Understanding the Digital Divide: Exploring School Principals' Perspectives on Educational Artificial Intelligence in Science and Art Centers (BİLSEMs)

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Abstract

In Turkiye, Science and Art Centers (BİLSEM) promote digital literacy and nurture talented students' unique abilities with personalized, tech-based programs. However, disparities in technological infrastructure and availability create significant inequalities across these centers. Despite a growing body of research on digital competencies, limited attention has been paid to inequalities. Addressing this gap, this study explores school principals' perspectives on educational artificial intelligence and institutional technological competence in BİLSEMs.

This research, funded by the Scientific and Technological Research Council of Turkiye (TUBITAK), is entitled "The Impact of Digital Competencies for Mitigating the Digital Gap: School Principals' Technology Leadership Competencies and Organizations' Digital Competencies in Science and Art Centers," and runs from 2024 to 2026. We plan international collaborations on training programs to develop digitally skilled citizens through teamwork and new partnerships.

In the methodology section, a content analysis of qualitative data was conducted using MaxQDA 2024. Data were collected through 20 semi-structured interviews with school principals. By doing this, we have evaluated how principals understand the digital divide, especially concerning the effective and appropriate use of digital services was examined.

The findings reveal that differences in familiarity with artificial intelligence applications, contribute to varying levels of digital readiness across these institutions. These differences point to an emerging form of information and knowledge asymmetry in the adoption and use of AI in education. The study provides an initial framework for understanding the digital divide as not only a matter of access but also of knowledge. It also offers practical insights for policy development and future collaborative initiatives to foster more equitable and effective digital learning environments.

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Points for Practitioners

Strategic Management and Leadership: This research is aimed at assessing the knowledge and proficiency of school principals on using educational AI technologies. The examination of these factors allows establishing a platform for the development of relevant professional programs that meet the interests of the studied population. Improved assistance makes it possible for principals to manage the process of technology introduction in their institutions and fill teacher vacancies, as well as gain additional technological resources for all BİLSEMs. At the moment, unequal distribution of resources prevents some institutions from creating strong and technologically advanced educational environments.

Bridging the Digital Divide: This research focuses on addressing the existing digital divide by pinpointing those who benefit from digitalization and those who remain underprivileged when using various digital resources. This approach helps obtain substantial evidence to assist policymakers in distributing funds and other resources in order to reduce the existing knowledge and information gap that complicates AI adoption in education.

International Partnerships: This project is conducted as part of a wider initiative involving the promotion of digital literacy and collaborative opportunities, creation of new collaborations, and international cooperation to improve teachers' skills and provide a wide range of courses.

Keywords:

Digital divide, artificial intelligence, organizational digital competencies, science and technology policy, science and art centers

1. Introduction

Digital technologies have changed education in deep ways, not just in how teachers teach and students learn, but also in how schools are organized. The digital divide is not merely concerned with who is able to connect online any longer. Currently, the emphasis is on more significant disparities—disparities in the way people engage with technology, the expertise they bring, and the limits of what schools can effectively address.(Helsper & Reisdorf, 2017; Van Dijk, 2020). Particularly in education, these inequalities have emerged not only among students but also across schools, reflecting divergencies in infrastructure, human resources, and leadership capacity.

Science and Art Centers (BİLSEM) in Türkiye represent a Sui generis educational setting in the evolving landscape of education. Established to support the gifted and talented students, BİLSEMs provide enriched, individualized, and technology-supported learning environments they need to push beyond the usual academic boundaries. (Ministry of Education [MoNE], 2007).

As institutions expected to integrate advanced technologies into the educational practices, BİLSEMs occupy a critical position in fostering digital literacy and preparing students for current digitalized societies. However, emerging evidence suggests significant disparities among BİLSEMs in technological infrastructure, the availability of permanent teaching staff, and institutional capacity.

These gaps ensure that the digital divide alive in the system. This isn’t just about whoever has the best gadgets or the fastest connection. That does make a difference, indeed. But there is more. Organizational conduct and leadership of processes are dependent upon understanding, management and integration of technology in education. The real barriers are more basic than equipment or infrastructure.(Selwyn, 2004; Van Dijk, 2020; The role of school principals is particularly important in this regard. The institutional digital capacity is directly determined by the capacity of institutions to develop a digital vision, to build collaborative practices and to enable the effective use of emerging technologies (Dexter, 2008; Flanagan & Jacobsen, 2003)

At the same time, the growing integration of artificial intelligence into educational contexts introduces new dimensions to the digital divide. Beyond access and basic digital skills, institutions are now differentiated by their ability to understand, adopt, and meaningfully use AI-based tools. (Luckin & Holmes, 2016). This creates an emerging information and knowledge asymmetry, in which some institutions are better positioned to benefit from technological advancements than others.

Despite the increasing importance of these issues remains limited and fragmented. Most studies focus on student achievement, stakeholder perceptions, or teacher-related factors. (Çelik-şahin, 2014; Karaduman & Ceviz, 2018; Yılmaz & Yılmaz, 2021). However, the interaction between organizational digital competence, leadership, and the digital divide remains underexplored from the perspectives of school principals.

This study fills this research gap by exploring school principals' perspectives on educational artificial intelligence. Drawing on qualitative data collected via semi-structured interviews, it investigates how principals comprehend digital inequality along with AI's part in disparities in digital readiness. The goal is to bring out richer insights into digital inequality in specialized education and point to enhanced strategies for schools to promote equitable digital practices.

2. Literature review

The concept of the digital divide has evolved as academic research. First, the problem seemed simple. Some people had access to digital technologies, others did not. In the 1990s, this represented a clear and significant inequality, which is why the focus on infrastructure was understandable. (Compaine, 2001)It is less convincing now. The first-level digital divide emphasized physical access to computers, internet connectivity, and related infrastructure. While this perspective was important for highlighting inequalities in the distribution of technology, it soon became evident that access alone could not adequately explain the persistence of digital inequalities across different social groups and institutional contexts.

Following research, a more nuanced understanding emerged by shifting attention toward disparities in digital matters. For example, Hargittai (2002) argues that even among individuals with similar levels of access, significant differences existed in their ability to effectively navigate and utilize digital technologies. This marked the emergence of what is often referred to as the second-level digital divide, which focuses on competencies, digital literacy, and differentiated patterns of use. Expanding on this perspective, As another example, Van Dijk (2020) conceptualized digital inequality as a multidimensional phenomenon comprising motivational, material, skills, and usage access, thereby underscoring the layered nature of digital exclusion.

As (Yavuz, 2023) notes, the digital divide is a 'moving target' that evolved from simple disparities in physical access to a complex phenomenon includes skills, motivation, and usage opportunities. This transition is further categorized into first-order effects (access), second-order effects (value creation), and third-order effects (social and economic impacts).

More recent approaches have further extended this framework by incorporating outcome-oriented perspectives. (Helsper & Reisdorf, 2017)proposed that digital inequalities should be understood not only in terms of access and skills but also in terms of the tangible and intangible benefits individuals and organizations derive from digital engagement. This third-level digital divide highlights how disparities in outcomes—such as educational

attainment, professional opportunities, and social participation—are shaped by unequal capacities to leverage digital technologies effectively. In this sense, digital inequality becomes deeply embedded within broader socio-economic and institutional structures. In this sense, digital inequality becomes deeply embedded within broader socio-economic and institutional structures. (Mossberger, 2008) Further expand this by defining digital citizenship as the ability to participate in society online, arguing that regular and effective use of ICTs is now a prerequisite for economic opportunity and civic engagement. Consequently, the institutional ability to foster such citizenship is inextricably linked to the school's organizational digital competence, shifting the focus from individual access to collective strategic readiness.

Such multi-dimensional concept is particularly relevant in the context of education, since the deployment of technologies to support learning depends on many factors at different levels, including personal competences, organization capabilities, and environment characteristics. Educational organizations are not just passive subjects regarding technology but rather act as mediators, influencing their use. This point is clearly illustrated by Eickelmann and Vennemann (2017), who prove that the impact of various aspects of school environment, such as leadership, technological infrastructure, and teacher development, has a critical effect on students' digital experiences and achievements.

Within this expanded analytical framework, the concept of organizational digital competence has gained increasing prominence. Moving the attention from the individual, this perspective draws upon the ability of institutions as collective actors to effectively integrate, manage and sustain digital technologies. Organizational digital competence means not just technological infrastructure, but also strategic vision, governance frameworks, pedagogical practices, and cultural orientations towards innovation It reflects the extent to which an organization can align its resources, processes, and actors to support meaningful digital transformation. However, the effectiveness of these public access points depends on shifting their function from centers of entertainment to environments for learning and self-development (Yildiz et al., 2003) emphasize that providing physical infrastructure is insufficient without integrated educational programs and technical support services to ensure that users can fruitfully utilize ICT access to enrich their lives

Several influential frameworks have contributed to the operationalization of organizational digital competence in education. The DigCompOrg framework(Kampylis et al., 2015) conceptualizes digitally competent educational organizations across multiple dimensions, including leadership and governance, teaching and learning practices, professional development, assessment, infrastructure, and collaboration. The Jisc (2018) digital capability framework similarly recognizes the need for institutional strategies, staff development and digital culture in making sustainable digital transformation. What these frameworks have in common is the assumption that digital competence is not a set of individual skills but an emergent property of organizational systems.

Digital competence is not the sum of individual skills, but also an emergent property of organizational systems, which is especially relevant in the context of digital government.

Mossberger (2008) posits that for public institutions to successfully transform digitally, the technical infrastructure needs to be compatible with the institutional norms and administrative readiness. Educational institutions thus constitute an important actor in wider digital ecosystems. Their success in the use of technology

will depend on their ability to create enabling environments, to foster experimentation and to institutionalize innovation. According to the European (European Commission, 2020) successful digital transformation in education requires a holistic approach, including investment in infrastructure, capacity building, leadership development and policy alignment. Thus, the digital skills of organizations can create huge inequalities between institutions, even if they belong to the same national education system. Technology leadership is the digital ability of an organization. School principals as an important actor in the process of digital transformation in education. They are responsible for managing day to day activities and also assisting in determining strategic directions by creating a shared vision for technology in their teaching practice (Dexter, 2008). In this sense, technology leadership is a nexus of structural conditions and educational outcomes.

Research on educational leadership has identified effective technology leadership to have several critical dimensions. Often a vision is also required to help clarify objectives and get stakeholders aligned around a common vision of digital transformation. Collaboration is also important and is the distributed expertise in educational organisations. School principals are street-level bureaucrats (Lipsky, 2010), with high discretion in the implementation of digital policies from the perspective of public administration. National frameworks serve as a strategic compass for AI integration, yet the achievement of these objectives rests on the perceptions and the institutional capacities of the principals. The "discretionary space" is crucial in deciding if AI tools will be transformative pedagogical tools or bureaucratic add-ons that reinforce existing hierarchies. The implementation of BİLEMs by the AI is not a neutral bureaucratic task, but a value-laden process, where the institutional 'grammar' of technology adoption is conditional on leadership discretion. (Fountain, 2001); (Harris, 2008).

So leadership in today's schools is less about top-down control and more about facilitating networks of practice. Similarly, (Spillane, 2006) conceptualises leadership as a distributed practice that is enacted in interactions among a number of actors and not solely by formal roles.

This move to distributed leadership reflects wider trends in organisational theory, especially in the context of growing complexity and uncertainty. Traditional hierarchical models based on centralized decision making and formal authority often are ill fitted for digitally mediated environments requiring flexibility, adaptability and continuous learning. (Gronn. 2002) In the case of such leadership, good leadership, as Elmore (2000) put it, is characterized by dividing work into teams, which encourages group problem solving and the generation of new ideas. This could imply the involvement of teachers, and ICT co-ordinators and others in the development of digital practices in schools.

Empirical studies have shown that technology leadership relates to successful technology integration. Studies have shown that the existence of strong leadership support in schools increases the chances of implementing innovative practices, effective utilization of digital tools, and improved educational outcomes. (Pettersson, 2018; Choi 2023).

The debate is about the extent to which leadership can overcome structural constraints such as poor infrastructure, lack of funds or staff shortages. Visionary leadership can make a difference, but it cannot solve systemic inequities. More sophisticated analytical approaches are needed here.

The rapid progress of artificial intelligence (AI) technologies is complicating the landscape. Artificial intelligence based tools are gradually entering the educational environment. They offer the potential for individualized

learning, automated assessment and data-driven decision making. (Holmes & Luckin, 2016) These technologies offer the potential to improve education through instant feedback and personalized instruction. But they also pose big questions about ethics, data privacy and institutional readiness.

Importantly, the integration of AI in education is not evenly distributed. Differences in awareness, expertise, and strategic capacity among institutions can lead to new forms of digital inequality. (Selwyn, 2016) argues that digital technologies often reproduce and amplify existing social inequalities, rather than eliminating them. In the context of AI, this suggests that institutions with higher levels of organizational digital competence are better positioned to capitalize on emerging technologies, while others risk falling further behind. This risk is closely related to the 'democratic divide,' which (Yavuz, 2023) identifies the gap between those who use digital resources to engage in public life and those marginalized by socioeconomic status. According to Reinforcement Theory, e-participation may primarily benefit those who are already politically active, thereby deepening existing disparities in the policy-making process.

This dynamic broadens the idea of digital divide beyond the access and literacy to advanced technology and strategic integration. While others risk falling further behind." This reflects what (Mossberger & Tolbert, 2021) describe as the evolving nature of the digital divide in the era of data-driven governance, where disparities in navigating algorithmic systems create new layers of social and institutional exclusion.

The emergence of AI introduces a new layer to the digital divide, characterized by what can be termed as 'algorithmic exclusion.(Meijer, 2015)highlights that public sector innovation depends on the alignment of technological affordances with institutional values. In specialized organizations like BİLSEMs, disparities in organizational digital competence can lead to an 'algorithmic divide' in which certain institutions capitalize on data-driven insights. In contrast, others struggle with the opacity of automated systems, thereby exacerbating institutional inequalities. Organizational digital competence is an emergent property that enables public institutions to transition from passive technology users to active orchestrators of algorithmic governance.

In this changing context, the role of school principals is even more important. As facilitators of institutional change, principals shape the adoption of AI technologies in traditional educational institutions. Their views, opinions, and degree of understanding to AI can impact corporate goals and practices. The crucial role of AI in education is increasing, but studies on leadership in the area is still scarce. Recent studies tend to focus either on the digital competence or on the leadership, without properly integrating these facets in an integrated structure.

Moreover, there are just a few study studies about Science and Art Centers (BİLSEMs) in Türkiye. Such institutions are special in the education system, where gifted and talented students are being taught using enhanced curricula and new pedagogical methodologies. Given their task of developing advanced skills, BİLSEMs are expected to play an important role in the acceptance and diffusion of emerging technologies, such as AI. However, little is known about how these institutions catalyze the digital transition or how their organizational capabilities differ. The focus on BİLSEM principles can enable a unique exploration of the Turkish education system/public innovation.

This gap is particularly important because BİLSEMs may exhibit significant heterogeneity in terms of resources, leadership practices, and technological readiness. "This institutional heterogeneity is complicated by what (Yildiz, 2010) describes as a problem of 'macro-level coordination,' in which various government agencies implement

digital access points in an unplanned manner. Consequently, for BİLSEMs to function as true 'innovation hubs,' leadership must move beyond supply-side policies to foster genuine demand and digital literacy among gifted ones. Such variations can contribute to institutional-level digital divide. The differences between schools affect students' opportunities and digital citizenship more broadly there. Understanding these dynamics requires moving beyond individual-level analyses to examine the organizational and leadership factors that shape technology integration.

In Turkiye, the prevalence of classic ICT devices such as PCs remains low, but the penetration of mobile phones is high, with about 90% of the population having access to them. This high penetration provides underdeveloped countries a “leapfrog” opportunity to bridging the digital divide via m-government services. (Ghyasi & Kushchu, 2004, p. 4; Yildiz, 2007, p. 255)

The present study addresses these gaps by investigating the viewpoints of BİLSEM school administrators on educational artificial intelligence within a thorough analytical framework. A key theme is the integration of digital divide theory, organizational digital competency and technological leadership . The study demonstrates the importance of leadership cognition on institutional responses to evolving technologies by adopting the perspective of principals. It also sheds light on how variations in knowledge, understanding and strategic orientation can lead to the shaping of institutional disparities.

Therefore, the study implies, digital transformation in education is not only a technical challenge but also a matter of organization, leadership and digital citizenship issue. As the educational system continues to respond to technological change, understanding these dynamics will be essential for ensuring equitable and effective outcomes.

3. Research design and methodology

In this study, a qualitative research was employed to analyze the views of the principals on educational artificial intelligence (AI), organizational digital competences, and the digital divide in BİLSEMs. Qualitative research is especially suitable for studying complex, context-dependent phenomena, and for capturing participants’ lived experiences and interpretations (Creswell & Poth, 2018). Considering the exploratory nature of this study and the scarcity of studies combining digital divide, organizational competency, and AI in the specialized educational context, the qualitative approach offers a deeper and more nuanced understanding. This study is guided by an interpretivist paradigm which assumes that social reality is produced via the meanings and interactions of persons (Schwandt, 2014). The study therefore explores .school principals’ interpretations of technological change, their assessment of institutional capacity and their sensemaking of new AI applications in education.

The research is carried out at Science and Art Centers (BİLSEMs) in Türkiye. These institutions are not only creative educational environments but also variety of technical infrastructure, staff and organizational capabilities. Such heterogeneity makes them a valuable environment for the analysis of “institutional-level” digital disparities. (Eickelmann & Vennemann, 2017). It has been suggested that the strategic utilization of existing local infrastructures such as internet cafes, in addition to official educational institutions, is an important public policy instrument in addressing the digital divide in Turkiye.. As (Yıldız, 2002) argues, these facilities are already common in every sub-province and small town, and if backed by correct regulations and incentives, provide a ready-made network for public access to technology.

This study forms part of a TÜBİTAK-funded project (2024–2026) titled *"The Impact of Digital Competencies for Mitigating the Digital Gap: School Principals' Technology Leadership Competencies and Organizations' Digital Competencies in Science and Art Centers."* The present paper represents an initial phase focusing on principals' perspectives on AI and institutional digital readiness.

The study sample is composed of 20 principals who are selected by the purposive sampling. This sampling technique is appropriate when participants are selected for their relevance to the study topics and their potential for providing rich, informed views. (Patton, 2022). School principals were chosen because they are at the center of decision making related to technology integration and organizational planning (Dexter, 2008)

To increase the analytical depth, heterogeneity in participants' geographical location, institutional size, staffing conditions and technology resources was explored. Data were gathered using semi-structured interviews. They provide a combination of consistency and flexibility as is customary in qualitative research (Kvale, 2009)

An interview protocol was established based on the research on the digital divide, organizational digital competency and technological leadership. Interviews were performed face-to-face, and lasted 45 to 60 minutes. All interviews were recorded with the ethical procedure. Then, they transcribed verbatim to assure data accuracy (Creswell & Poth, 2016)

The study employs qualitative content analysis to interpret the interview data systematically. Content analysis is an appropriate method for identifying patterns, themes, and meanings within textual data. (Schreier, 2012)The analysis was conducted using MaxQDA 2024 software, which facilitates systematic coding and organization of qualitative data. The analytical process followed a structured, iterative approach. (Miles et al., 2014)

4. Analysis of interview data

The analysis of the interviews showed that the digital divide in Science and Art Centers (BİLSEMs) in Türkiye is not limited to differences in physical access to technological tools. The findings also suggest that the structure is multidimensional and influenced by the differences in artificial intelligence awareness, institutional infrastructure, organizational sustainability, human capital, and leadership attitudes towards digitalization. The interview data reveal that BİLSEMs differ markedly in their institutional preparedness for digital transformation, particularly regarding new technologies such as artificial intelligence (AI). Interviews also suggest that the organizational digital competence is heterogeneous across institutions. Some BİLSEMs seem to operate as digitally integrated learning environments with advanced infrastructure and innovation-oriented leadership, while others are struggling with outdated technologies, unstable staffing structures and lack of institutional strategies. These differences reveal the presence of digital inequality at the institutional level within the same national education system. The findings are presented under four overarching themes.

4.1 Theme one: Artificial Intelligence and knowledge asymmetry

One of the most striking findings from the interviews is the substantial differences between principals in their understanding and implementation of educational artificial intelligence. The interviews indicate a distribution of AI related awareness in BİLSEMs that is uneven and can be characterized as a kind of "knowledge asymmetry" or "AI-readiness divide." Some principals had a very developed knowledge and strategic planning regarding AI integration, and others had a superficial familiarity with the topic.

Several principals noted AI as a strategic institutional priority (but not a passing technological fad) who focused on institutional investment, teacher training, and curriculum integration related to practices. For instance, an administrator from İstanbul noted that the institution had purchased a corporate ChatGPT subscription and granted teachers access to AI tools for lesson preparation, project management, and administrative tasks. The AI tools were part of the institution's broader digital transformation strategy, the principal said, rather than being individual classroom experiments.

Similarly, another principal from Samsun described AI as an essential part of the research and innovation activities of institutions. This participant estimated that teachers were encouraged to use AI in educational projects, especially in biology education and interdisciplinary studies. The main stressed that AI tools are increasingly being seen not just as teaching aids but also as vehicles for developing a research culture and innovation among students.

A similar view was obtained from the interviews in Bitlis. The principal said a special AI workshop had been recently established in the institution, adding that students have already prepared twenty-three projects for Teknofest competitions. This example shows that some BİLSEMs are going beyond the use of basic technologies and are trying to institutionalize AI supported production, experimentation and innovation activities. Some institutions seem to view AI not only as a supplementary educational technology but as a fundamental organizational strength.

But not all of the participants possessed this level of awareness or preparedness. Several principals admitted they did not know much about AI technologies. Some participants only referred to "classic programs like ChatGPT" and reported that they did not possess more in-depth expertise concerning educational AI applications. In some cases the questions were passed on to ICT teachers or other staff, indicating that they did not feel sufficiently informed to discuss the subject in detail. Others openly admitted that they did not fully understand how AI could be integrated into educational processes.

4.2 Theme two: Infrastructure gaps and sustainability

Another theme that emerged from the interviews is related to the deep inequalities in technological infrastructure and sustainability of digital resources in BİLSEMs. The findings reveal that some institutions have advanced technological facilities and extensive digital ecosystems while others have aging machinery, damaged infrastructure and limited access to the internet. Some of the principals described very high tech environments in their institutions. The institution has 67 computers, 43 smart boards, 8 3D printers, a laser cutting machine and a 3D cinema hall, one of the principals from İstanbul said. These examples show that some BİLSEMs have created rather large-scale technological ecosystems to accommodate interdisciplinary activities.

Another principal said the institution had smart boards in all classrooms and students had access to digital libraries, printers and other technology tools. These principals saw technology as part of institutional culture and educational practice, not as an add-on. Technology was seen as a key dimension of digital competence in organizations.

But the interviews uncovered significant structural inequities. Many principals talked about the limitations of old technologies and poor infrastructure. Izmir and Ankara principals said their computers were running on old processors and had not been updated in five or six years. One participant said even basic educational software was often "running slowly because of lack of hardware capacity.

Another frequent problem was the Internet infrastructure. “We still have 50 Mbps DSL connection, we don’t have fiberoptic infrastructure in our institution” said the principal from Konya. “This was a major constraint on the use of digital platforms, online learning tools and cloud based applications,” said the participant. This became especially problematic when many students attempted to use the digital resources simultaneously.

External crises also showed how they can worsen existing institutional digital inequalities. The head of the institution addressed that the technological infrastructure of the institution was severely damaged by the earthquake in Malatya. The equipment was destroyed, the classrooms were unusable and the institute had to devise improvised and temporary solutions to continue with the educational activities. For example, digital transformation processes can be susceptible to bigger social and environmental shocks.

Another important issue was sustainability of digital infrastructure. Many principals said that technology investments were often more a function of local sponsorships, philanthropists, or parent associations than reliable funding mechanisms from the government. This is largely because a lot of the technological resources had been raised locally through local donors and sponsorship agreements . Another participant said that the maintenance of smart boards and digital equipment depended largely on external technical support, funded by local networks.

4.3 Theme three: Limitations in human capital

The third, concerns the constraints of human capital, particularly the shortage of qualified teachers and the instability of technical staff. The interviews show that the organizational digital competence is based not only on the technological infrastructure but also on the availability of stable and qualified human resources able to manage and sustain the digital transformation processes.

A number of principals mentioned that technological equipment itself was not sufficient without qualified personnel who could exploit the resources effectively. Rize principal said that although the institution wanted to expand digital literacy and technology-focused programs, it had serious difficulties in recruiting information technology teachers. The participant said the institution’s ability to develop sustainable digital projects was hampered by the lack of specialized personnel

Teacher turnover was another important issue. The principal from Bitlis described the turnover rate among teachers as very high. Teachers frequently asked to be transferred after only a short time, breaking the continuity of robotics, coding and digital education programs. The participant noted that high staff turnover was eroding institutional memory and disrupting long-term digital planning.

The interviews suggest that human capital instability poses serious barriers for organizational learning and technological sustainability. Institutions with relatively advanced technical equipment may still be challenged to maintain digital programs in the absence of qualified teachers and/or with unstable staffing structures. In this sense, digital competence appears to be closely related to institutional continuity and professional expertise.

4.4. Theme Four: Digitalization and technology education

The last theme is about the principals’ different perceptions of digitalization and technology education. The interviews revealed considerable differences of understanding of digitalization within the institutions. Some

principals perceived technology as an interdisciplinary and institution-wide educational culture, while others perceived digitalization mainly related to the teaching of computer science, coding or robotics.

Several participants described very integrated approaches to digital transformation. The principal from Bursa said technology should be integrated into all disciplines including philosophy, geography, literature, music and art. The participant cited examples such as AI-generated mythological characters, digital storytelling activities, and green-screen geography lessons. “Digitalisation should not be only technical subjects but part of the whole pedagogical culture of the institution,” the principal said.

In the same vein, the principal from Sivas also stated that the music students transferred their compositions to digital environments, while the art students employed design software and graphic tablets to create their works. Those examples show a wider understanding of digital competence that is not limited to technical instruction, but also emphasizes creativity, interdisciplinary collaboration and artistic production.

Some principals also discussed AI assisted educational activities in humanities and social sciences. One participant said that students in literature wrote stories with illustrations generated by AI, while others in history and math used digital modeling tools. These cases illustrate how some BILSEMs are interested in embedding digital technologies into richer educational experiences, rather than as isolated technical acts.

But not all institutions could take such comprehensive approaches. In some cases, digitalization was paired with coding workshops, robotics activities or computer labs. Some principals perceived digital competence as a technical training and not as an institutional change. In these institutions humanities, music and arts disciplines were often perceived as less related to digital strategies.

The distinction between instrumental and transformative digitalization is particularly pertinent. Instrumental digitalization considers technology as a technical skill or separate educational discipline. Transformative digitalization, on the other hand, integrates digital creativity and technological thinking throughout the curriculum and institutional culture. The interviews reveal a broad range of BILSEMs as to which of these approaches they follow .

5. Discussion

The results indicate that the digital divide in Science and Art Centers (BİLSEMs) is not only confined to the accessibility to gadgets or internet. Instead, the interviews reveal a multidimensional gap in leadership capacity, teacher expertise, institutional strategy, and readiness to integrate future technology such as artificial intelligence. This reinforces the concept that digital inequality has shifted from first-level difficulties of access towards layered inequalities of skills, use and outcomes (Van Dijk, 2020; Helsper & Reisdorf, 2017; Yıldız, 2010).

A prominent theme in the interviews is the presence of an AI-readiness divide. Some principals reported very proactive institutional efforts. The principal who coded M18 (İstanbul-3) said the school had switched to a corporate subscription system for ChatGPT for teachers and that AI was being used in class preparation and management. Similarly, M17 (Bitlis) said that an AI workshop had been organized and students had developed 23 Teknofest projects on this subject. AI had been put “at the very center” of institutional research programs such as biology education, said M13 (Samsun). But some principals were not as familiar. M8 (Balıkesir) replied, “I know

classic programs like ChatGTP, but I do not have much expertise." M2 (İstanbul-1) indicated that colleagues would know more than the principal directly.

These differences show that certain organizations are experimenting purposefully with AI, while others are at a basic awareness level. This data reinforces Selwyn's (2016) claim that technology advancements tend to replicate existing inequities unless institutions are able to adapt them critically and effectively. In the Turkiye context, differences in institutional preparation also reflect broader differences in digital transformation capacity as pointed out by Yıldız (2007, 2010).

The interviews also highlight the necessity of digital competence of organisations. Frameworks such as DigCompOrg stress that digital transformation is not only a question of infrastructure, but also of governance, staff development, culture and pedagogy (Kampylis et al., 2015). Several principals highlighted institutions such as these that are ready holistically. For example, M18 (Istanbul-3) said it has 67 computers, 43 smart boards, 8 3D printers, a laser cutting machine and a 3D movie hall. M11 (Sivas) similarly stated that all classrooms were equipped with smart boards and that digital resources were accessible to students. These experiences imply that some BİLSEMs are evolving into integrated digital ecosystems, rather than independent technical assets.

But several principals mentioned structural limitations. M1 (Ankara-1) said that computers had not been changed for five or six years and they still were only with i3 CPUs. Similarly, M15 (İzmir) said that it was difficult to speak about technological proficiency when the gear was obsolete and even the internet connection was delayed. M7 (Konya) said there was no fiber infrastructure and that they were still using copper lines and 50-megabit DSL. M6 (Malatya) said that the earthquake damage had practically devastated the technology infrastructure.

These inequalities offer significant evidence for Yıldız's (2010) argument. According that digital differences in Türkiye are not merely about household-level access but are rather driven by inconsistent institutional implementation and macro-level coordination difficulties. To sum up, access to technology is mediated by administrative capability, location and governance systems.

Another common element was the reliance on local sponsorship and informal resource mobilisation . M3 (Bursa) said that almost 60% of the sponsorship money was given to IT resources and that the upkeep of smart boards was dependent on an outside specialist. M7 (Konya) spoke about the support from parents and local philanthropists in establishing chemistry labs, English language labs and digital workshops. These examples show that some institutions compensate for a lack of official funding through social capital and local networks. But this also causes uneven development trajectories among schools. This tendency is in line with Yıldız, Bensghir and Çankaya (2003) who claimed that technical potential in Türkiye depend on unevenly dispersed local support systems

Leadership was a critical variable in the conversion of resources into institutional capacity. A few of the principals had a clear vision of digital. M3 (Bursa) highlighted that technology should be integrated into all courses, including subjects such as philosophy and geography, music. He gave instances of using AI to create mythological creatures or teaching geography with green screen. M13 (Samsun) said that they were preparing teachers to use CorelDRAW and Tinkercad in order to incorporate digital modelling into lectures on mathematics and history. These findings are consistent with the technological leadership literature that points to the principal's role in providing direction, encouraging innovation, and supporting teachers (Dexter, 2008; Flanagan & Jacobsen, 2003).

Simultaneously, the interview findings corroborate the distributed leadership paradigm. Successful institutions did not rely on administrators alone, but on the partnership of IT teachers, engineers, workshop instructors and external players. M9 (Istanbul-2) spoke about professors working with students, six AI training sessions for teachers and plans for an AI laboratory. This suggests that leadership is a communal practice, rather than a hierarchical role. (Spillane, 2006; Harris, 2008)

Another issue that comes up in the interviews is the gap between instrumental digitalization and transformative digitalization. In certain universities, digital competency was still very tightly linked to coding, robotics or computer science. For example, M5 (Van) focused on digital gaming workshops and tournaments, while M17 (Bitlis) focused on compulsory computer science instruction in the second, third and fourth grades. In other centers, digital technologies were integrated across the disciplines. M11 (Sivas) said music students moved works to digital surroundings while art students used graphic tablets and design applications

M14 (Mersin) noted that literature students wrote stories that were illustrated with AI tools. The distinction is conceptually crucial. Instrumental digitalization considers technology as a distinct technical discipline; transformational digitalization embeds digital creativity in the curriculum. This finding confirms Yıldız's (2002) notion.-technology creates public value when integrated into daily learning and social behaviors instead of being relegated to discrete technical settings-.

The findings are likewise consistent with Yavuz (2023) from a larger democratic perspective. There is an argument that digital divisions are increasingly shaping participation, inclusion and voice in public life. If certain gifted kids do receive stable access to AI-supported research, design tools, and data analysis, and others do not, such educational inequities may be translated into future civic and professional inequalities. Therefore, inequalities among BİLSEMs should be seen not only as inequalities at the classroom level but also as inequalities in future chances of digital citizenship.

Finally, the interviews reveal that leadership cannot overcome all structural restraints. For example, to M16 (Rize-1), despite significant institutional impetus, stressed the need for IT teachers. M17 (Bitlis) has high teacher turnover, with teachers applying for transfers after short time. Even the most ambitious leaders have limits when the instability of workforce and inadequacy of infrastructure remain. This demonstrates that visionary leadership is required but not adequate without coordinated personnel and investment plans (Petterson, 2018, Choi,2023)

The findings therefore suggest that the digital divide in specialized education has reached a new stage. It is no longer about access to devices, it is about who can strategically regulate technology, who can mobilize knowledge and who can translate AI into instructional value. In this regard, the study confirms the claim of Yildiz (2010) that digital inequality is an organizational and governance challenge, as well as a technology challenge.

6. Conclusion

The present research provides insight into the formation of the digital divide phenomenon at Science and Art Centers (BİLSEMs) through the prism of artificial intelligence (AI), organizational digital competence, and technology leadership from the viewpoint of school principals. The study demonstrates conclusively that the digital divide should not be defined based on the restricted understanding of computer availability or internet connectivity alone. On the contrary, the digital gap among BİLSEMs is formed due to the uneven distribution of leadership

capabilities, organizational strategic planning, human resource management, and ability to comprehend and implement emerging technological trends like AI.

The core contribution of this research consists in describing a multidimensional, organizationally mediated digital divide. According to the study findings, although some BİLSEMs demonstrate comprehensive digital infrastructures involving advanced technological equipment and highly developed digital strategies, others face difficulties caused by poor connectivity, outdated technologies, and inconsistent institutional approaches to the use of information technology (IT). As a result, while the issue of technology accessibility should be taken into account in defining digital divide, it does not appear to be the only relevant variable because the decisive criterion is the effectiveness of resource management and coordination within the institutional context.

Furthermore, this research shows that there is an "AI readiness divide" within BİLSEMs. Different perceptions and understandings of AI among principals of BİLSEMs lead to uneven approaches to working with new technologies. While some principals treat AI as an integral part of their development strategy and invest in necessary actions, others still operate at the level of basic awareness and have no strategic approaches to integrating innovative tools into institutional practice. Therefore, AI adds yet another dimension to the digital divide phenomenon, which includes cognitive and organizational capabilities in addition to material factors.

Finally, this paper makes it clear that the concept of organizational digital competence is crucial for understanding the issue of digital divide. Digital transformation is not simply the sum of individual competencies but involves the emergence of an emergent capability within institutional contexts characterized by coordination, alignment, and synergy of various components. Infrastructure, organizational culture, professional development, and organizational strategy should work together to produce desired effects, which is why some BİLSEMs lacking proper human resources face problems despite having advanced technological equipment.

The concept of technology leadership emerges as a mediating mechanism that mediates between structural conditions and educational outcomes. Principals can act as change agents through the definition of a clear digital transformation vision, promotion of collaborative practices, and development of digital competencies of teachers. At the same time, studies show that the concept of leadership goes beyond its formal meaning and successful cases demonstrate distributed leadership when responsibilities are equally spread among teachers, IT specialists, and stakeholders from outside.

At the same time, the study draws attention to the limitations of leadership and emphasizes that even if effective leadership exists, it cannot help institutions develop successfully in case there are unfavorable structural conditions. The issues of lack of human resources, teacher turnover, and instability in financial conditions are some of the obstacles to success. Furthermore, the dependence on sponsorship or donations leads to diverse development paths for different BİLSEMs which, in turn, creates more gaps.

In general, there are several implications for practice. As far as leadership is concerned, it is necessary to ensure adequate professional development of principals. Principals need additional education and experience in the spheres of digital technologies and their governance. Otherwise, the process of digitalization will become purely formalized. Secondly, attention should be paid to the maintenance of the human capital of institutions. Policies related to retention of qualified teachers (especially specialists in ICT) are essential. Thirdly, it is necessary to

focus on full-fledged digitalization rather than on sporadic activities like coding lessons. The introduction of technologies into subjects from the sphere of humanities, arts, and sciences is crucial.

In addition, a stable model of funding is required for further development of BİLSEMs. Relying on sponsorships or donations, which may not be stable or permanent, is unacceptable. Therefore, developing sustainable sources of funding is needed. Finally, it seems reasonable to implement an audit system for AI readiness of institutions, since such an evaluation can allow us to assess institutions' ability to implement technology properly.

This study theoretically contributes to the literature by reconceptualizing the digital divide on the organizational level. Earlier approaches concentrated on individuals or households, the findings show that institutions themselves are key sites of digital inequality. In this sense, the digital divide is to be understood as a multi-dimensional phenomenon, where organizational capacity is a mediator between technological resources and outcomes. Moreover, the integration of AI adds a new dimension of inequality related to algorithmic awareness, strategic use and institutional readiness. This “algorithmic divide” builds on existing frameworks by including the contribution of new technologies in the creation of educational opportunities.

The study also contributes to the broader topic of digital transformation in the public sector beyond the BİLSEMs. Specialized educational institutions are a microcosm of the wider processes of change of the digital state, where governance, administration and capacity are complexly interconnected. Understanding how these dynamics play out institutionally can be enlightening to policy debates on digitization, innovation and equity in education systems in general.

In conclusion, the study highlights that the digital revolution of education cannot be confined to the availability of technology instruments. Technology is no cure for better outcomes, for more equity What matters is how institutions understand, manage and integrate these technologies in relevant educational and organizational activities. The fear is that digital reforms would repeat and possibly worsen existing inequities rather than diminish them, without tackling deeper structural and organisational disadvantages.

To succeed in the digital transformation a holistic approach is needed which combines investments in infrastructure, leadership development, stability of human resources and institutional build-up of capability. Solving these interconnected difficulties is important for BİLSEMs and comparable educational institutions to make the most use of the potential of digital technology and for all students to benefit from the existing opportunities.

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