (Suphakicco, 2022). Ulaganja u digitalne kapacitete učitelja te kontinuirano unaprjeđivanje školske infrastrukture čine temelj učinkovite digitalne transformacije (Timotheou i sur., 2023). Digitalne tranzicije neizbježno utječu i na gospodarske i na društvene strukture. One ne samo da stvaraju nove zahtjeve za suvremenim kompetencijama, nego također dovode do nesklada i nestabilnosti između kompetencija i stalno promjenjivoga tržišta rada (Hippe i Jakubowski, 2022).

Potaknuti gospodarskim promjenama i nepredviđenim poremećajima poput pandemije COVID-19, pojavljuju se novi digitalni modeli rada, uključujući hibridne i rad na daljinu (Janković i sur., 2025; Wontorczyk i Rożnowski, 2022). Takvi uvjeti dodatno su naglasili postojanje digitalnoga jaza, ukazali na ograničene digitalne kompetencije učitelja te razotkrili nedostatke u tehnološkoj infrastrukturi obrazovnih institucija (Li, 2025; Miljković Krečar i Pavlin-Bernardić, 2025; Novković Cvetković i sur., 2024; Soomro i sur., 2020).

Nadovezujući se na prethodna istraživanja o digitalnom vodstvu i razvoju kapaciteta, u ovome radu uvodi se konceptualni pristup u kojem se vodstvo, digitalne kompetencije

i strateška ulaganja promatraju kao jedinstvena tri ključna preduvjeta na razini škole, koja povezuje ljudske kapacitete, organizacijsko usmjerenje i tehničke resurse unutar centralizirane strukture. U Grčkoj visoka razina centralizacije obrazovnoga sustava pruža prikladan kontekst za istraživanje načina na koji digitalno upravljanje može potaknuti inkluziju i ojačati društvenu otpornost. U tom smislu, Grčka predstavlja koristan primjer za razumijevanje kako može izgledati pravedna digitalna transformacija unutar javnih institucija. Važno je naglasiti da u centraliziranim javnim sustavima mogućnost inovacija na razini škole često ovisi o vanjskoj raspodjeli resursa, što može dodatno naglasiti ulogu strateških ulaganja u odnosu na individualne kapacitete.

Konceptualni okvir istraživanja

Konceptualni model ovoga istraživanja temelji se na trojci digitalnih kompetencija, strateških ulaganja i vodstva kao ključnih preduvjeta za upravljanje digitalnom transformacijom u javnom obrazovanju (Slika 1; prilagođeno prema Brunetti i sur., 2020; Heavin i Power, 2018; Navaridas-Nalda i sur., 2020). Konceptualno, ova tri ključna preduvjeta utemeljena su na pristupu sociotehničkih sustava. Vodstvo predstavlja organizacijski i kulturni podsustav, strateška ulaganja tehničko-strukturalnu osnovu, dok digitalne kompetencije čine ljudske kapacitete koji povezuju ta dva elementa (npr. Mumford, 2006; Trist i Bamforth, 1951).

Polazeći od teorije transformacijskoga vodstva (Bass, 1999), model pretpostavlja da vodstvo djeluje kao primarni bihevioralni i kulturni katalizator koji omogućuje donošenje investicijskih odluka i razvoj kompetencija. Iz perspektive teorije ovisnosti o resursima (Pfeffer i Salancik, 2015), strateška ulaganja predstavljaju sposobnost škola da osiguraju i raspodijele ograničene resurse u svrhu poticanja inovacija. Okvir digitalnih kapaciteta (Kane, 2019) dodatno pozicionira digitalne kompetencije kao mikrorazinske čimbenike koji omogućuju pretvaranje vizije vodstva i ulaganja u učinkovite ishode digitalne transformacije.

Slika1. Tri ključna preduvjeta za digitalnu transformaciju

Digitalna transformacija u osnovnom obrazovanju ne podrazumijeva samo uvođenje digitalnih alata, nego predstavlja složen i višedimenzionalan proces koji se temelji na trima ključnim preduvjetima, kako je prikazano na Slici 1. U nedostatku

međudjelovanja tih triju dimenzija, digitalna transformacija ostaje djelomična i nema temelje za održivu integraciju u obrazovni kontekst.

Postojeća literatura ukazuje na to da ravnatelji škola imaju središnju ulogu u odgovoru na ove zahtjeve, djelujući kao ključni nositelji u poticanju i upravljanju digitalnom transformacijom obrazovanja (Navaridas-Nalda i sur., 2020; Okunlola i Naicker, 2025; Ruloff i Petko, 2025). Oni moraju uskladiti očekivanja učitelja, učenika, obitelji i šire zajednice sa zahtjevima sustava te specifičnostima vlastitih škola.

Kao drugo, digitalne kompetencije smatraju se temeljnim preduvjetom za uspješnu provedbu digitalne transformacije u obrazovanju (Schlegel i Kraus, 2023; Tóth i sur., 2022; Županić Benić i Kajm Ferčec, 2025). Osim osnovnih tehničkih vještina, one obuhvaćaju širi skup znanja, stavova i sposobnosti koji omogućuju učiteljima učinkovitu integraciju digitalnih tehnologija u procese poučavanja i učenja (Falloon, 2020). Slično tome, Basilotta-Gómez-Pablos i sur. (2022) ističu da je razvoj digitalnih kompetencija učitelja ključan za poticanje inovativnih pedagoških pristupa i razvoj digitalne pismenosti učenika.

Treće, strateška ulaganja široko se prepoznaju kao nužan preduvjet za učinkovitu realizaciju digitalne transformacije u obrazovanju (Brunetti i sur., 2020; Mohamed Hashim i sur., 2022). Ona nadilaze samu dostupnost tehnoloških alata i infrastrukture te uključuju dugoročno planiranje, održivo financiranje i usklađivanje resursa s pedagoškim ciljevima (Liu, 2024). Strateška ulaganja osiguravaju da škole ne raspolažu samo potrebnom tehnologijom, nego i kapacitetima za njezinu učinkovitu primjenu, čime se omogućuju sustavne i trajne promjene u poučavanju i učenju (Nhung i sur., 2025).

Vodstvo, ulaganja i kompetencije promatraju se kao međusobno povezani prediktori, dok ukupna digitalna transformacija škola predstavlja sustavni ishod koji proizlazi iz njihove interakcije. U praktičnom smislu, ova tri preduvjeta odnose se na tri usko povezane dimenzije koje podupiru digitalnu transformaciju na razini škole. Vodstvo se odnosi na sposobnost ravnatelja da usmjeravaju promjene i stvaraju poticajno okružje za korištenje digitalnih tehnologija. Digitalne kompetencije opisuju sposobnost učitelja da integriraju digitalne alate u svakodnevnu nastavnu praksu. Strateška ulaganja odnose se na osiguravanje tehnološke infrastrukture, opreme i mogućnosti stručnoga usavršavanja koje omogućuju školama učinkovito korištenje digitalnih resursa. U ovome kontekstu, ove tri dimenzije analiziraju se kao međusobno povezani čimbenici koji oblikuju cjelokupni proces digitalne transformacije unutar centralizirane strukture upravljanja grčkoga osnovnog obrazovanja.

Digitalna transformacija u grčkom osnovnom obrazovanju

Digitalna transformacija postala je jedan od ključnih prioriteta obrazovnih sustava diljem svijeta, mijenjajući pedagoške prakse, modele vodstva i institucionalne kapacitete. Međutim, u grčkome kontekstu znanstvena literatura i dalje je relativno ograničena, osobito kada je riječ o osnovnom obrazovanju. Većina postojećih istraživanja usmjerena je ili na visoko obrazovanje ili na javni sektor, dok su specifični izazovi i mogućnosti u javnim osnovnim školama nedovoljno istraženi. Ovaj jaz naglašava važnost usmjeravanja

istraživanja na grčko osnovno obrazovanje te doprinos razvoju kvalitetnoga znanstvenog dijaloga koji povezuje teoriju i praksu. Iz institucionalne perspektive, visok stupanj centralizacije određuje pravila i tokove resursa unutar kojih škole oblikuju dimenzije triju navedenih preduvjeta. Nekoliko suvremenih istraživanja ukazuje na rastući interes za ovo područje, ali istodobno naglašava potrebu za ciljanijim analizama. Primjerice, Kokkonos i sur. (2025) istraživali su digitalne tehnologije i prakse vodstva u grčkim osnovnim školama, usredotočujući se na to kako demografske karakteristike oblikuju percepcije digitalnoga vodstva te su utvrdili značajne razlike s obzirom na dob, razinu obrazovanja, radno iskustvo i ulogu u školi. Slično tome, istraživanja o znanjima i kompetencijama potrebnima za digitalnu transformaciju u grčkome javnom školskom sustavu u postpandemijskom razdoblju ističu hitnu potrebu za razvojem digitalnih kompetencija učitelja, uz istodobno prepoznavanje trajnih nedostataka u infrastrukturi i stručnom usavršavanju (Kalogeratos i Pierrakeas, 2022).

Na razini visokoga obrazovanja digitalna transformacija definira se kao strateški prioritet javnih politika, pri čemu se naglašava potreba za dugoročnim planiranjem i usklađivanjem s institucionalnim ciljevima (Exarchou i sur., 2024). Izvan područja obrazovanja, istraživanja u grčkoj javnoj upravi također pružaju korisne uvide. Xanthopoulou i sur. (2023) pokazali su da su čimbenici poput kvalitete tehnologije, vodstva, osposobljavanja zaposlenika, evaluacije i snažne digitalne kulture ključni za uspješnu transformaciju. Također su utvrdili da je pandemija bolesti COVID-19 djelovala kao katalizator promjena, pri čemu su je mnogi javni službenici doživjeli kao priliku, a ne kao prijetnju.

Ova je perspektiva relevantna i za škole jer vodstvo i strategija mogu potaknuti ili usporiti digitalne promjene. Sveukupno, navedena istraživanja ukazuju na rastući interes za digitalnu transformaciju u Grčkoj, ali istodobno otkrivaju jasan nedostatak: osnovnomu obrazovanju posvećeno je vrlo malo pažnje. Ovo se istraživanje usmjerava na grčko osnovno obrazovanje kako bi doprinijelo popunjavanju toga jaza u literaturi. Ispituje na koji se način vodstvo, digitalne kompetencije i strateška ulaganja međusobno isprepliću u tome kontekstu, promatrajući osnovne škole kao ključno okružje za analizu šireg procesa digitalnih promjena. Grčki slučaj pritom se promatra i kao primjer relevantan za oblikovanje obrazovnih politika u drugim centraliziranim javnim sustavima u regiji.

Svrha i istraživačka pitanja

Ovim istraživanjem ispituje se međudjelovanje vodstva, digitalnih kompetencija i strateških ulaganja kao ključnih preduvjeta za upravljanje digitalnom transformacijom u grčkim osnovnim školama. Usmjereno je na prikupljanje percepcija i iskustava učitelja u javnom osnovnom obrazovanju, s ciljem procjene razine njihovih digitalnih kompetencija, kvalitete praksi vodstva i stupnja strateških ulaganja u tehnološku infrastrukturu.

Poseban naglasak stavlja se na ispitivanje u kojoj mjeri spol ravnatelja i dobne skupine učitelja utječu na percepcije praksi vodstva, digitalnih kompetencija, strateških ulaganja i ukupnoga sudjelovanja u procesu digitalne transformacije škola.

Konačni cilj istraživanja jest identificirati strukturne i ljudske čimbenike koji omogućuju smisleno i održivo provođenje digitalne transformacije unutar centraliziranoga obrazovnog sustava. U tome okviru, istraživanje nastoji odgovoriti na sljedeća istraživačka pitanja:

(1) Kakav je odnos između digitalnih kompetencija, strateških ulaganja i vodstva te na koji način ove dimenzije djeluju kao ključni pokretači digitalne transformacije?
(2) Kakvo je trenutačno stanje digitalnih kompetencija učitelja u osnovnome obrazovanju u Grčkoj?
(3) U kojoj se mjeri provode strateška ulaganja u infrastrukturu i tehnološke resurse s ciljem podrške digitalnoj transformaciji?
(4) Kakav je utjecaj praksi školskoga vodstva na omogućavanje i održavanje digitalne transformacije u javnim osnovnim školama?
(5) Postoje li razlike između ravnatelja i ravnateljica u pogledu njihovih praksi vodstva, digitalnih kompetencija, strateških ulaganja i ukupnoga angažmana u upravljanju digitalnom transformacijom?
(6) Kako se percepcije učitelja o vodstvu, kompetencijama, ulaganjima i digitalnoj transformaciji razlikuju među različitim dobnim skupinama?

Metodologija

Istraživački dizajn

Ovo istraživanje temelji se na kvantitativnom istraživačkom dizajnu koji koristi strukturirani upitnik sastavljen od zatvorenih pitanja. Cilj istraživanja jest pokazati da prakse vodstva, digitalne kompetencije učitelja i strateška ulaganja djeluju kao ključni preduvjeti za upravljanje i integraciju digitalne transformacije u školama. Takav dizajn omogućuje sustavno prikupljanje usporedivih podataka od velikoga broja učitelja te uočavanje povezanosti i trendova unutar obrazovnoga konteksta.

Korištenje zatvorenih pitanja osigurava jasnoću i dosljednost odgovora, čime se olakšava statistička analiza koja vodi do valjanih i pouzdanih zaključaka (Aithal i Aithal, 2020). Iako se istraživanje usredotočuje na grčko osnovno obrazovanje, njegovi rezultati mogu imati implikacije i za oblikovanje obrazovnih politika u drugim centraliziranim sustavima.

Sudionici

Uzorak se sastojao od 323 učitelja u javnim osnovnim školama tijekom školske godine 2024./2025. Žene su činile 70,6 %, a muškarci 29,4 % uzorka. Najveći udio sudionika bio je u dobnoj skupini od 30 do 39 godina (43,3 %), a slijedili su učitelji stariji od 50 godina (32,8 %). Više od polovice sudionika imalo je završen diplomski studij (53,6 %), dok je većina bila zaposlena na neodređeno vrijeme (76,5 %). Među školama u kojima sudionici rade, 125 ih je vodio ravnatelj, a 198 ravnateljica. Tablica

1 prikazuje detaljan pregled demografskih obilježja uzorka, uključujući raspodjelu sudionika prema spolu, dobnim skupinama, godinama radnoga staža, radnom statusu i razini obrazovanja.

Namjerno uzorkovanje primijenjeno je zbog strukturnih ograničenja grčkoga obrazovnog sustava i nepostojanja sveobuhvatnoga registra učitelja. Sudjelovanje je bilo dobrovoljno, a podatci su prikupljeni putem mrežnoga upitnika distribuiranoga putem mreže učitelja i društvenih medija. Iako takav pristup može dovesti do pristranosti samoselekcije, omogućio je demografsku raznolikost s obzirom na spol, dob i radno iskustvo (Campbell i sur., 2020; Andrade, 2021).

Tablica 1.
Deskriptivna statistika uzorka

Demografske varijable		N
Spol	Muški	95
	Ženski	228
Spol ravnatelja škole	Muški	125
	Ženski	198
Dobna skupina	< 29 godina	24
	30 - 39 godina	140
	40 - 49 godina	53
	≥ 50 godina	106
Radni staž (godine)	< 5	66
	6 - 10	54
	11 – 15	70
	16 – 20	34
	≥ 21	99
Radni status	Stalni radni odnos	247
	Zamjena	76
Razina obrazovanja	Preddiplomski studij	133
	Drugi preddiplomski studij	12
	Diplomski studij (magistar)	173
	Doktorat (PhD)	5

Analiza snage (G*Power 3.1.9.6) potvrdila je da je minimalno 77 sudionika dovoljno za detekciju srednjih učinaka (snaga = 0,80, α = ,05, f^2 = 0,15). Stvarni uzorak od 323 sudionika stoga je osigurao visoku statističku snagu.

Instrument

Strukturirani online upitnik razvijen je s ciljem prikupljanja percepcija učitelja o praksama vođenja, digitalnim kompetencijama, strateškim ulaganjima i ukupnoj digitalnoj transformaciji. Upitnik je obuhvaćao 29 čestica: šest demografskih pitanja i 23 čestice koje se odnose na četiri temeljne dimenzije.

Konkretno, prakse vođenja procijenjene su pomoću 8 čestica, strateška ulaganja s 5 čestica, digitalne kompetencije sa 6 čestica, a digitalna transformacija s 4 čestice. Odgovori su prikupljeni primjenom Likertove ljestvice od 5 stupnjeva (1 = uopće ne, 5 = u velikoj mjeri).

Razvoj instrumenta slijedio je višefazni proces validacije. Pokusno istraživanje provedeno je radi provjere pouzdanosti, dok su tri stručnjaka potvrdila sadržajnu valjanost. Vrijednosti Cronbachova α za sve skale bile su veće od 0,70, čime je potvrđena unutarnja konzistentnost. Reprezentativne čestice za svaku dimenziju prikazane su u Tablici 2, dok je cjeloviti upitnik dostupan u Prilogu.

Tablica 2.
Primjeri čestica za svaku dimenziju upitnika

Dimenzija	Broj čestica	Primjer čestice
Prakse vođenja	8	Ravnatelj potiče suradničke aktivnosti s nastavnim osobljem škole.
Strateška ulaganja	5	Digitalni uređaji dostupni su u školi kako bi ih učenici mogli koristiti prema potrebi.
Digitalne kompetencije	6	U kojoj mjeri možete izrađivati digitalne materijale za svoje učenike u različitim formatima (npr. video, slike, audio, tekst)?
Digitalna transformacija	4	Ravnatelj surađuje s učiteljima u razvoju digitalne organizacije škole (npr. digitalne učionice, blogovi, *online* knjižnice, repozitoriji s digitalnim sadržajem).

Postupak

Istraživanje je odobrilo Etičko povjerenstvo Sveučilišta Egeja (Odluka br. 2, 19. listopada 2024.). Sudjelovanje je bilo dobrovoljno i temeljilo se na informiranom pristanku ispitanika. Upitnik je distribuiran online putem profesionalnih mreža i društvenih mreža kojima se koriste učitelji razredne nastave u Grčkoj.

Podatci su prikupljeni na siguran i anoniman način. Ispitanici su mogli ispuniti upitnik u vrijeme koje im je odgovaralo. Online format minimizirao je ometanje radnih obveza, uz istodobno osiguravanje pristupačnosti i zaštite podataka.

Analiza

Podatci su analizirani primjenom deskriptivne i inferencijalne statistike u programu SPSS (verzija 25.0). Deskriptivni pokazatelji (aritmetičke sredine, standardne devijacije, frekvencije) pružili su uvid u percepcije učitelja. Cronbachov α korišten je za procjenu unutarnje konzistentnosti, dok su inferencijalne analize uključivale:

- Pearsonove korelacije – za ispitivanje povezanosti između vođenja, kompetencija, ulaganja i transformacije.
- T-test za nezavisne uzorke – za ispitivanje razlika s obzirom na spol ravnatelja.
- Jednofaktorska ANOVA (uz Bonferroni post-hoc testove) – za utvrđivanje razlika među dobnim skupinama nastavnika.
- Hijerarhijska multipla regresija – za određivanje prediktivne snage pojedinih čimbenika na digitalnu transformaciju.

Primijenjena je Bonferronijeva korekcija ($\alpha = 0{,}0125$) radi kontrole obiteljske pogreške tipa I. Pristranost zajedničke metode testirana je Harmanovim jednofaktorskim testom;

rezultati su pokazali da nije bila statistički značajna (Fuller i sur., 2016). Pretpostavke regresijske analize su provjerene (normalnost, multikolinearnost, neovisnost pogrešaka). Model je bio statistički značajan (F (3,319) = 122,59, p < ,001), što potvrđuje pouzdanost provedenih analiza.

Rezultati

Radi lakšega tumačenja, rezultati su prikazani u skladu s istraživačkim pitanjima. Svaka pododjeljak odgovara jednom ili više pitanja te sažima na koji način nalazi na njih odgovaraju.

Vodstvo, kompetencije i strateška ulaganja kao ključni pokretači digitalne transformacije

Izračunate su Pearsonove korelacije (Tablica 3). Varijable su mjerene na kontinuiranim ljestvicama, a svi koeficijenti pouzdanosti bili su zadovoljavajući (α = 0,726 – 0,878).

Tablica 3.
Pearsonove korelacije između varijabli digitalne transformacije

	Prakse vođenja	Digitalne kompetencije	Strateška ulaganja
Prakse vođenja	–		
Digitalne kompetencije	,033	–	
Strateška ulaganja	,550***	,100	–
Digitalna transformacija	,537***	,131*	,702***

Napomena. *p < ,05, **p < ,01, ***p < ,001. Dvostrani testovi značajnosti.

Vodstvo je bilo snažno povezano s digitalnom transformacijom (r = 0,537, p < ,001), dok su strateška ulaganja pokazala još jaču povezanost (r = 0,702, p < ,001). Digitalne kompetencije bile su slabije, ali statistički značajno povezane (r = 0,131, p < ,05).

Općenito, vođenje i strateška ulaganja pokazuju najjače povezanosti s digitalnom transformacijom, dok digitalne kompetencije ukazuju na slabiju povezanost. Hijerarhijska multipla regresijska analiza korištena je za utvrđivanje njihove prediktivne snage (Tablica 4).

Tablica 4.
Hijerarhijska multipla regresijska analiza čimbenika digitalne transformacije

Model	Model 1			Model 2			Model 3		
Prediktori	B	SE B	β	B	SE B	β	B	SE B	β
Konstanta	,35	,25		-,11	,31		-,14	,25	
Prakse vođenja	,70	,06	,54***	.69	,06	,53***	,28	,06	,22***
Digitalne kompetencije				.13	,05	,11*	,08	,04	,07
Strateška ulaganja							,67	,05	„58***
R^2	,29			,30			,53		
ΔR^2	,29			,01			,23		

Napomena. p < ,05, **p < ,01, ***p < ,001. Dvostrani testovi značajnosti.

Vodstvo je samostalno objasnilo 29 % varijance (β = 0,54, p < ,001). Uključivanje digitalnih kompetencija povećalo je R^2 za 0,01 (β = 0,11, p < ,05). Kada su u model uključena strateška ulaganja, R^2 je porastao na 0,53 (β = 0,58, p < ,001).

Stoga se vodstvo i strateška ulaganja izdvajaju kao dominantni prediktori, dok digitalne kompetencije imaju podržavajuću ulogu. Detaljna dijagnostika (VIF < 2; Durbin–Watson = 1,98; normalno distribuirani reziduali) potvrdila je prikladnost modela i odsutnost multikolinearnosti.

Pregled digitalne transformacije u osnovnom obrazovanju: deskriptivni nalazi

Deskriptivni statistički pokazatelji za četiri dimenzije prikazani su u Tablici 5.

Tablica 5.
Deskriptivni statistički pokazatelji varijabli digitalne transformacije

Varijable	N	Min	Max	M	SD
Prakse vođenja	323	1,00	5,00	3,98	,70
Strateška ulaganja	323	1,00	4,83	2,78	,78
Digitalne kompetencije	323	1,50	5,00	3,67	,79
Digitalna transformacija	323	1,00	5,00	3,14	,91

Prakse vođenja imale su najvišu prosječnu vrijednost, slijede digitalne kompetencije, dok su strateška ulaganja zabilježila najnižu vrijednost. Nastavnici percipiraju poticajno vodstvo i zadovoljavajuću razinu digitalne spremnosti, ali nedostatnu infrastrukturu i resurse.

Ukupna razina digitalne transformacije bila je umjerena (M = 3,14), što upućuje na istodobno postojanje napretka i sustavnih prepreka. Ponavljanja interpretacija prosječnih vrijednosti i rezultata korelacijske analize izostavljena su radi sažetosti.

Usporedba varijabli digitalne transformacije s obzirom na spol ravnatelja

Provedeni su t-testovi za nezavisne uzorke kako bi se usporedile percepcije između škola koje vode muški i ženski ravnatelji (Tablica 6).

Tablica 6.
T-test za nezavisne uzorke prema spolu ravnatelja škole

Varijable	Muški		Ženski		t	df	p	Cohenov d
	M	SD	M	SD				
Prakse vođenja	3,92	,78	4,01	,66	-1,013	321	,312	-,124
Digitalne kompetencije	3,94	,81	3,56	,75	4,070	321	< ,001	,497
Strateška ulaganja	2,90	,75	2,73	,78	1,743	321	,082	,213
Digitalna transformacija	3,24	,85	3,10	,93	1,277	321	,203	,156

Napomena. Obiteljska pogreška tipa I u četiri t-testa kontrolirana je primjenom Bonferronijeve korekcije (α = 0,0125). Dvostrani testovi.

Značajna razlika utvrđena je samo za digitalne kompetencije: nastavnici pod vodstvom muških ravnatelja procijenili su vlastite kompetencije višima ($p < ,001$, $d = ,50$). Ova razlika odražava samoprocjenu te je treba tumačiti s oprezom. Nisu utvrđene razlike s obzirom na spol ravnatelja u praksama vođenja, strateškim ulaganjima ili digitalnoj transformaciji. Nakon primjene Bonferronijeve korekcije ($\alpha = 0,0125$), rezultat za digitalne kompetencije ostao je statistički značajan. Proširena rasprava o pristranosti samoprocjene i ponavljanje neznačajnih rezultata izostavljeni su radi sažetosti.

Razlike među dobnim skupinama nastavnika u ključnim dimenzijama digitalne transformacije

Jednofaktorska analiza varijance (ANOVA) korištena je za ispitivanje razlika među četirima dobnim skupinama (≤ 29, 30 – 39, 40 – 49, ≥ 50).

Tablica 7.
Rezultati ANOVA analize prema dobnim skupinama nastavnika

Varijabla	Izvor	SS	df	MS	F	p
Prakse vođenja	Između grupa	6,20	3	2,07	4,37	,005**
	Unutar grupa	150,91	319	,47		
	Ukupno	157,11	322			
Digitalne kompetencije	Između grupa	22,53	3	7,51	13,40	< ,001***
	Unutar grupa	178,84	319	,56		
	Ukupno	201,38	322			
Strateška ulaganja	Između grupa	11,29	3	3,76	6,57	< ,001***
	Unutar grupa	182,78	319	,57		
	Ukupno	194,07	322			
Digitalna transformacija	Između grupa	10,55	3	3,52	4,40	,005**
	Unutar grupa	255,07	319	,80		
	Ukupno	265,63	322			

Napomena. *p < ,05, **p < ,01, ***p < ,001. Dvostrani testovi značajnosti. Obiteljska pogreška tipa I u četirima ANOVA analizama kontrolirana je primjenom Bonferronijeve korekcije ($\alpha = 0,0125$).

Post-hoc usporedbe pružile su dodatni uvid u razlike među skupinama. Nastavnici u dobi ≥ 50 godina izvijestili su o značajno višim razinama praksi vodstva ($M = 4,17$, $SD = 0,64$) u usporedbi s onima u dobi 30 - 39 godina ($M = 3,86$, $SD = 0,73$; $p < ,01$). Što se tiče digitalnih kompetencija, nastavnici u dobi ≥ 50 godina ($M = 3,31$, $SD = 0,83$) izvijestili su o znatno nižim razinama u odnosu na mlađe skupine, uključujući one u dobi 20 - 29 ($M = 4,00$, $SD = 0,57$; $p < ,001$), 30 - 39 ($M = 3,88$, $SD = 0,68$; $p < ,001$) i 40-49 ($M = 3,71$, $SD = 0,80$; $p < ,050$).

Sličan obrazac uočen je i za strateška ulaganja, pri čemu su nastavnici u dobi ≥ 50 godina ($M = 3,00$, $SD = 0,69$) izvijestili o višim vrijednostima u usporedbi s onima u dobi 30 - 39 godina ($M = 2,58$, $SD = 0,77$; $p < ,001$). Naposljetku, nastavnici u dobi ≥ 50 godina također su izvijestili o višim razinama ukupne digitalne transformacije ($M = 3,38$, $SD = 0,85$) u odnosu na skupinu 30 - 39 godina ($M = 2,97$, $SD = 0,94$; $p < ,01$).

Ovi nalazi ukazuju na dobno uvjetovane razlike: stariji nastavnici izražavaju pozitivnije procjene vođenja i strateških ulaganja, dok mlađi nastavnici iskazuju više razine samoprocijenjenih digitalnih kompetencija.

Sažetak ključnih nalaza

Nalazi ovoga istraživanja pružaju sveobuhvatnu sliku čimbenika koji potiču digitalnu transformaciju u grčkim osnovnim školama. Prakse vođenja, digitalne kompetencije nastavnika i strateška ulaganja bili su pozitivno povezani s digitalnom transformacijom, potvrđujući njihovu komplementarnu ulogu. Među njima, vodstvo i strateška ulaganja izdvojili su se kao najjači prediktori, zajednički objašnjavajući više od polovice varijance ishoda digitalne transformacije (R^2 = ,53). Digitalne kompetencije, iako statistički značajne, imale su sekundarni utjecaj nakon što su uzeti u obzir učinci vodstva i ulaganja, što upućuje na to da tehnološka spremnost podupire, ali sama po sebi ne pokreće sustavne promjene.

Nastavnici koji rade u školama kojima upravljaju muški ravnatelji izvijestili su o višim samoprocjenama digitalnih kompetencija, dok nisu uočene značajne razlike u percepcijama vođenja, ulaganja ili ukupne transformacije. Ovaj obrazac sugerira da spol ravnatelja može utjecati na samopercepciju nastavnika, ali ima ograničen utjecaj na organizacijske dimenzije digitalne transformacije. Razlike povezane s dobi bile su izraženije. Stariji nastavnici skloniji su pozitivnijim procjenama vođenja, ulaganja i ukupne digitalne transformacije, dok mlađi nastavnici iskazuju više razine samoprocijenjenih digitalnih kompetencija.

Općenito, digitalna transformacija u grčkim osnovnim školama ocijenjena je kao umjerena. Napredak je ponajprije ograničen nedostatnim strateškim ulaganjima i strukturnim preprekama koje otežavaju potpunu realizaciju digitalnih promjena u obrazovnome sustavu.

Diskusija

Ovo istraživanje ispitalo je kako prakse školskoga vodstva, digitalne kompetencije i strateška ulaganja međudjeluju kao ključni čimbenici koji podupiru digitalnu transformaciju u grčkim osnovnim školama. Percepcije nastavnika ukazuju na važna područja snage, ali i otkrivaju trajne izazove koji usporavaju napredak digitalnih promjena u javnome obrazovanju. Nalazi pokazuju da prakse školskoga vodstva i strateška ulaganja predstavljaju najjače prediktore digitalne transformacije u školama. Ova povezanost u skladu je sa širim empirijskim dokazima koji povezuju vodstvo, upravljanje i održive investicijske prakse s ključnim pokretačima organizacijske transformacije (Alkaraan i sur., 2023; Alqatan i sur., 2025). Ovaj rezultat također podupire konceptualni okvir istraživanja, koji digitalnu transformaciju promatra kao rezultat interakcije između vodstva, digitalnih kompetencija i strateških ulaganja unutar školskoga okružja (Heavin i Power, 2018; Navaridas-Nalda i sur., 2020).

Ovaj nalaz u skladu je s literaturom koja naglašava da se digitalna transformacija ne može razumjeti isključivo kao kulturni ili pedagoški proces, već zahtijeva sinergiju vizionarskoga vodstva i sustavne alokacije resursa (Xafakos i sur., 2020). Dominacija strateških ulaganja u ovome modelu može odražavati materijalna ograničenja centraliziranih sustava, u kojima kapacitet vodstva i razvoj kompetencija ostaju ovisni o stabilnom

protoku resursa i institucionalnoj podršci. Ova međuovisnost upućuje na posrednički mehanizam, u kojem vodstvo djeluje kao bihevioralni mehanizam koji prevodi ulaganja u ishode digitalne transformacije. Ovaj nalaz sugerira da bi Ministarstvo obrazovanja trebalo prioritetno razvijati politike koje podupiru školsko vodstvo putem resursa i osposobljavanja, osiguravajući da se vizionarsko vodstvo podudara s adekvatnim dugoročnim ulaganjima. Šire gledano, ovaj obrazac pokazuje kako centralizirani sustavi mogu ograničiti digitalne promjene. Škole mogu biti spremne djelovati, ali napredak ovisi o infrastrukturnim i financijskim resursima koji su pod vanjskom kontrolom.

Na razini vodstva, Heavin i Power (2018) te Zervoudakis i sur. (2024) ističu da su vođe s kapacitetom prilagodbe i strateškoga usklađivanja tehnoloških inovacija s organizacijskim ciljevima ključni za uspješno upravljanje promjenama. Slično tome, u obrazovanju su Navaridas-Nalda i sur. (2020) pokazali da percepcije ravnatelja o korisnosti digitalnih obrazovnih resursa (EDR), zajedno s čimbenicima kao što su tehnička podrška i digitalna kultura škole, imaju presudnu ulogu u oblikovanju tijeka digitalne transformacije.

U pogledu strateških ulaganja, brojna istraživanja ističu njihovu važnost kao temeljni preduvjet digitalne transformacije. Fernández i sur. (2023) pokazali su da institucije koje usvajaju jasnu strategiju i ulažu u resurse postižu bolje rezultate od onih koje se oslanjaju na fragmentirane inicijative. Pregled Singuna (2025) ukazuje da je nedostatak digitalnih resursa i infrastrukture jedna od najznačajnijih prepreka. Studija Svjetske banke (Rodriguez-Segura, 2022) dokumentira da su stabilno financiranje, adekvatna infrastruktura i osposobljavanje nastavnika ključni za poboljšanje ishoda učenja, bez njih EdTech inicijative ostaju neučinkovite. Konačno, Brunetti i sur. (2020) naglašavaju da rješavanje digitalne transformacije zahtijeva koordinaciju među dionicima i naglasak na ulaganja ne samo u tehnologiju, već i u osposobljavanje i održivu upotrebu alata. Usporedivi podatci OECD-a pokazuju da nordijski obrazovni sustavi, u kojima je financiranje digitalizacije decentralizirano i autonomija veća, postižu snažnije ishode temeljene na kompetencijama, dok u južnoj Europi i azijsko-pacifičkom kontekstu koncentracija resursa određuje razinu digitalne zrelosti (OECD, 2023).

Što se tiče digitalnih kompetencija, nalazi pokazuju da, iako su pozitivno povezane s digitalnom transformacijom, ne predstavljaju neovisni prediktivni čimbenik kada se uzmu u obzir vodstvo i strateška ulaganja. To sugerira da kompetencije djeluju prvenstveno kao komplementarni čimbenik, jačajući utjecaj vodstva i resursa, umjesto da djeluju kao samostalan pokretač. Slični zaključci zabilježeni su u prethodnim istraživanjima koja pokazuju da digitalne kompetencije nastavnika postaju učinkovitije kada su podržane snažnim vodstvom i adekvatnim institucionalnim resursima (Kudek Mirošević i sur., 2024; Raptis i sur., 2025a; Schmitz i sur., 2023; Timotheou i sur., 2023). Dosljedne nalaze iznose i Antonopoulou i sur. (2025), pokazujući da kompetencije nastavnika dobivaju na važnosti tek kada su povezane s podržavajućim vodstvom i organizacijskim strukturama koje osiguravaju resurse i profesionalni razvoj.

Izvješće OECD-a (2023) naglašava da, unatoč formalnim okvirima za razvoj digitalnih kompetencija nastavnika, te kompetencije ostaju nedostatne bez pratećih politika

podrške i koordiniranoga djelovanja na razini škole. Također, Schmitz i sur. (2023) pokazuju da je transformacijsko vođenje ključno jer sama prisutnost kompetencija ne dovodi automatski do uspješnoga usvajanja tehnologije bez jasnih strategija i kontinuiranih ulaganja. Posljedično, razvoj kompetencija treba biti integriran u šire strategije vođenja i potporne politike kako bi funkcionirao kao medij promjene, a ne kao izolirani čimbenik.

Analiza prema spolu pokazala je ograničene razlike. Nastavnici u školama s muškim ravnateljima iskazali su više samoprocjene digitalnih kompetencija u usporedbi s onima u školama sa ženskim ravnateljima. Međutim, nisu utvrđene značajne razlike u praksama vođenja, strateškim ulaganjima ili ukupnoj transformaciji. Ovaj nalaz sugerira da spol prvenstveno utječe na samopercepciju digitalnih kompetencija nastavnika, ali ne mijenja strukturne čimbenike koji pokreću obrazovne promjene. Slični zaključci pojavljuju se u globalnoj literaturi o **vodstvu** pri čemu su razlike povezane više sa socijalnim i profesionalnim percepcijama kompetencija nego s organizacijskom učinkovitošću (Tamar i sur., 2023). U skladu s time, Okunlola i Naicker (2025) u Nigeriji utvrdili su da nastavnici koji rade s ravnateljicama percipiraju nešto više digitalne kompetencije, iako spol nije bio presudan čimbenik. Slično tome, istraživanje u Jordanu (Alqudah, 2023) pokazalo je da su nastavnici pod vodstvom ravnateljica pozitivnije ocijenili digitalno vođenje, pri čemu su razlike bile izraženije kod onih s većim profesionalnim iskustvom. Ovi nalazi razlikuju se od rezultata ovoga istraživanja, pri čemu su nastavnici u školama s muškim ravnateljima iskazali više razine samoprocijenjenih digitalnih kompetencija. Ova razlika naglašava kontekstualnu uvjetovanost odnosa između spola ravnatelja i percepcija nastavnika.

Dob se pokazala kao presudan čimbenik. Stariji nastavnici pozitivnije su ocijenili vođenje, strateška ulaganja i ukupno sudjelovanje u transformaciji, dok su istodobno percipirali niže razine digitalnih kompetencija u usporedbi s mlađim kolegama. To odražava dvostruki digitalni jaz: mlađi nastavnici posjeduju snažnije tehnološke kompetencije, dok stariji nastavnici imaju prednost u organizacijskom iskustvu i strateškoj viziji. Ovi nalazi u skladu su s međunarodnim istraživanjima koja naglašavaju složenu ulogu dobi, koja donosi i prednosti i ograničenja u digitalnom okružju (Hippe i Jakubowski, 2022). Istraživanje u Indiji (Rawal, 2024) naglašava da ovaj jaz nadilazi generacijske razlike i uključuje sistemske nejednakosti u pristupu infrastrukturi i osposobljavanju. Grigorescu i sur. (2025) utvrdili su da se samoprocijenjena digitalna kompetencija smanjuje s dobi, dok su Zervas i Stiakakis (2024) pokazali da se mlađi zaposlenici brže prilagođavaju, dok starijem osoblju treba dodatna podrška. Jameson i sur. (2022) dodatno potvrđuju da stariji nastavnici često pokazuju smanjenu digitalnu fleksibilnost. Zajedno, ovi nalazi sugeriraju da dob ima dvostruki utjecaj na digitalnu transformaciju u obrazovanju: može ograničiti digitalne kompetencije, ali istodobno jača kapacitet **vodstva**, stratešku orijentaciju i institucionalnu koherentnost.

Ovi nalazi podudaraju se s međunarodnim istraživanjima koja naglašavaju da digitalnu transformaciju treba razumjeti ne samo kao tehnološki proces, već i kao proces sa

socijalnim, kulturnim i organizacijskim dimenzijama. Espina-Romero (2025) ističe da održiva digitalna promjena zahtijeva otvorenost, etičku odgovornost i primjenu znanja koja stvara konkretnu društvenu vrijednost, što je u skladu sa stavom ovoga istraživanja da vođenje i ulaganja treba promatrati kao više od upravljačkih funkcija. Slično tome, Sánchez (2025) tvrdi da percepcija i usvajanje tehnologije variraju ovisno o kulturnom i ekonomskom kontekstu, što pomaže objasniti raznolikost razina kompetencija u ovome istraživanju. Sveukupno, ove perspektive potvrđuju da su vođenje i strateška ulaganja ključni pokretači, dok kompetencije djeluju unutar društvenih i organizacijskih okvira koji u konačnici određuju njihovu učinkovitost. Ova interpretacija u skladu je i sa sociotehničkim pristupima koji naglašavaju da tehnološke promjene u organizacijama ovise o interakciji ljudskih sposobnosti, organizacijskih struktura i tehnoloških resursa (Mumford, 2006; Trist i Bamforth, 1951).

Iako su u skladu sa širim empirijskim dokazima, nalazi se trebaju promatrati u kontekstu grčkoga obrazovnog sustava. Javne osnovne škole u Grčkoj djeluju unutar visoko centraliziranoga sustava u kojem se politike, financiranje i ključne odluke donose na razini ministarstva. Ova struktura ograničava autonomiju škola, osobito u područjima strateških ulaganja i digitalne infrastrukture. U takvome kontekstu, školsko vodstvo nastoji integrirati digitalne alate u nastavu, suočavajući se pritom s ograničenim resursima i fragmentiranim pristupom tehnologiji (Antonopoulou i sur., 2025). Unatoč tome, trajni izazovi poput nejednakoga pristupa digitalnim alatima, ograničenoga profesionalnog razvoja i sporoga tempa sustavnih reformi i dalje oblikuju tijek digitalne transformacije (Giavrimis, 2023). Ove okolnosti naglašavaju da jačanje digitalnih kompetencija nastavnika, osiguravanje kontinuiranoga osposobljavanja i dugoročnih ulaganja nisu samo poželjni, već i nužni uvjeti za napredak digitalnoga obrazovanja u Grčkoj na smislen i održiv način (Raptis i sur., 2025b). Ova zapažanja također su u skladu s istraživanjima o centraliziranim obrazovnim sustavima, pri čemu institucionalne strukture i odluke na razini politika često određuju tempo digitalne transformacije na razini škole (Perifanou i sur., 2022; Ventista i sur., 2024). Takve mjere istodobno potiču društvenu jednakost, digitalno građanstvo i otpornost zajednice, povezujući transformaciju na razini škole sa širim društvenim razvojem.

Implikacije

Nalazi ovoga istraživanja imaju važne implikacije za obrazovne politike i svakodnevnu školsku praksu. Pokazuju da se digitalna transformacija grčkih osnovnih škola ne može ostvariti isključivo jačanjem digitalnih kompetencija nastavnika. Potrebna je kombinacija podržavajućega vodstva i pažljivo planiranih strateških ulaganja (Navaridas-Nalda i sur., 2020; Timotheou i sur., 2023). Donositelji obrazovnih politika trebaju prepoznati dvostruku ulogu koju nastavnici pripisuju ravnateljima: s jedne strane, kao pedagoško vodstvo koje inspirira i podupire nastavno osoblje, a s druge strane, kao strateškim upraviteljima koji osiguravaju usklađenost resursa i infrastrukture s potrebama škole.

Rezultati također naglašavaju važnost stabilnoga, dugoročnoga financiranja, koje je ključno za osiguravanje pristupa suvremenim tehnološkim alatima, pouzdanoj infrastrukturi

i kontinuiranom profesionalnom razvoju, uz istodobno smanjenje nejednakosti među školama. Jednako je važna i kultura suradnje i inovacija, u kojoj su digitalne kompetencije dio širega okvira institucionalne podrške. U visoko centraliziranim javnim obrazovnim sustavima, u kojima je autonomija škola ograničena, takve dugoročne investicijske odluke postaju ključna poluga za omogućavanje ili ograničavanje digitalne transformacije na razini škole.

Naposljetku, razlike utvrđene u samoprocjenama digitalnih kompetencija nastavnika u odnosu na spol ravnatelja i dobne skupine upućuju na potrebu za ciljanim inicijativama profesionalnoga razvoja koje će adresirati različite dobne skupine, oslanjajući se na njihove snage i istodobno podupirući područja koja zahtijevaju daljnji razvoj. Izvan grčkoga konteksta, ove implikacije primjenjive su i na druge centralizirane obrazovne sustave, u kojima su kapacitet vodstva i digitalne promjene na sličan način oblikovani centraliziranim upravljanjem i prioritetima ulaganja na razini sustava. Sveukupno, istraživanje sugerira da održiva digitalna transformacija u grčkom osnovnom obrazovanju zahtijeva strateško rekonfiguraciju koja povezuje ulaganja, vodstvo i ljudski kapital. U centraliziranim sustavima poput grčkoga, digitalnu transformaciju lakše je održati kada odluke o vodstvu ostaju povezane sa svakodnevnom nastavnom praksom. Redovit dijalog između školskoga vodstva i nastavnika može pomoći u osiguravanju da digitalni prioriteti odražavaju stvarne potrebe nastave.

Ograničenja i buduća istraživanja

Ovo istraživanje ima nekoliko ograničenja koja je potrebno uzeti u obzir. Prvo, istraživanje se temelji na presječnom (cross-sectional) dizajnu, što znači da su podtaci prikupljeni u jednoj vremenskoj točki. Kao rezultat toga, uzročno-posljedične veze između vodstva, digitalnih kompetencija, strateških ulaganja i digitalne transformacije ne mogu se pouzdano utvrditi. Drugo, istraživanje se oslanjalo isključivo na kvantitativne podatke prikupljene putem upitnika, čime je ograničena dubina kvalitativnoga uvida. Treće, uzorak je obuhvaćao samo nastavnike iz javnih osnovnih škola u Grčkoj, što ograničava mogućnost generalizacije na druge obrazovne razine ili privatne škole. Četvrto, podatci se temelje na samoprocjenama nastavnika, koje mogu biti pod utjecajem subjektivnih percepcija ili društveno poželjnih odgovora. Stoga nalazi odražavaju percepcije sudionika o digitalnoj transformaciji, a ne objektivne pokazatelje školskih praksi.

Dodatno ograničenje proizlazi iz namjernoga (purposive) uzorkovanja, koje je bilo nužno zbog nepostojanja sveobuhvatnih registara aktivnih nastavnika u Grčkoj. Iako je ovaj pristup omogućio uključivanje sudionika različitih profila, dobrovoljna priroda sudjelovanja znači da rezultati mogu odražavati pristranost samoselekcije, budući da su nastavnici s većim digitalnim samopouzdanjem vjerojatnije sudjelovali. Iako uzorak obuhvaća širok geografski raspon i uključuje sudionike različitih dobnih skupina i veličina škola, ne može se smatrati statistički reprezentativnim za sve učitelje u grčkim osnovnim školama. Rezultate stoga treba tumačiti kao indikativne, a ne potpuno generalizabilne. U metodološkom smislu, oslanjanje na prigodno sudjelovanje ograničava

eksternu valjanost jer izostanak randomizacije smanjuje mogućnost generalizacije nalaza na sve nastavnike u sustavu.

Također treba napomenuti da nalazi koji se odnose na spol ravnatelja odražavaju razlike u samoprocijenjenim digitalnim kompetencijama nastavnika. Slično tome, nalazi o dobnim razlikama odnose se konkretno na dobne skupine nastavnika i način na koji one oblikuju njihove percepcije digitalne transformacije. Nadalje, longitudinalno istraživanje nije bilo moguće jer je studija imala presječni dizajn. Konačno, analize su bile usmjerene na vodstvo, digitalne kompetencije i strateška ulaganja, dok su drugi čimbenici, poput kulture suradnje, psihološke spremnosti i uključenosti roditelja, ostali izvan opsega istraživanja.

Buduća istraživanja mogla bi nadopuniti ove nalaze primjenom longitudinalnih dizajna i korištenjem višestrukih izvora podataka, kao što su pokazatelji na razini škole ili intervjui sa školskim vodstvom. Daljnja istraživanja mogla bi imati koristi od mješovitih metodoloških pristupa i komparativnih dizajna koji ispituju digitalnu transformaciju na različitim obrazovnim razinama i u centraliziranim sustavima, uz istodobno nastojanje da se, gdje je moguće, prevladaju ograničenja uzorkovanja. Kvalitativni pristupi mogli bi dodatno rasvijetliti kako nastavnici i školsko vodstvo reflektiraju o digitalnim potrebama te kako doživljavaju digitalne promjene u svakodnevnoj praksi.

Zaključak

Vodstvo i strateška ulaganja predstavljaju glavne pokretačke snage digitalne transformacije u grčkim osnovnim školama, dok digitalne kompetencije imaju potporni karakter. Perspektive nastavnika ukazuju na to da su snažno vodstvo i dostatna ulaganja presudni za ostvarivanje smislenoga i održivoga napretka, dok same digitalne kompetencije ne mogu generirati transformaciju bez institucionalne podrške. Razlike povezane sa spolom pojavile su se ponajprije u samoprocijenjenim digitalnim kompetencijama nastavnika, dok su dobne razlike odražavale generacijski obrazac u percepciji tehnologije, vodstva i strateške usmjerenosti.

U praktičnom smislu, unaprjeđenje digitalne transformacije zahtijeva koherentne i dugoročne strategije koje povezuju razvoj vodstva, ciljana ulaganja u infrastrukturu i kontinuirano profesionalno učenje. Politike trebaju osigurati pravedan pristup digitalnim alatima i poticati suradnju, promatrajući vodstvo ne samo kao pedagoško usmjeravanje, već i kao pokretača digitalnoga upravljanja koje povezuje obrazovanje s društvenim inovacijama. Izgradnja snažnih digitalnih škola također jača lokalne zajednice, pridonoseći smanjenju nejednakosti i povećanju sudjelovanja u digitalnome gospodarstvu. Kada škole postanu digitalno osnažene, doprinose oblikovanju otvorenijega, inkluzivnijega i otpornijega društva. U konačnici, digitalna transformacija u obrazovanju nije samo tehnološki proces, već i pokretač društvene kohezije i održivoga razvoja. Iako je utemeljeno u grčkom kontekstu, istraživanje pruža uvide koji su analitički relevantni i za druge visoko centralizirane javne obrazovne sustave, u kojima kapacitet vodstva i strateška ulaganja na sličan način oblikuju putanje digitalne transformacije.

Prilog

Strukturirani online upitnik

Prakse vođenja

1. Ravnatelj uključuje nastavnike u proces donošenja odluka tijekom sjednica vijeća.
2. Ravnatelj potiče osoblje na preuzimanje inicijative u rješavanju problema unutar i izvan školskoga okružja.
3. Ravnatelj promiče suradničke aktivnosti s nastavnim osobljem škole.
4. Ravnatelj koristi e-poštu za komunikaciju s osobljem o administrativnim i organizacijskim pitanjima.
5. Ravnatelj koristi digitalne tehnologije za informiranje osoblja o seminarima vezanima uz tehnološke inovacije u obrazovnome procesu.
6. Komunikacija između ravnatelja i roditelja olakšana je putem digitalnih medija.
7. Ravnatelj potiče korištenje digitalnih alata za jačanje suradnje između nastavnika i roditelja.
8. Ravnatelj osigurava da su roditelji informirani o nadolazećim događajima i aktivnostima putem mrežne stranice škole.

Strateška ulaganja

1. Ravnatelj surađuje s nastavnicima u oblikovanju digitalne strategije škole.
2. Škola organizira seminare za jačanje digitalnih kompetencija roditelja u suradnji s općinom i lokalnim dionicima.
3. Digitalni uređaji dostupni su u školi kako bi ih učenici mogli koristiti prema potrebi.
4. Prijenosni uređaji dostupni su učenicima za posudbu i korištenje kod kuće prema potrebi.
5. Ravnatelj potiče nastavnike na sudjelovanje u programima osposobljavanja za digitalne kompetencij**e** i korištenje novih tehnologija.

Digitalne kompetencije

1. U kojoj mjeri možete izrađivati digitalne materijale za svoje učenike u različitim formatima (npr. video, slike, audio, tekst)?
2. U kojoj mjeri možete učinkovito filtrirati informacije tijekom pretraživanja interneta?
3. U kojoj mjeri svakodnevno koristite digitalne medije za komunikaciju?
4. U kojoj mjeri poduzimate mjere za zaštitu svojih digitalnih uređaja?
5. U kojoj mjeri možete prepoznati i riješiti tehničke probleme na svojem uređaju?
6. U kojoj mjeri tražite prilike za unaprjeđenje svojih digitalnih kompetencija?

Digitalna transformacija

1. Ravnatelj surađuje s nastavnicima u razvoju digitalne organizacije škole (npr. digitalne učionice, blogovi, online knjižnice, repozitoriji s digitalnim sadržajem).
2. U školi se potencijal novih tehnologija (npr. interaktivne ploče, prijenosna računala, 3D pisači, računala, dronovi) koristi u nastavi.

3. Ravnatelj koristi digitalne tehnologije za umrežavanje i suradnju s drugim školama.
4. Ravnatelj koristi digitalne tehnologije za povezivanje s lokalnim dionicima neformalnoga obrazovanja i za promicanje školskih aktivnosti (npr. digitalni muzeji, koncerti, obilasci).