Vol.1, Issue.1, (2025)

Digital Culture and Education Review

Bridging the Digital Divide: Exploring Strategies for Inclusive Education in the Age of Technology

Jakub Kubiczek[1], Sirab Ali[2*]

[1]University of Economics, Katowice, Silesian Voivodeship, 40003, Poland

[2] School of International Business, Hainan University, Haikou, 570228, Hainan, China

Article Information

Article Type: Research Article

Dates:
Received: 2 May 2025
Revised: 21 May 2025
Accepted: 28 May 2025
Available online: 15 June 2025

Corresponding Author: Sirab Ali
sirabali@hainanu.edu.cn
ORCID: https://orcid.org/0009-0004-1565-7002

ABSTRACT

The rapid digital transformation of education has emphasized the importance of technology in shaping student academic performance. Digital devices, internet connectivity, digital literacy, technological infrastructure, and access to these technologies are key determinants of learning outcomes, but the relationships among these are seldom examined. This paper aims to investigate the impact of access to digital devices, digital literacy, internet connectivity, and technological infrastructure on student performance and examine the technological infrastructure's mediating role. Data were collected through a structured survey conducted among 350 university students in Poland, whereas after evaluation only 219 were found completed. To test the proposed hypotheses and assess both the measurement and structural models, Partial Least Squares Structural Equation Modeling (PLS-SEM) was employed. The relationships were analyzed using path analysis, and the constructs were evaluated for reliability, validity, and discriminant validity. Study results and findings indicate that digital devices, digital literacy, internet connectivity, and technological infrastructure significantly enhance students' performance ($p<0.001$). Access to Digital Devices was positively associated with Student Academic Performance (H1: Increasing access to digital devices improves students' academic performance with $\beta = 0.195$ and $t = 5.450$, $p < 0.001$). Similarly, Digital Literacy was found to have a direct positive impact on Student Academic Performance (H2: Results provide significant support that higher levels of digital literacy increase academic success ($\beta = 0.220$, $t = 6.565$, $p < 0.001$). Internet Connectivity also positively influenced Student Academic Performance (H3: ($\beta = 0.228$, $t = 6.361$, $p < 0.001$). Technology and its shared inhabitants must be exposed to and taught by digital literacy. No significant effects were observed for control variables such as gender, age, and experience.

The study's findings concluded and underscore the relevance of digital literacy and technological infrastructure in amplifying academic outcomes. In this great digital age, institutions must invest in technological infrastructure and digital literacy to bridge the digital gap and enable students to succeed academically.

Keywords: Digital literacy, Technological infrastructure, Academic performance, Internet connectivity, Digital devices.

1. INTRODUCTION

The deadly pandemic COVID-19 highlighted the urgent need for educational transformation in the context of digitalization, emphasizing its critical role in learning an aspect that had previously been less prioritized. While technological advancements have permanently reshaped the learning environment, they have also widened the gap in access, further exacerbating existing inequalities. Technology integration in education has been the subject of consistently positive studies enhanced learning outcomes (Zimu, 2024), personalized instruction, and increased accessibility to marginalized groups (Hanif et al., 2023). For example, due to digital tools, literacy has improved, such as the ability to remote learning during crises like the COVID-19 pandemic (Bachtiar, 2024). While the same tools can strengthen inequities when there is an inequality in access to high-speed internet, devices, and digital literacy (Huang, 2023), tools like microphones enable specific experiences beyond the classroom and can lead to more equitable experiences (Bachtiar, 2024). Through its digital divide, a lack of access, skills, and meaningful use of technology, students from low-income families, rural areas, and underrepresented minorities are disproportionately affected (Warschauer et al., 2004). As multiple governments and NGOs pursued interventions, the challenge of seamless integration and technology usage to fulfill inclusive education remains persistent. To address this issue, we need comprehensive strategies based on infrastructure development, teacher training, and culturally relevant pedagogies, which would close the gap (Valadez & Durán, 2007).

1. *What are the key barriers to achieving equitable access to technology in education across diverse socio-economic and cultural contexts?*
2. *What strategies can be implemented to bridge the digital divide and promote inclusive education through technological integration?*

The shift to using technology in schools has advanced, yet researchers still need better data about who has equal digital access to basic digital skills and internet connections. Research shows that digital tools improve teaching methods while making school easier for everyone, including underprivileged groups (Hanif et al., 2023; Zimu, 2024). However, many research reports ignore the long-term technology barriers in education, which remain practical barriers to digital learning resources. Students with limited income, those living outside cities, and minorities deal with major digital resource obstacles that block their educational progress (Warschauer et al., 2004). Several programs exist, but we need complete and unified efforts to improve teaching facilities with training and suitable educational approaches for all students. Researchers must investigate what stops students from receiving equal digital access in school today (Hanif et al., 2024). Our research needs to find ways digital literacy and technical equipment can support a school system that includes every student during this digital learning phase.

2. LITERATURE REVIEW

2.1 Unified theory of acceptance and use of technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is the most widely adopted theoretical framework to understand user acceptance and using technology. Venkatesh et al. (2003) initially proposed to combine key constructs from eight theory models, such as the Technology Acceptance Model (TAM), the Theory of Planned Behavior (TPB), and the Innovation Diffusion Theory (IDT), in one. In this work, UTAUT is the result of this combination. The objective of this framework is to clearly identify what shapes a person's interest in using technology and their actual behavior exclusively (Strzelecki, 2024). The model finds that technology acceptance is most affected by performance expectancy, effort expectancy, social influence and facilitating conditions. Performance expectancy is about users feeling that a system will help them perform better on the job which is linked to TAM's perceived usefulness. Perceived ease of use in TAM is similar to effort expectancy which deals with the ease of using the technology. On the other hand, convenience means it is convenient to own the technology, based on the TAM aspect of time to first use (Venkatesh et al., 2003). The effect of other people's opinions helps shape how someone uses technology and if they have the necessary support and resources to do so. Things like gender, age, experience and how it was used by choice also shape these constructs (Iskender et al., 2024; Warschauer et al., 2004).

The UTAUT framework looks at how different kinds of prompts can shape users' attitude and level of participation in using AI-generated content. This means that performance expectancy describes how structured prompts can help an AI improve the emotional quality, cultural fit and linking together of its stories and writings (Marchewka & Kostiwa, 2007). Having these elements ensures digital solutions like AI in creative education are not only understood by people but also make sense for everyone (Hanif et al., 2023). Through support from AI, users' understanding of how to interact with it can be strengthened which can help improve their ease of use, especially if tricks are well marked and easy to understand. As a result, people face fewer obstacles in becoming digitally literate and involved which helps address major issues of the digital divide (Kim et al., 2023).

Within this framework, social influence reflects the collective perceptions of quality and value associated with AI-generated content, which can shape individual engagement and acceptance. Facilitating conditions relate to the availability and accessibility of necessary tools and resources such as user-friendly AI models that empower learners to engage with technology effectively (Labajová, 2023). This aligns with the broader goal of creating equitable digital learning environments (Zimu, 2024). This study contributes to a better understanding of how technological frameworks shape user engagement and satisfaction in creative and educational contexts. Applying UTAUT, the study explores how prompt design, perception of AI-generated content, and human-AI collaboration can enhance inclusive learning practices. These insights reinforce the role of supportive digital infrastructure in promoting equitable access to emerging technologies, ultimately helping to bridge the digital divide in education.

2.1 Research model

The research model is developed based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and the literature. The thesis study's theoretical model is that access to devices, digital literacy, internet connectivity, techno, and logical infrastructure are key technological and digital factors that affect student academic performance. In addition, the mediating effect of infrastructure in the relationship between digital literacy and academic performance through technological infrastructure is also examined.

2.2 Digital devices and student academic performance

Digital devices enable students' engagement in digital learning resources and online platforms to impact academic performance positively. It is well-recognized from prior studies that students' ability to complete assignments, participate in online discussions, etc., can be significantly raised by such devices as laptops, tablets, and smartphones (Berhanu & Raj, 2024). However, a shortage of access can intensify educational inequalities, making it difficult for students to study (Kumar et al., 2024). Therefore, it is hypothesized:

H1: *Access to digital devices has a positive impact on student performance*

2.3 Digital literacy and student academic performance

Defining digital literacy as the readiness to leverage digital tools and technology is an important factor of academic achievement in contemporary educational settings. Students with a higher level of digital literacy are more prepared to work in a digital learning environment, to continue to evaluate online resources critically, and to apply technology to further their academic agenda. Several research themes are highlighted where digital literacy raises engagement, creativity, and learning efficiency (Zimu, 2024). Consequently, the following hypothesis is proposed:

H2: *Digital Literacy has a positive impact on the academic Performance*

2.4 Internet connectivity and student academic performance

Internet connection is key for students to access online learning materials, attend virtual classes, and collaborate with peers, but also with the teachers themselves. Iskender et al. (2024) argue that studies indicate positive correlations between the students' stable access to the internet and how much they learn in school. However, connectedness is a poor functional state, reducing learning processes and academic performance. Thus, it is hypothesized:

H3*: Internet Connectivity has a positive association with student academic Performance*

2.5 Technological infrastructure and student academic performance

Technological infrastructure facilitates academic performance, such as the availability of hard and soft tools, platforms, and support systems for learning. A robust infrastructure ensures that students can have seamless access to learning resources and technology-driven educational activities (Gordon et al., 2024). Higher student engagement and academic success are more common for schools referred to as educational institutions with advanced infrastructure (Strzelecki & ElArabawy, 2024). Hence, the following hypothesis is proposed:

H4*: Technological infrastructure has a positive influence on student academic performance*

2.6 Digital literacy and technological infrastructure

Digital literacy helps students learn how to interact with the technological infrastructure, maximizing their capacity to use best what is available. According to research, those possessing higher digital literacy will utilize infrastructure to reach educational ends (Strzelecki, 2024). The importance of creating digital skills that go hand in hand with infrastructure development in this interplay is underscored. Therefore, it is hypothesized:

H5: *Digital Literacy has a positive impact on technological infrastructure*

2.7 Digital literacy, technological infrastructure, and student academic performance

Digital literacy is well documented as a mediating factor in the relationship between the technological infrastructure and students' academic performance. Students possessing strong digital skills make better use of existing infrastructure to help improve their learning outcomes (Rachmad et al., 2024). This leads to the belief that there must be a positive correlation between digital literacy and structural infrastructure, as the positive effects on academic performance are magnified when combined. Hence, the final hypothesis is proposed, and the detailed research framework is presented in Figure 1 below.

H6: *Technological infrastructure mediates positively between student academic performance and digital literacy.*

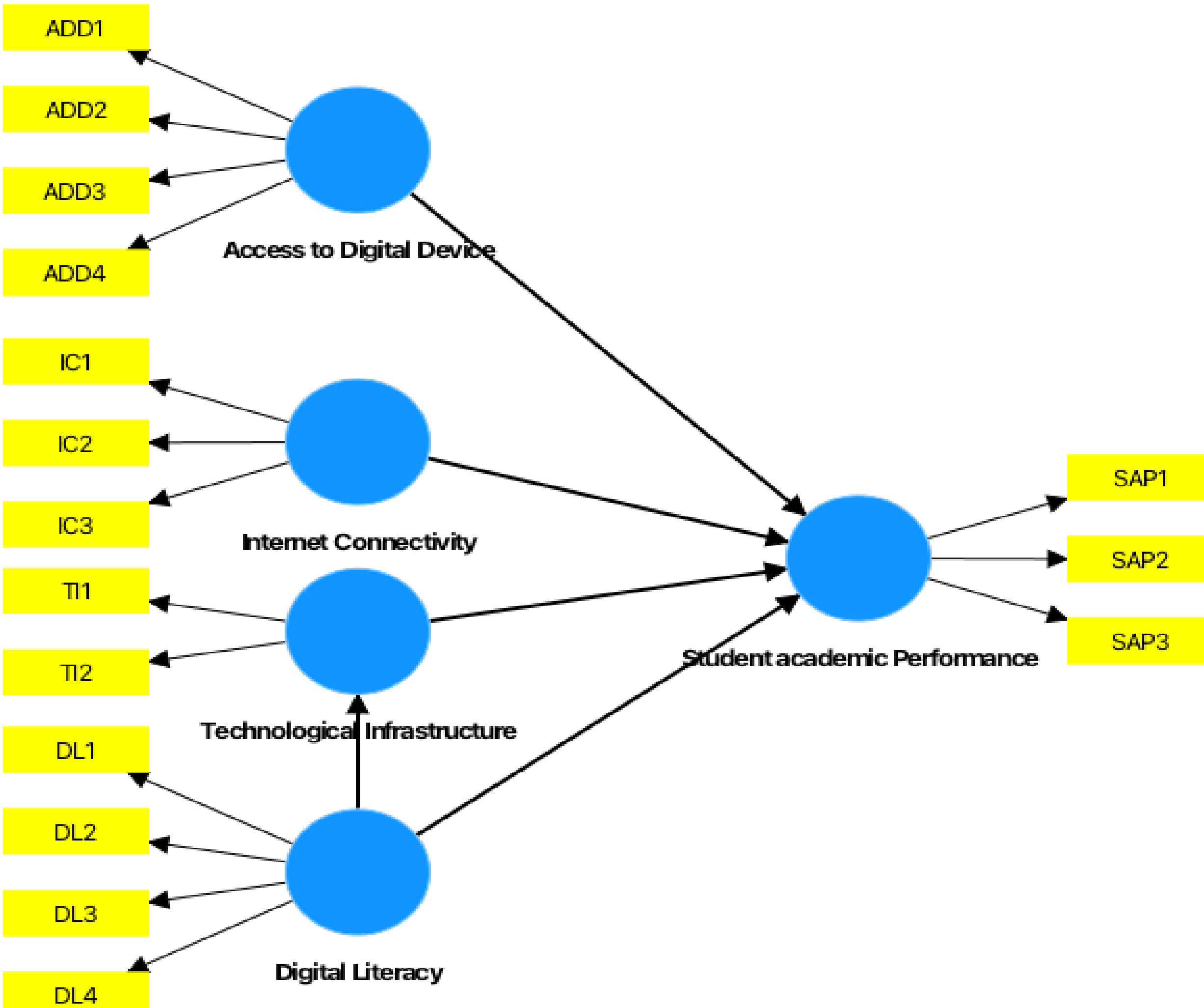

Figure 1: Research Framework

3. METHODOLOGY

3.1 Measures

This study involved five constructs: access to Digital Devices, Digital Literacy, Internet Connectivity, Technological Infrastructure, and Student Academic Performance. Table 1 shows that each construct is measured with several items adapted from validated scales. Survey questions were sourced from past studies to ensure content validity. Adapting items for Access to Digital Devices from (Joseph & Uzondu, 2024) for which accessibility of devices was explored in terms of supporting academic tasks. For the evaluation of students' competencies in utilizing digital tools effectively, those Digital Literacy items were adapted from (Lybeck et al., 2024). Internet Connectivity items are based on (Peruzzo & Allan, 2024) that look at accessibility, reliability of Internet connectivity, and its impact on learning. We derived items from (Vysochan et al., 2024) to measure Technological Infrastructure items, which consisted of the availability and quality of educational technology resources (Zhao & Qian, 2024). Also, it measured improvement in academic outcomes by using items from (Kuhn et al., 2024) to test Student Academic Performance. The data was collected from Poland's students.

All items were rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). A pilot study involving 15 students was undertaken to refine item wording, verify clarity, and determine how best to administer items to achieve maximum accuracy of the resulting scores. The pilot study resulted in minor changes in wording to make the items more comprehensible.

3.2 Sample and data collection

This study's target population is any university student using digital technologies for academic purposes in various institutions. A structured online survey-based questionnaire was designed and distributed through a wide Google survey platform (a detailed survey with items is presented in Table 1). The diverse sample was recruited through email invitations and social media platforms. All the respondents were from Poland students. The responses were collected within a data collection period of two weeks.

Participants were drawn from many disciplines and education levels to ensure we achieved representativeness. As many as 329 of the 350 questionnaires handed out were returned. A final sample of 219 valid responses was retained after screening for incomplete responses and patterns with low response validity. Respondents' demographic profiles showed a balanced representation of gender, academic year, and how they use digital technology. Since it may be used for exploring complex relationships of latent constructs, this study employed Partial Least Square Structural Equation Modeling (PLS-SEM) for data analysis. It also made it possible to evaluate direct and indirect effects, including the mediating effect of Technological Infrastructure in Digital Literacy Student Academic Performance relationship. Gender, age and the frequency of technology use were added as control variables to the analysis so they could impact the results.

Table 1: Constructs and Items

Construct	Items	Source
Access to Digital Devices	ADD1: I can access a personal laptop/tablet for academic work. ADD2: I use my digital devices regularly to complete assignments. ADD3: My device supports all necessary academic applications.	(Joseph & Uzondu, 2024)
Digital Literacy	DL1: I use digital technology to do my academic work well. DL2: I am able to judge whether online academic sources are reliable. DL3: I know how to resolve common problems that come up with digital tools.	(Lybeck et al., 2024)
Internet Connectivity	IC1: I have reliable internet access for academic purposes. IC2: My internet connection rarely interrupts my academic work. IC3: I can access all necessary online learning platforms without difficulty.	(Vysochan et al., 2024)
Technological Infrastructure	TI1: My institution provides sufficient digital tools for academic learning. TI2: The online learning platforms provided by my institution are user-friendly. TI3: There is adequate technical support for resolving issues with digital learning tools.	(Zhao & Qian, 2024)
Student Academic Performance	SAP1: My academic performance has improved due to using digital tools. SAP2: I feel more productive in my studies with access to digital technology. SAP3: I achieve better academic outcomes due to reliable internet and digital infrastructure.	(Kuhn et al., 2024)

The demographic data table 2 for the survey conducted in Poland among 319 students has been prepared and displayed. It contains details on categories like gender, age, education level, digital device ownership, and internet usage frequency, with corresponding frequencies and percentages for each demographic.

Table 2: Demographic statistics

Category	Demographics	Frequency	Percentage
Gender	Male	165	51.72
Gender	Female	154	48.28
Age	18-20	98	30.72
Age	21-23	152	47.65
Age	24 and above	69	21.63

Education Level	Undergraduate	210	65.83
Education Level	Master's	90	28.21
Education Level	PhD	19	5.96
Digital Device Ownership	Yes (Own Device)	285	89.34
Digital Device Ownership	No (Shared Device)	34	10.66
Internet Usage Frequency	Daily	300	94.04
Internet Usage Frequency	Occasionally	19	5.96

4. DATA ANALYSIS AND RESULTS

To test the proposed research model, this study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS. This research study examines how student academic outcomes relate to online technology use, basic bright screen and web skills, internet access, and technology availability. Researchers selected these variables because they strongly affect learning results, especially during online access inequality periods. The research uses students' academic performance as its primary performance test, while digital devices, digital literacy, internet connectivity, and technological setup act as factors that predict performance outcomes. Partial Least Squares Structural Equation Modeling (PLS-SEM) was chosen as the estimation model to determine the hypotheses and study variable connections. This study uses PLS-SEM analysis because it offers several advantages for research purposes.

This research aims to discover relationships among several independent and dependent variables, so PLS-SEM helps test these elements through one integrated model. This method effectively studies how digital devices connect with digital literacy to create the necessary technical systems.PLS-SEM efficiently manages smaller sample sizes because this factor was crucial when the study used a sample of 319 university students to gather data. The method produces dependable results from modest sample sizes, fitting our research well. PLS-SEM analyzes the measurement model to validate construct accuracy while inspecting how different variables relate to the structural model. Our complete research design matches our primary goal of measuring direct performance links and how technology infrastructure supports learning.

The research includes several predictors of digital devices, digital literacy, internet connection, and technological infrastructure that correlate closely. PinS uses precise algorithms to detect interdependent predictor factors, which makes its calculations more reliable. Through path analysis, this study assessed direct links between research factors and evaluated measurement outcomes for reliability and distinct validity. These tests confirmed that the measurements worked as intended while showing the distinct nature between our multiple constructs for research validity. Using PLS-SEM enables the study to analyze both direct digital technology effects on academic results and explore the role of technology infrastructure mediation that shows these factors' interactions and digital divide solutions in education. According to Sharif et al. (2024)'s two-step approach, the analysis began with a test of the measurement model to show the reliability and validity of the constructs, followed by a test of the structural model to test proposed hypotheses. The results are explained, and the relevant tables are below.

4.1 Measurement model

4.1.1 Reliability and Validity

Cronbach's alpha and composite reliability (CR) were used to assess the reliability of the constructs. The threshold value for the Cronbach alpha and composite reliability must be greater or equal to 0.7; for AVE, it must be greater or equal to 0.5 (Tavakol, 2017). As shown in **Table 3**, the threshold (0.7) for Cronbach's alpha and CR was above, suggesting strong internal consistency. In one example, Access to Digital Devices reached a Cronbach's alpha of 0.848 and a CR of 0.898, and Digital Literacy was 0.836 with a CR of 0.890. The results show that the constructs do indeed measure the intended concepts.

Table 3: Construct reliability and validity

	Cronbach's alpha	**Composite reliability (rho_a)**	**Composite reliability (rho_c)**	**Average variance extracted (AVE)**
Access to Digital Devices	0.848	0.849	0.898	0.687
Digital Literacy	0.836	0.841	0.890	0.670
Internet Connectivity	0.836	0.843	0.901	0.752
Student Academic Performance	0.797	0.797	0.881	0.712
Technological Infrastructure	0.776	0.804	0.898	0.815

The Average Variance Extracted (AVE) and standardized item loadings were used to evaluate convergent validity. Table 3 demonstrates that all AVE values were greater than 0.50, and all item loadings were above 0.70, which meets minimum thresholds. For example, ADD1 had a loading of 0.881, which means that the items correlate strongly with their construct; DL1 also loaded at 0.876.

Table 4: Cross loadings

Items	**Access to Digital Devices**	**Digital Literacy**	**Internet Connectivity**	**Student Academic Performance**	**Technological Infrastructure**
ADD1	0.881				
ADD2	0.828				
ADD3	0.797				
ADD4	0.808				
DL1		0.876			
DL2		0.817			
DL3		0.788			
DL4		0.790			
IC1			0.890		
IC2			0.848		
IC3			0.863		
SAP1				0.888	
SAP2				0.819	

SAP3	0.823	
TI1		0.880
TI2		0.926

4.1.2 Discriminant Validity

Discriminant validity was assessed using the Fornell-Larcker criterion and Heterotrait-Monotrait (HTMT) ratio. However, Table 5 shows that in all constructs, we found that the square root of AVE is higher than the correlations with other constructs, showing discriminant validity.

Table 5: Heterotrait-monotrait ratio (HTMT) - Matrix

	Access to Digital Devices	**Digital Literacy**	**Internet Connectivity**	**Student Academic Performance**	**Technological Infrastructure**
Access to Digital Devices					
Digital Literacy	0.339				
Internet Connectivity	0.350	0.349			
Student Academic Performance	0.428	0.473	0.454		
Technological Infrastructure	0.216	0.352	0.176	0.376	

The square root of AVE for Access to Digital Devices (0.831) is higher than its correlation with Digital Literacy (0.291). All HTMT ratios were below the threshold of 0.90 in **Table 6** for further discriminant validity evidence.

Table 6: Fornell-Larcker criterion

	Access to Digital Devices	**Digital Literacy**	**Internet Connectivity**	**Student Academic Performance**	**Technological Infrastructure**
Access to Digital Devices	0.829				
Digital Literacy	0.291	0.818			
Internet Connectivity	0.300	0.297	0.867		
Student Academic Performance	0.357	0.392	0.376	0.844	
Technological Infrastructure	0.180	0.293	0.146	0.297	0.903

4.1.3 Common Method Bias (CMB)

In order to deal with the problem of standard method bias (CMB), Harman's single-factor test and the standard latent factor test were performed (Al Ramahi et al., 2024). Harman's test yielded that five factors accounted for 85.64% of the variance, with the first accounting for just 38.44%, well short of the critical threshold of 50%. In addition, these values summarize that the common latent factor approach did not find differences in standardized regression weights, which suggests that CMB is unlikely to have influenced the findings. The detailed measurement model is presented in Figure 2 below.

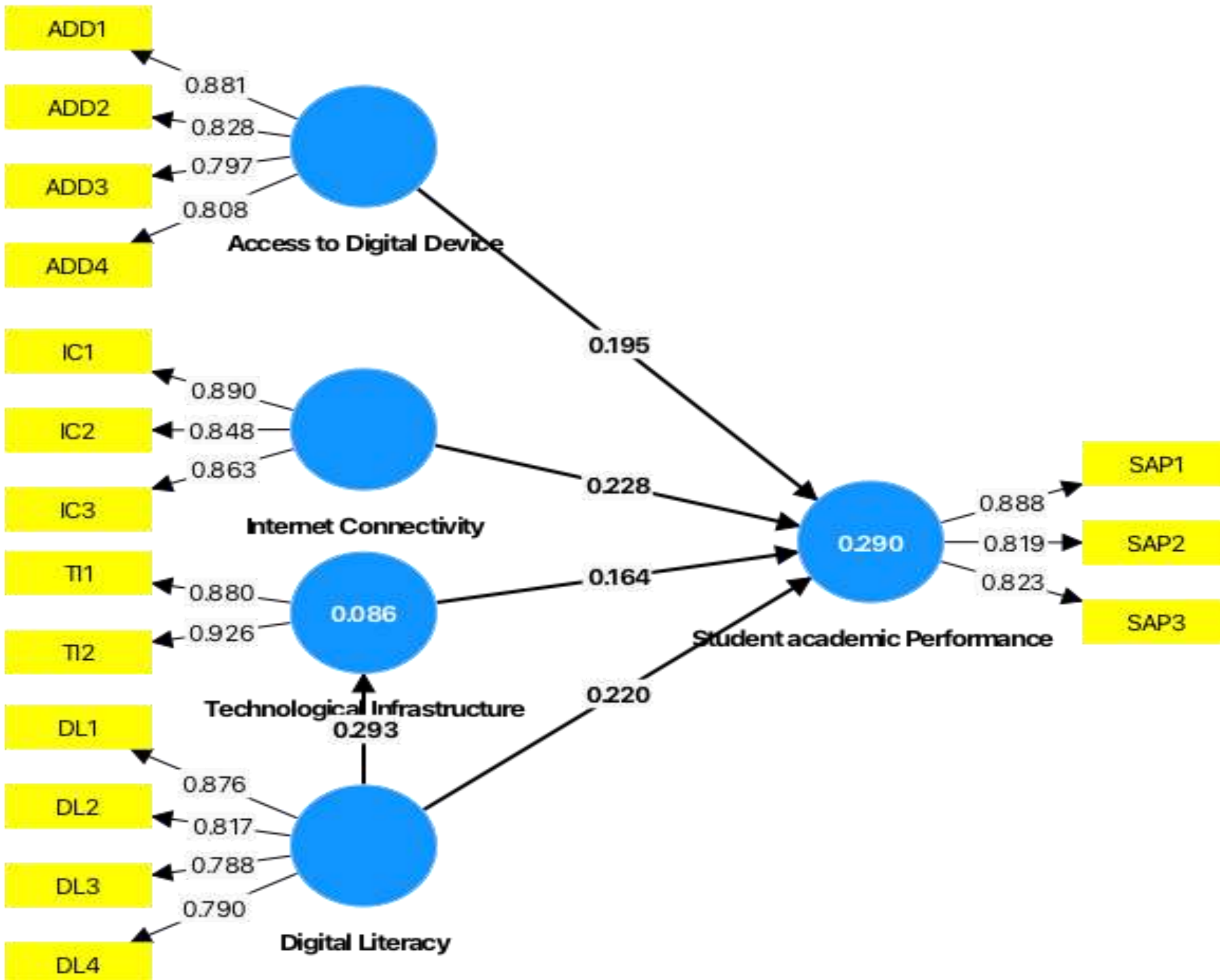

Figure 2: Measurement Model

4.2 Structural equation modelling

4.2.1 Model fit and collinearity

The model was checked for multicollinearity using values of variance inflation factors (VIF). There was no evidence of multicollinearity because each VIF value was still within the recommended range. So, the regression coefficients stay stable and the selected predictors are proven to be independent. It was determined that the constructs were reliable and valid and so the hypotheses were investigated using the structural model (Hair et al., 2019). Tables 7 lists the Variance Inflation Factor (VIF) used to identify multicollinearity. All constructs were free from collinearity as indicated by the VIF scores less than 5. According to the values given, VIF showed that ADD1 had a VIF of 2.728 and DL1 had a VIF of 2.669, so the predictor variables were not correlated.

Table 7: Collinearity statistics (VIF)

Items	VIF
ADD1	2.728
ADD2	1.902
ADD3	1.776
ADD4	1.776
DL1	2.669
DL2	1.689
DL3	1.799
DL4	1.741
IC1	2.492
IC2	1.894
IC3	1.874
SAP1	2.184
SAP2	1.626
SAP3	1.696
TI1	1.673
TI2	1.673

4.2.2. Structural Model

The structural model and its parameters were assessed using Partial Least Squares Structural Equation Modeling (PLS-SEM) through Smart PLS. The relationships and the overall model fit were analyzed to see if they hold. The path coefficients, t statistics, and p values for the relationships between constructs are listed in Table 8.

We tested the hypothesized relationships, and all were statistically significant, $p < 0.001$, with strong support for the proposed model. For example, Access to Digital Devices was positively associated with Student Academic Performance (H1: Increasing access to digital devices improves students' academic performance with $\beta = 0.195$ and $t = 5.450$, $p < 0.001$). Similarly, Digital Literacy was found to have a direct positive impact on Student Academic Performance (H2: Results provide significant support that higher levels of digital literacy increase academic success ($\beta = 0.220$, $t = 6.565$, $p < 0.001$).
Internet Connectivity also positively influenced Student Academic Performance (H3: ($\beta = 0.228$, $t = 6.361$, $p < 0.001$)). This confirms that access to a reliable internet is a critical foundation of educational activities. Technological infrastructure significantly positively affected Student Academic Performance (H4: This suggests how institutional support can support digital learning ($\beta = 0.164$, $t = 4.776$, $p < 0.001$). Table 8 shows the path coefficients of the study.

Table 8: Path coefficients

Relationships	Original sample (O)	T statistics (|O/STDEV|)	P values
H1: Access to Digital Device -> Student Academic Performance	0.195	5.450	0.000
H2: Digital Literacy -> Student Academic Performance	0.220	6.565	0.000
H3: Internet Connectivity -> Student Academic Performance	0.228	6.361	0.000
H4: Technological Infrastructure -> Student Academic Performance	0.164	4.776	0.000
H5: Digital Literacy -> Technological Infrastructure	0.293	7.994	0.000
H6: Digital Literacy -> Technological Infrastructure -> Student Academic Performance	0.048	4.201	0.000

Furthermore, the results revealed that Digital Literacy positively affects Technological Infrastructure (H5: A (a) = $\beta = 0.293$, $t = 7.994$, $p < 0.001$). The implication is that students with higher digital literacy are more likely to use and integrate technological resources more effectively than their peers. The mediating effect of Technological Infrastructure on the relationship between Digital Literacy and Student Academic Performance was also significant (H6: The results indicate that technological infrastructure effectively serves as a critical bridge amplifying the impacts of digital literacy on academic performance ($t = 4.201$, $p < 0.001$; $\beta = 0.048$). The detailed structural model is presented in Figure 3.

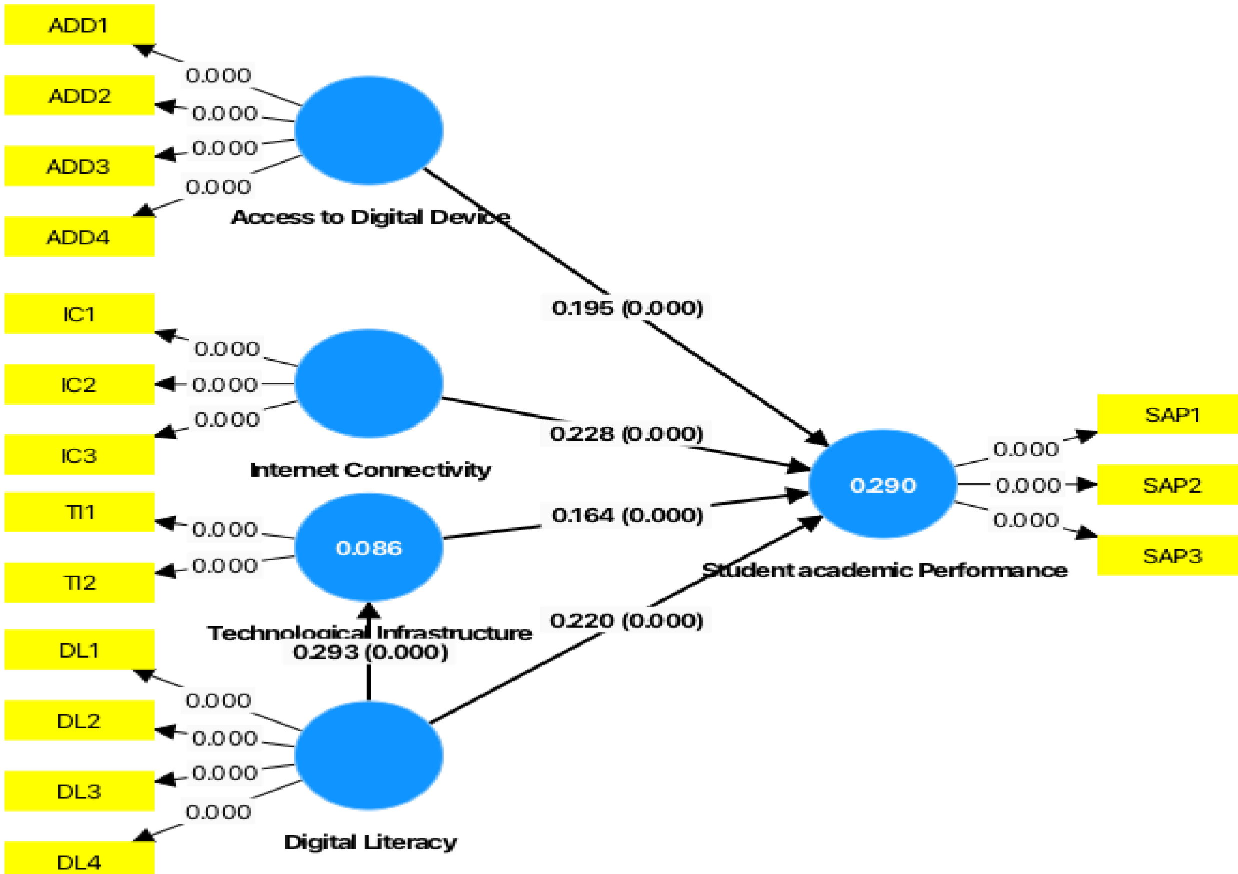

Figure 3: Structural model

5. Results and Discussions:

The aim of this study was to explore how things like Digital Devices, Digital Skills, Internet and Infrastructure affected Student Academic Performance using the Unified Theory of Acceptance and Use of Technology (UTAUT) as its framework. This research mainly looked at data using the Partial Least Squares Structural Equation Modeling (PLS-SEM) and proved that all the hypothesized relationships hold true for bridging the digital divide in educational settings. Having access to digital devices was linked in a positive way with better academic performance ($\beta = 0.195$, $t = 5.450$, $p < 0.001$), meaning that students need digital devices to excel in school-related activities. The same has been discovered in other recent studies (Vigdor et al., 2014; Warschauer et al., 2004), that giving everyone fair access to technology helps reduce educational differences. If children have few or no electronic devices, they often fall behind in digital learning which adds to the digital divide problem. Easy access to personal devices makes it possible for students to learn by themselves, attend to their lessons as required and interact with information online which all play a part in increasing their grades (Zhang et al., 2025). Skills in digital literacy were associated with effective academic performance amongst students ($\beta = 0.220$, $t = 6.565$, $p < 0.001$), proving that only knowing how to use technology is not enough and students must also be able to use IT well to benefit from technology. This aligns with prior research emphasizing the role of digital competencies in enhancing students' learning experiences (Tang & Chaw, 2016). Digital literacy encompasses more than basic operational skills it involves critically evaluating, creating, and communicating using digital platforms. Students who are digitally literate can engage in higher-order learning tasks, such as problem-solving and research, thereby achieving better academic results (Belshaw, 2012). Furthermore, digital literacy empowers students to become self-directed learners, capable of independently accessing and synthesizing information, a quality that is particularly important in today's rapidly evolving knowledge economy (Livingstone & Helsper, 2007). Internet connectivity and academic performance: Another key finding was the significant positive effect of Internet Connectivity on Student Academic Performance ($\beta = 0.228$, $t = 6.361$, $p < 0.001$).

This supports the argument made by Van Deursen and Van Dijk (2014) that digital inequality extends beyond device access to include the quality and consistency of internet access. Inadequate connectivity limits students' access to real-time digital content and affects their ability to participate in collaborative learning environments, access cloud-based tools, and engage in multimedia-based education. With education increasingly relying on synchronous and asynchronous online learning platforms, uninterrupted internet access is now a critical factor in student success (Coleman, 2021). This result confirms the need to prioritize digital infrastructure improvements in educational policies to ensure equity and inclusion, especially in rural or underserved areas. Technological infrastructure and academic performance: Technological infrastructure also significantly influenced Student Academic Performance ($\beta = 0.164$, $t = 4.776$, $p < 0.001$. The study supports research that points out that digital tools succeed only when placed in a supportive and technologically strong environment (Afzal et al., 2023). Using simple software, having IT support, having tools for online learning and access to digital information makes digital education better for everyone. The fact that schools and universities benefit from this relationship demonstrates the need for a good digital environment to use educational technologies fully. In addition, institutions help reduce the structural barrier that keeps some groups from accessing digital services(Cheshmehzangi et al., 2023).

Digital Literacy helps build Technological Infrastructure and Technological Infrastructure also helps Digital Literacy ($\beta = 0.293$, $t = 7.994$, $p < 0.001$). This matches the argument by Okello et al. (2020), who said that when institutions build digital competence, they use technology more smoothly and effectively. As digital technology users want access to advanced applications, institutions are encouraged to make their services better and more advanced. Because of this, an environment is formed where human and technology work together to provide for learning. The study showed that Technological Infrastructure acted as a mediator in how Digital Literacy influenced Student Academic Performance ($\beta = 0.048$, $t = 4.201$, $p < 0.001$). It means digital literacy affects performance by both direct and indirect means, through its impact on digital literacy and on using new technology. The findings support the view put forward by (Sulianta et al., 2024), who stated that digital engagement depends on individual capabilities and the environment. Performance in school is improved when students and the infrastructure are prepared for digital work. This means that equipping schools with better technology can help students who are taught digital skills make greater educational progress (Jamil & Muschert, 2024).

All taken together, these results tell us that the digital divide has several dimensions. Previously, much of the talk about the digital divide concentrated on access (first-level divide), but now it is being suggested that skills and usage (second-level divide) and outcomes (third-level divide) are also very important (Chetty et al., 2018). It adds to the on-going discussion by demonstrating that access, skills, infrastructure and connectivity combine to affect educational results. Since these constructs are closely linked, it is clear that more is needed than only supplying hardware such as training people to use technology and building capacity within organizations. The paper agrees that Access to Digital Devices, Digital Literacy, Internet Connectivity and Technological Infrastructure play a role in Student Academic Performance. Studies suggest that Technological Infrastructure helps mediate between digitally skilled schooling and better academic results. All in all, the outcomes of these studies matter and can help provide better education and positive digital change across the world.

6. Conclusion:

The goal of this study was to see how Access to Digital Devices, Digital Literacy, Internet Connectivity and Technological Infrastructure affect Student Academic Performance, based on the Unified Theory of Acceptance and Use of Technology (UTAUT). Among the 319 Polish university students, researchers used Partial Least Squares Structural Equation Modeling (PLS-SEM) to test the hypotheses and these revealed that each construct is significantly related to academic performance. Students can use digital tools to learn and having strong digital literacy allows them to engage with them properly. With strong and reliable internet, accessing online materials and group projects becomes much easier and having a dependable technological system gives support to digital classes. Importantly, better technology at school helps students use digital literacy effectively, allowing them to do better in their studies. The findings point out that access, skills and infrastructure are all important parts of the digital divide needed for fair education. The study mentions that merely giving access to devices and the internet is useless, students require digital skills and institutions should focus on providing comfortable and safe learning environments. From this, educational institutions and policy makers should now focus on ways to improve devices, internet access, digital skills and school infrastructure to create a fair education system for all. Nevertheless, because the study looked only at Polish university students, it cannot be applied in all places. With this kind of design, you cannot always make strong claims about causation. Future studies might examine these connections across different environments and include things such as motivation and teaching quality, to learn more about how digital education influences learning. After understanding these limits, people can work towards real changes that give everyone equal opportunities to use technology for success.

6.2 Theoretical implications

In this study, we unify the key constructs of the Unified Theory of Acceptance and Use of Technology (UTAUT) and apply them to student academic performance. The findings add empirical support for the role of digital literacy and infrastructure in enabling educational success in the digital era. In addition, this study discusses technological infrastructure as a mediating variable in explaining the relationships between digital skills and explicit academic outcomes.

6.3 Practical implications

This study has implications for educational institutions and policymakers. For students to gain good grades in their studies, institutions should now invest in digital infrastructure and encourage educational programs with digital literacy content. Access to digital devices and reliable internet connectivity must be equally available for an inclusive learning environment. In addition, policymakers should work to narrow the digital divide by encouraging projects that increase technology access for underserved populations.

6.4 future research and limitations

This study has several limitations. The sample was drawn from students in only one geographic region, limiting the generalizability of the findings. Future research in other cultural and educational contexts should explore the relationships between these areas. Third, the cross-sectional study design does not allow for any causal inferences. Longitudinal studies are recommended to establish causality. Finally, future models could include more factors, such as individual motivation and teaching quality, to make a more complete picture of what drives academic performance in the digital age.

Acknowledgements: We express our sincere gratitude to the **University of Economics, Katowice**, and the School of International Business, **Hainan University**, for their institutional support and resources that facilitated this research. We also thank our colleagues and research assistants for their valuable feedback and assistance during the study. Special appreciation goes to the participants who generously contributed their time and insights, making this work possible. This research received no specific funding from any agency in the public, commercial, or not-for-profit sectors.

Author contributions: Jakub Kubiczek: Conceptualization, writing the original draft. **Jakub Kubiczek**: variable construction and methodology. **Sirab Ali**: supervision, funding acquisition. **Jakub Kubiczek**: formal analysis, data handling. **, Sirab Ali** Writing review and editing. All authors have read and agreed to the published version of the manuscript.

Ethical Statement: This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The research protocol was reviewed and approved by the Ethics Committee of the University of Economics, Katowice and the Research Ethics Board of Hainan University. All procedures were designed to ensure the protection of participants' rights, privacy, and confidentiality. No personal data was collected without consent, and all data were anonymized during analysis to prevent identification of individuals.

Consent to Participate: All participants in this study provided informed consent prior to their involvement. Participants were fully informed about the study's purpose, procedures, potential risks, and benefits, and were assured that participation was voluntary with the right to withdraw at any time without consequence. Written consent was obtained from each participant, and copies of the consent forms are securely stored in accordance with institutional data protection policies at the University of Economics, Katowice, and Hainan University.

Competing Interests: No conflict of interest

Grant/Funding information: The Author declared that no grants supported this work.

Data Availability Statement: Data availability on request form corresponding author

Declaration Statement of Generative AI: Author is declared for not using AI during preparation of this study

REFERENCES

Afzal, A., Khan, S., Daud, S., Ahmad, Z., & Butt, A. (2023). Addressing the digital divide: Access and use of technology in education. *Journal of Social Sciences Review*, *3*(2), 883-895. http://dx.doi.org/10.54183/jssr.v3i2.326

Al Ramahi, J. W., Sharqawi, L., Sarah, A.-N., Awwad, E., Al-Obaidi, H. M., Mohammad, A. H., Nofal, S., Al-Janabi, D. R., Zuhair, I., & Al-Masaeid, H. J. (2024). Portraying Diabetic Foot Ulcers: Comparative Evaluation of Diabetic Foot Infections versus Diabetic Foot Ulcers. *Advances in Infectious Diseases*, *14*(2), 297-309. http://dx.doi.org/10.4236/aid.2024.142022

Bachtiar, B. (2024). Insights into Classroom Dynamics: Indonesian EFL Teachers' Self-Efficacy in Instruc-tional Strategies. *Jurnal Basicedu*, *8*(1), 837-848. https://doi.org/10.31004/basicedu.v8i1.7208

Belshaw, D. (2012). *What is' digital literacy'? A Pragmatic investigation* Durham University].

Berhanu, K., & Raj, S. (2024). The role of social media marketing in Ethiopian tourism and hospitality organizations: Applying the unified theory of acceptance and use of technology model. *Cogent Social Sciences*, *10*(1), 2318866. http://dx.doi.org/10.1080/23311886.2024.2318866

Cheshmehzangi, A., Zou, T., Su, Z., & Tang, T. (2023). The growing digital divide in education among primary and secondary children during the COVID-19 pandemic: An overview of social exclusion and education equality issues. *Journal of Human Behavior in the Social Environment*, *33*(3), 434-449. http://dx.doi.org/10.1080/10911359.2022.2062515

Chetty, K., Qigui, L., Gcora, N., Josie, J., Wenwei, L., & Fang, C. (2018). Bridging the digital divide: measu-ring digital literacy. *Economics*, *12*(1), 20180023. http://dx.doi.org/10.5018/economics-ejournal.ja.2018-23

Coleman, T. (2021). Digital divide in UK education during COVID-19 pandemic: Literature review. https://doi.org/10.17863/CAM.110826

Gordon, J. A., Balta-Ozkan, N., & Nabavi, S. A. (2024). Towards a unified theory of domestic hydrogen acceptance: an integrative, comparative review. *International Journal of Hydrogen Energy*, *56*, 498-524. http://dx.doi.org/10.1016/j.ijhydene.2023.12.167

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European business review*, *31*(1), 2-24. http://dx.doi.org/10.1108/EBR-11-2018-0203

Hanif, H., Kurniawati, K., & Rizki, D. (2024). Empowering Efl Learners: The Impact Of Digital Literacy In Bl-ended English Language Teaching Method. *Berajah Journal*, *4*(3), 761-770. http://dx.doi.org/10.47353/bj.v4i3.382

Hanif, S., Bibi, S., & Gul, F. (2023). Effect of Academic Self-efficacy and Self-esteem on Students' Academic Achievement in Low-income Families in Pakistan. *Journal of Contemporary Trends and Issues in Education*, *2*(3), 23-38. https://doi.org/10.55628/jctie.v3i1.73

Huang, X. (2023). On the Strategies of Cultivating Higher Vocational Students' Sense of Self efficacy in English Learning. *International Journal of Education and Humanities*, *6*(3), 98-101. https://doi.org/10.54097/ijeh.v6i3.4332

Iskender, A., Sirakaya-Turk, E., Cardenas, D., & Hikmet, N. (2024). Restaurant patrons' intentions toward QR code menus in the US during COVID-19: acceptance of technology adoption model (ATAM). *Journal of Foodservice Business Research*, *27*(5), 497-522. http://dx.doi.org/10.1080/15378020.2022.2133518

Jamil, S., & Muschert, G. (2024). The COVID-19 pandemic and E-learning: The digital divide and educa-tional crises in Pakistan's universities. *American Behavioral Scientist*, *68*(9), 1161-1179. http://dx.doi.org/10.1177/00027642231156779

Joseph, O. B., & Uzondu, N. C. (2024). Bridging the digital divide in STEM education: Strategies and best practices. *Engineering Science & Technology Journal*, *5*(8), 2435-2453. http://dx.doi.org/10.51594/estj.v5i8.1378

Kim, S. S., Watkins, E. A., Russakovsky, O., Fong, R., & Monroy-Hernández, A. (2023). " help me help the ai": Understanding how explainability can support human-ai interaction. Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems, http://dx.doi.org/10.1007/s10111-024-00765-7

Kuhn, A., Schwabe, A., Boomgarden, H., Brandl, L., Stocker, G., Lauer, G., Brendel-Kepser, I., & Krause-Wolters, M. (2024). Who gets lost? How digital academic reading impacts equal opportunity in higher education. *new media & society*, *26*(2), 1034-1055. http://dx.doi.org/10.1177/14614448211072306

Kumar, S., Goel, U., Joshi, P., & Johri, A. (2024). Factors affecting Information & Communication Technology (ICT) adoption among MSMEs. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(1), 100205. http://dx.doi.org/10.1016/j.joitmc.2023.100205

Labajová, L. (2023). The state of AI: Exploring the perceptions, credibility, and trustworthiness of the users towards AI-Generated Content. In.

Livingstone, S., & Helsper, E. (2007). Gradations in digital inclusion: Children, young people and the digital divide. *New media & society*, *9*(4), 671-696. http://dx.doi.org/10.1177/1461444807080335

Lybeck, R., Koiranen, I., & Koivula, A. (2024). From digital divide to digital capital: the role of education and digital skills in social media participation. *Universal Access in the Information Society*, *23*(4), 1657-1669. http://dx.doi.org/10.1007/s10209-022-00961-0

Marchewka, J. T., & Kostiwa, K. (2007). An application of the UTAUT model for understanding student perceptions using course management software. *Communications of the IIMA*, *7*(2), 10. http://dx.doi.org/10.58729/1941-6687.1038

Okello, M. K., George, A. N., & Mbotela, K. (2020). An Investigation into Availability of ICT Infrastructure and Adequacy of ICT Technical Personnel for Implementation of Digital Literacy Programme in Public Primary Schools in Waitaluk Division. *Trans-Nzoia County, Kenya*.

Peruzzo, F., & Allan, J. (2024). Rethinking inclusive (digital) education: Lessons from the pandemic to reconceptualise inclusion through convivial technologies. *Learning, Media and Technology*, *49*(2), 244-258. https://doi.org/10.1080/17439884.2022.2131817

Rachmad, Y. E., Bakri, A. A., Nuraini, R., & Nurdiani, T. W. (2024). Application of The Unified Theory of Acceptance and Use of Technology Method to Analyze Factors Influencing The Use of Digital Wallets in Indonesia. *Jurnal Informasi Dan Teknologi*, 229-234. http://dx.doi.org/10.60083/jidt.v6i1.504

Sharif, S. P., Mostafiz, I., & Guptan, V. (2024). A systematic review of structural equation modelling in nursing research. *Nurse researcher*, *32*(2). http://dx.doi.org/10.7748/nr.2018.e1577

Strzelecki, A. (2024). Students' acceptance of ChatGPT in higher education: An extended unified theory of acceptance and use of technology. *Innovative higher education*, *49*(2), 223-245. http://dx.doi.org/10.1007/s10755-023-09686-1

Strzelecki, A., & ElArabawy, S. (2024). Investigation of the moderation effect of gender and study level on the acceptance and use of generative AI by higher education students: Comparative evidence from Poland and Egypt. *British Journal of Educational Technology*, *55*(3), 1209-1230. http://dx.doi.org/10.1111/bjet.13425

Sulianta, F., Rumaisa, F., Puspitarani, Y., Violina, S., & Rosita, A. (2024). Developing An It Infrastructure Model For Enhancing Digital Literacy Through Web-Based Learning: A Comprehensive Framew-ork. *JIKO (Jurnal Informatika dan Komputer)*, *7*(3), 182-186. http://dx.doi.org/10.33387/jiko.v7i3.8761

Tang, C. M., & Chaw, L. Y. (2016). Digital Literacy: A Prerequisite for Effective Learning in a Blended Learning Environment? *Electronic Journal of E-learning*, *14*(1), 54-65.

Tavakol, M. (2017). The reliability of assessments: the Bayesian Cronbach's alpha. *Medical teacher*, *39*(5), 561-561. http://dx.doi.org/10.1080/0142159X.2017.1296121

Valadez, J. R., & Durán, R. P. (2007). Redefining the digital divide: Beyond access to computers and the Internet. *The High School Journal*, *90*(3), 31-44. http://dx.doi.org/10.1353/hsj.2007.0013

Van Deursen, A. J., & Van Dijk, J. A. (2014). The digital divide shifts to differences in usage. *New media & society*, *16*(3), 507-526. http://dx.doi.org/10.1177/1461444813487959

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478. http://dx.doi.org/10.2307/30036540

Vigdor, J. L., Ladd, H. F., & Martinez, E. (2014). Scaling the digital divide: Home computer technology and student achievement. *Economic inquiry*, *52*(3), 1103-1119. http://dx.doi.org/10.1111/ecin.12089

Vysochan, L., Koziar, M., Stelmah, N., & Vasylyuk-Zaitseva, S. (2024). Digital transformation in education: Using technologies for enhancement of efficiency of teaching. *Futurity Education*, *4*(1), 186-209. https://doi.org/10.57125/FED.2024.03.25.10

Warschauer, M., Knobel, M., & Stone, L. (2004). Technology and equity in schooling: Deconstructing the digital divide. *Educational policy*, *18*(4), 562-588.

Zhang, T., Li, Z., & Qi, Y. (2025). Research on digital literacy literature: Topic mining and evolutionary an-alysis. *Journal of Librarianship and Information Science*, 09610006241309645. http://dx.doi.org/10.1177/09610006241309645

Zhao, X., & Qian, Y. (2024). Does digital technology promote green innovation performance? *Journal of the Knowledge Economy*, *15*(2), 7568-7587. http://dx.doi.org/10.1007/s13132-023-01410-w

Zimu, Y. (2024). Examining the Relationship between Teacher Self-Efficacy and Student Engagement in Technology-enhanced Learning Environments. *development*, *6*(2), 115-119. http://dx.doi.org/10.2991/978-94-6463-380-1_29

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations or the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim made by its manufacturer, is not guaranteed or endorsed by the publisher