

Digital economy development and higher education spillovers in Algeria

Hammache Souria

Mouloud Mammeri University of Tizi-Ouzou (Algeria),
souria.hammache@ummto.dz

Received: 09/02/2025

Accepted: 25/03/2025

Published: 25/05/2025

Abstract:

This study examines the relationship between higher education and technological development in Algeria, in particular its role in the country's successful digital transition. We carried out an empirical study, covering the period from 2000 to 2024. The analysis relies on multiple regression methods to assess the impact of higher education on the digital economy development. The results show that, although of Algeria's considerable progress in the development of higher education, challenges remain, particularly in terms of matching training to the needs of the digital labor market. It suggests that educational reforms and ongoing modernization of the education system are needed to fully support Algeria's digitalization strategy. The digital transition cannot be achieved without accelerating investment in digital infrastructure, and improving the regulatory framework to stimulate innovation.

Keywords: Digital development; Higher Education; Digital skills; Digital transition ; Algeria.

JEL Classification Codes: I23, I25, I28

Corresponding author: Hammache Souria, e-mail: souria.hammache@ummto.dz .

1. INTRODUCTION

The relationship between education and economic digitization is highly complementary and interdependent. Higher education plays a central role in the technological development and digital transformation of today's economies. In Algeria, this sector represents a strategic pillar for supporting innovation, strengthening digital skills and accelerating the transition to a digitized economy. As the country aims to diversify its economy and reduce its dependence on hydrocarbons, the integration of digital technologies appears to be an essential priority for improving productivity, fostering entrepreneurship and boosting global competitiveness.

Today, the advancement of ICT has led businesses towards knowledge-driven growth and development. Consequently, adapting the workforce to the new requirements is becoming a strategic issue to succeed the digital transition. The new skill set needs to meet the demands of the new digital age, by mastering digital skills. The rapid evolution of information and communication technologies (ICT) has transformed the demands of the job market and reinforced the need for a higher education system capable of producing qualified graduates in fields such as artificial intelligence, big data, cybersecurity and e-commerce. In Algeria, although progress has been made, notably with the expansion of universities and the introduction of ICT-focused programs, challenges remain in terms of matching university training to the needs of the digital marketplace, (Morgan, A and al, 2022). The success of the digital transition largely depends on the ability of the education system to overcome structural obstacles, such as a lack of technological resources, insufficient in-service training for teachers and the absence of strong synergies between universities and businesses.

This study analyzes the extent to which higher education in Algeria contributes to the country's technological development and digitalization strategy. It also explores the challenges and opportunities associated with this transformation, while examining the impact of educational reforms on digital competitiveness. Then, the focus of this research is to determine the importance of education, particularly higher education, in the digitization

process and in the development of ICT in Algeria. It is widely accepted that education is a major factor in the success of a wealth-creating digital transition; however, the rapid development of technology with the arrival of AI, data management, clouding, machine learning, etc., has called into question traditional education as provided by universities today. The core objective of this study is to determine whether higher education in Algeria plays a role in fostering technological development. To assess the impact of higher education on Algeria's digitization policy, we carried out an empirical study using multiple regression analysis, covering the period from 2000 to 2024. The structure of the article is as follows: it begins with a literature review exploring the relationship between technological development and education, as well as the role of universities in advancing a successful digital strategy. This is followed by a presentation of the empirical model used, and finally, a discussion of the results.

2. Literature review

Digitalization is imposing a radical transformation in higher education. It calls for highly specific profiles and skills. Emerging technologies require mastery of programming, digital design, website development, data analysis and management. Digital technology draws simultaneously on several scientific fields. Traditional training no longer meets the needs of the ongoing digital transformation. Education, especially in higher education, must be deployed in such a way as to integrate digital interfaces, technological hardware, and software and connectivity solutions.

By strengthening education, encouraging lifelong learning, cultivating innovation cultures, supporting youth initiatives, and boosting English proficiency, higher education plays a critical role in economic digitalization by creating a skilled workforce that can propel the digital economy. (Kholiavko Nataliia and al, 2021). In order to develop a skilled workforce to support the rapidly expanding digital economy, education enables rapid, efficient development of the digital transformation process through training students in digital technologies, enhancing the quality of education, and encouraging collaboration between businesses and universities. (Oleksiy.T and al, 2023). Sustainable development depends

highly on education, an important component of the digital economy.

Several studies confirm the complex relationship between higher education and digital economy (Yuqing Geng and al, 2023). Higher education can have a negative or a positive impact on economic digitalization development.

2.1. A positive impact of higher education on digital economy development:

Previous researches proved the existence of a positive correlation between higher education and digital economy. According to Marino and al, (2019), universities can offer training, courses, and internships in the field of digitalization, which will enable the training of high quality, innovative generations which will contribute to the development of the digital economy. Anicic and al., (2022), studied the gap between generic competences and digital competences for employability. They concluded that universities should look for methods to change and modify their procedures so that student graduate with the skills required succeeding in the labor market, especially intensifying digital skills. Another important aspect to mention is relating to research activities; research laboratories foster the emergence of disciplines such as mathematics, physics, biology, computer science and engineering, which in turn encourage innovation and creativity, as well as the emergence of cutting-edge technologies that enable the development of a digital economy. In addition, the university is a breeding ground for innovative ideas transformable into lucrative projects and products. Technological innovation coming out of higher education tends to affect productivity growth and economic development. (Kong D.M and Zhang J, 2022).

2.2. A negative impact of higher education on digital economy development:

According to World Economic Forum (2019), over 37% of European workers, lack even the most fundamental digital skills, especially specific skills company's needs to implement a successful digital transition. Higher education programs focus on theoretical knowledge over the practical skills such as data analysis, or digital marketing or coding; this creates a gap

where students oriented to labor market lack the digital competencies required in nowadays-modern economy. According to the same source, 92% of jobs require digital skills, yet the not well-trained workforce does not possess the necessary skills required by the economy. This situation is mainly due to outdated and obsolete curricula, (World Economic Forum, 2019). Higher education institutes propose programs, which let students unprepared for the rising industries driven by AI, cloud computing, and machine learning. Van Deursen, A. J., & Van Dijk, J. A. (2014), highlighted in their research, the existence of a digital divide within developing countries. Many students in these countries lack the access to digital tools for an efficient learning. According to the authors, the digital divide is not just about access, but also about the skills needed to participate in the digital economy. Low-income countries remain at a disadvantage due to educational gaps. The digital skills gap exacerbate disparities in the economic benefits derived from digitization, (UNESCO, 2021).

3. Higher education and digital development in Algeria

Algeria has put in place a comprehensive strategy for the digitalization of the higher education sector. The digitization of higher education institutions has led to the introduction of digital platforms such as Progress, which manages the submission of doctoral theses and the professional careers of teaching and administrative staff, and the innovation platform, which manages innovative student projects and startups; the ASJP platform brings together all Algerian journals, enabling authors to publish their researches. The aim of this massive digitization is to promote data collection, transparency and reinforce the international visibility of Algerian universities. Nevertheless, the digitization of higher education establishments faces a number of challenges: the lack of modern infrastructures capable of absorbing these new technologies, administrative restrictions and slowness, legal adjustments and a lack of technical skills. Algeria has made progress in terms of digital infrastructure, ensuring broad internet coverage, investing in 4G and fiber optics, and supporting innovative initiatives by setting up a start-up financing fund. Nevertheless, technical and digital skills are in short supply. Freshly created start-ups are struggling to find qualified skills to meet their needs, which is significantly

slowing down their development. The lack of these specialized skills weakened the digital ecosystem in Algeria. (Dahimet A, Baroudi, M, 2022). ICT talents are scarce, and universities do not cover market needs, (Digital Arabia Network, 2020). According to Romi. M (2024), Algerian students have satisfactory digital skills, but advanced digital skills are in short supply. e.g., skills in educational digital problem solving, data processes skills, digital security skills, application development, database management systems, augmented reality, Block chain technology, and IA applications. This situation is illustrated in the table 1, which indicates the NRI score and rank of Algeria.

Table 1: Network Readiness Index (NRI) of Algeria (Rank/Score)

	2021	2023	2024
NRI Rank	94	103	100
NRI Score	38,95	37,92	39,24
Technology	100	101/49,33	85/36,32
People	90	95/35	71/40,24
Governance	120	112/27,82	109/41,07
Impact	90	90/21,43	119/39,34

Source : NRI data base : <https://networkreadinessindex.org/>

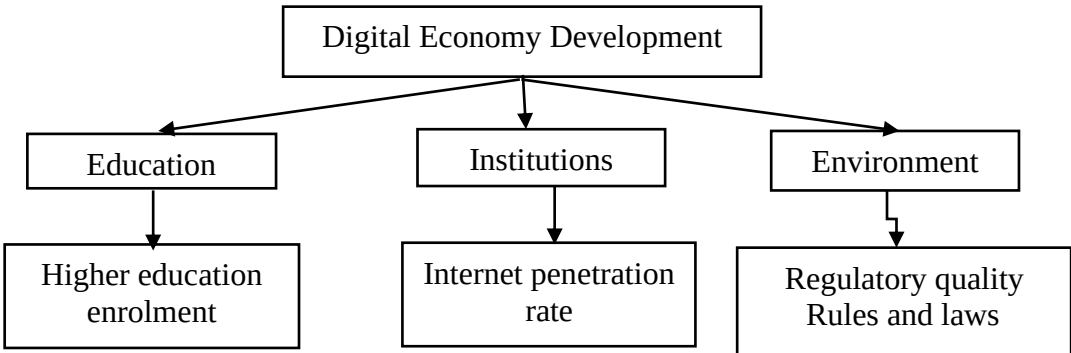
Overall, Algeria has made progress in terms of access to technology, but is still lagging behind the rapid developments in the digital sector. Infrastructures are still basic, and financial accessibility limits further access. In terms of governance, confidence in the digital system is very limited. The population is still reluctant to engage in digital transactions, for example, preferring to use cash instead of electronic transactions. Economic impact remains very low, with slow progress in terms of economic productivity. In addition to that, digital literacy rates remain low, with limited integration of ICT in educational and business contexts.

4. Research methodology

To identify the impact of higher education on the digitization policy of Algerian economy, we conducted an empirical study based on multiple regression, covering the period from 2000 to 2024.

Three components are considered in this research (figure 1). Digital transformation depends on three main factors. Institutional factors, factors relating to education and innovation, and finally, factors relating to the environment. The institutional factor refers to the availability of modern infrastructures capable of absorbing the emergence of technology: for example, data centers availability, and internet widespread. Education is another key factor in the development of the digital economy. Technical skills, a high-level education and the proliferation of a university-educated generation increase the chances of a successful digital transition. This transition cannot take place without a serene environment that guarantees a stable legal environment, and a business environment that encourages innovation and entrepreneurship. In the digitalization context, the regulatory quality is highly important. It measures the ability of the government to implement an efficient digital policy, and the ability to ensure the implication of the private sector in the economic digital transformation process. The theoretical framework in this study is presented in figure 1.

Fig.1.: Theoretical framework



Source: Author

The equation to estimate is:

$$ICTDI_t = \beta_0 + \beta_1 EDUCATION + \beta_2 GDPper_t + \beta_3 IPR_t + \beta_4 RQ_t + \beta_5 RL_t + \varepsilon_t$$

Where:

ICTDI: ICT development index is the dependent variable, the data is from international telecommunication union database. The score is from zero weak ICT development index, to 10 high ICT development index, which refer to a high degree of digitalization integration.

EDUCATION: Tertiary education enrolment, refer to the percentage of student enrolled in tertiary education; the data is from World Bank database.

GDPper: GDP per capita, is a control variable. It refers to a country GDP, divided to the population, data is from World Bank.

IPR: Internet penetration rate measures the degree of internet penetration. The data is in percentage. The data source is from the Global Digital Insight.

RQ: Regulatory quality refers to the ability of the government to implement policies that promote private sector. The source of data is World Bank database.

RL: Rules and laws measures in which extent the population has the confidence on the rules and laws system. The score is between -2.5 to 2.5. The data is from World Bank.

5. Descriptive statistics

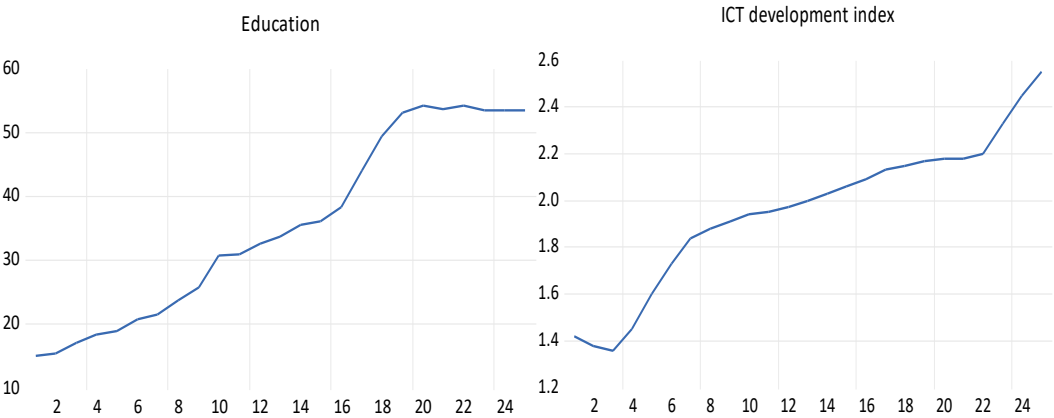
The table 2 indicates the descriptive statistics of the variables.

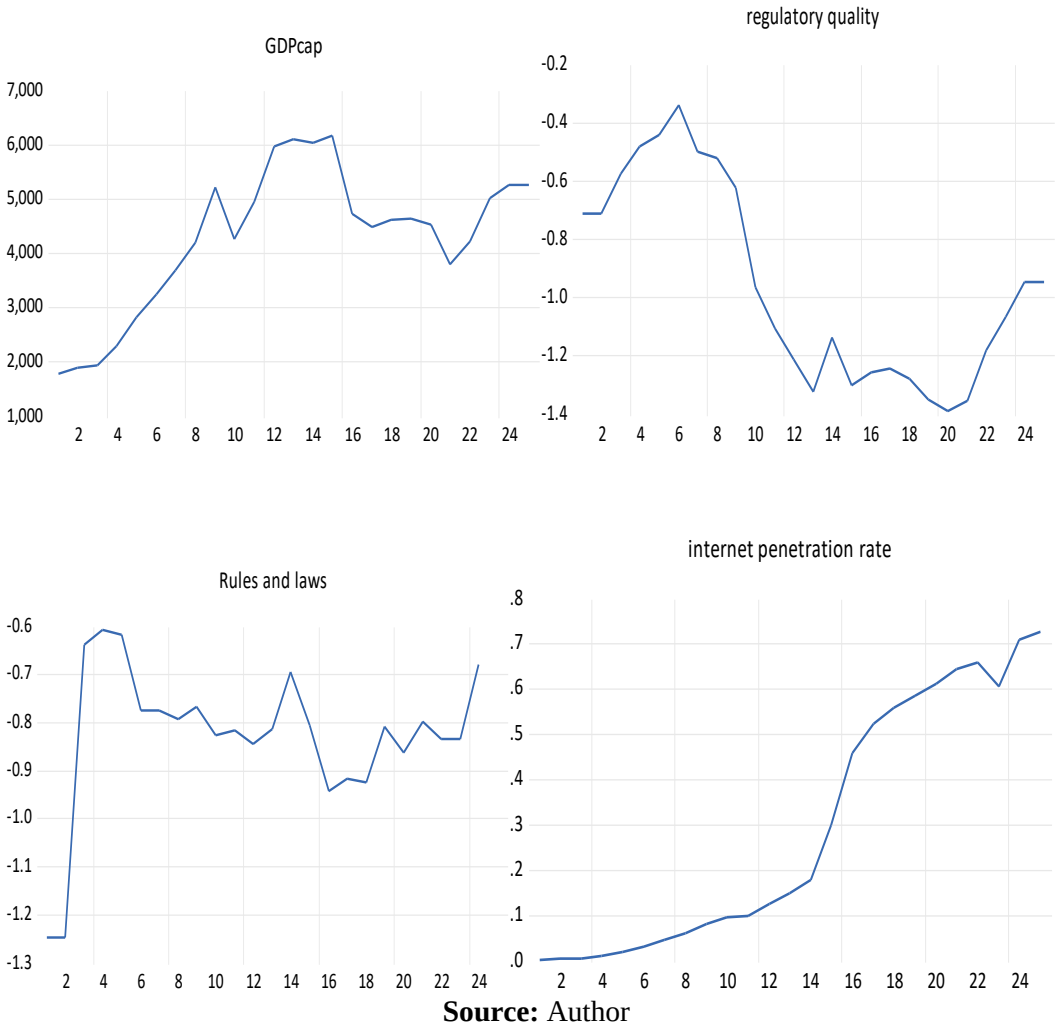
Table 2: Descriptive statistics

	ICTDI	EDU	GDPper	RQ	RL	IPR
Mean	1.9580	35.3444	4286.46	-0.9584	-0.8211	0.2918
Median	2.0000	33.7081	4530.10	-1.0635	-0.8069	0.1500
Maximum	2.5500	54.2099	6167.64	-0.3415	-0.6053	0.7290
Minimum	1.3600	15.000	1780.37	-1.3883	-1.2458	0.0010
Std.Dev	0.3212	14.4322	1327.32	0.3445	0.1563	0.2763
Skewness	-0.4030	0.0895	-0.5135	0.3899	-1.3774	0.3680
Kurtosis	2.5388	0.089	2.3403	1.6479	5.2079	1.3927
Jarque-Berra	0.8983	2.2829	1.5521	2.5378	12.9841	3.2552
Probability	0.6381	2.2829	1.5521	0.2811	0.0015	0.1963
Sum	48.9500	833.6112	107161.7	-23.9605	-20.5296	7.2960
Observation	25	25	25	25	25	25

The minimum value of the ICT development variable is 1.36 in 2002, and the maximum value is 2.55 in 2024 indicating an improvement in technology development in Algeria. Nevertheless, this places Algeria in the moderate to significant ICT development category, but still far from the optimum level of 10. The score shows that Algeria has made significant progress, but there are still challenges to be met in order to achieve higher levels of ICT development. The variables appear globally heterogeneous in terms of distribution, asymmetry and concentration. The “Rules and laws” variable stands out for its strong deviation from normality (Jarque-Bera significant). “GDP per capita” and ‘Internet penetration’ show strong variability, suggesting a marked dispersion between observations. Figure 2 highlights the evolution of the variables of the model. As we can see, the ICT development index has been trending upwards, indicating a growing adoption of technology in Algeria. For the education variable, we also note the same upward trend in the rate of enrolment in higher education establishments, although the percentage stabilized from 2018 onwards.

Fig .2: Graphic presentation of the variables





GDP per capita experienced steady growth until 2014. However, the oil crisis and the decline in revenues from hydrocarbon exports led to a sharp decrease, which persisted until 2021. In 2022, GDP per capita rebounded, marking a return to growth. The negative values of regulatory quality variable indicate a poorly conceived and arbitrarily applied policies, and low institutional capacity to regulate effectively in Algeria. The same applies to the rules and laws variable: negative values indicate an unstable legal and regulatory environment. Regarding the Internet penetration rate, the upward trend points to very appreciable Internet coverage in the country, reaching 73% of the population by 2024.

Table3: Correlation matrix

	ICTDI	Education	GDPper	RQ	RL	IPI
ICTDI	1					
Education	0.9140	1				
GDPper	0.7651	0.5705	1			
RQ	-0.6552	-0.7645	-0.6369	1		
RL	0.2198	0.1220	0.2538	0.1771	1	
IPI	0.8622	0.9660	0.4203	-0.6709	0.0644	1

Source: Author

The table 3 highlights the correlation matrix. The results suggest that there is a very strong, positive relationship between education and ICT development. Better education seems to be a key driver for ICT development in Algeria. GDP per capita (0.7651) is strongly correlated with ICT development; countries with a higher GDP invest more in ICT. For Internet Penetration rate (IPR, 0.8622): Very strong, positive relationship, indicating that ICT development is closely linked to internet access.

6. Empirical results and interpretation

6.1. Stationary:

The table 4 indicates the ADF test result for stationarity. The results suggest that all variables are non-stationary at level, but become stationary after differentiation. This means they are integrated of order 1 (I(1)).

Table 4: Augmented Dickey Fuller Test

Variables	Level		First difference		Result
	t-stat	prob	t-stat	prob	
ICTDI	-1.3289	0.5981	-3.7095	0.0114**	I(1)
Education	-1.0818	0.7049	-0.9042	0.0457	I(1)
GDP per	0.6414	0.8479	-4.1391	0.0002	I(1)
RQ	0.0264	0.6814	-3.4604	0.0014	I(1)
RL	-1.3643	0.1554	-4.6294	0.0001	I(1)
IPR	1.0934	0.9233	-2.4632	0.0163	I(1)

Source: Author

6.2. Regression results and regression:

We note the positive and significant effect of education (tertiary enrolment) in all models: Education has a positive effect on ICT development. A one-unit increase in the “education” variable leads to a direct increase in ICT development from 0.02 (model 1) to 0.012 (model 3). This result underlines the importance of investing in education to promote the adoption and use of ICT in Algeria. Although positive, its impact diminishes slightly in the third model, which could indicate saturation or a need to adapt education to the demands of modern technology. GDP per capita is positively correlated with ICT development, with a coefficient of 0.0001 in all models. This indicates that countries with higher GDP per capita tend to have better ICT development.

Table 5: Regression results

Variables	Model 1	Model 2	Model 3
C	1.0644 (0.0483)***	0.8786 (0.1026)***	1.0280 (0.1296)***
Education	0.0200 (0.0015)***	0.021 (0.0015)***	0.0121 (0.0053)**
GDPper	0.0001 (1.37E-05)***	0.0002 (1.44E-0)***	0.0001 (1.51E-0)***
Regulatory quality	0.3042 (0.0670)***	0.3904 (0.075)***	0.3432 (0.0770)***
Rules and laws		-0.2077 (0.1030)*	-0.1578 (0.1021)
Internet penetration			0.4094 (0.2337)*
R-squared	96.14	96.79	97.23
Normality test JB	0.4402	0.3473	0.2839
LM autocorrelation test	0.060	0.098	0.2055
Breusch-Pagan- Godfrey	0.9288	0.5994	0.8368

Source: Author

This shows the importance of a prosperous economy for Algeria in providing access to costly technologies and advanced digital infrastructure. The quality of regulations has a significant positive influence (coefficients between 0.30 and 0.39). This shows that a well-structured regulatory environment is conducive to ICT development. Clear and effective ICT policies encourage ICT growth in Algeria. The negative coefficient (-0.2077 in model 2 and -0.1578 in model 3) indicates that certain laws or regulations could be holding back ICT development. This could be due to excessive rigidity, administrative barriers or policies that do not adapt to digital innovations in Algeria. Although intuitively important, Internet penetration rate does not stand out as significant in this model. This could indicate shortcomings in digital infrastructure, high access costs, or a lack of connectivity in remote areas. This shows that having access to the Internet is not enough to claim ICT development in the country. It is important to point out that Algeria is lagging behind in terms of 5G or fiber optic connectivity. Concerning the robustness of the model, the residuals are normally distributed, the residuals are homoscedastic, and characterized by the absence of auto-correlation. The R squared is high, in all three models, suggesting that the model has a very good explanatory power.

7. Policy implication

Algeria should invest in ICT-based education and adapt the education system to ICT requirements. Create partnerships between government and technology companies to offer vocational training programs. Encourage universities and research centers to specialize in emerging technologies such as artificial intelligence, cybersecurity and big data. Strengthen the regulatory framework, simplifying and modernizing regulations to encourage investment in ICT. Reform telecommunications and digital trade laws to reduce administrative barriers. Grant tax incentives to local and international companies that invest in digital infrastructure or train local talent. It would also be important to increase connectivity and internet penetration in order to reduce access disparities and make the Internet accessible to a greater proportion of the population, especially in rural areas. To make the digital transition a success, it is important to invest in modernizing digital infrastructures capable of absorbing the new

technologies required. Encourage private companies to participate in the expansion of digital infrastructure through public-private partnerships. Algeria should work on one of the biggest obstacles to technological development: revising restrictive laws: Identify and remove laws that hinder innovation. Ease restrictions on imports of technological equipment or foreign direct investment in ICT.

8. CONCLUSION

This study explores the interactions between education and technological development in Algeria, with a focus on understanding the role of higher education in facilitating the country's digital transition. To address this objective, an empirical analysis was conducted, covering the period from 2000 to 2024. The results clearly suggest that education has a central and vital role to play in the country's technological development. The digitization strategy will not become a reality without the commitment and involvement of higher education establishments. Nevertheless, it is important to stress that Algerian universities should adapt their curricula to the new demands of the access market on more technical skills, train more students in digital skills and broaden training programs on basic and advanced technologies.

Algeria has significant potential to develop ICT, but this requires coordinated efforts on education, connectivity and the regulatory framework. Modernizing its laws and paying greater attention to digital disparities could position the country as a key player in the MENA region's digital transformation.

9. Bibliography List

- Aničić, K.P, Munda G, Šimić, D. (2023). Generic and digital competences for employability—results of a Croatian national graduates survey. *Higher education*, 86(2), 407-427. <http://doi.org/10.1007/s10734-022-00940-7>
- Dahimat, A and Baroudi, M, (2022), an overview on the Algerian national innovation system in the digital era, <https://mpira.ub.uni-muenchen.de/114987/> MPRA Paper No. 114987.
- Digital Arabia Network report, (2020), Digital transformation in Algeria, Assessing Digital Transformation in the country: Overview, challenges and opportunities.

- Dvoryadkina, E. and Efimova, E, (2019). Regional system of professional education in the information society.. <https://doi.org/10.2991/sicni-18.2019.142>
- Glazunova, O, (2023). A methodology for flipped learning in a cloud-oriented environment: enhancing future it specialists' training. *Educational Technology Quarterly*, 2023(3), 233-255. <https://doi.org/10.55056/etq.629>
- Khitskov, E., Veretekhina, S., Medvedeva, A., Mnatsakanyan, O., Shmakova, E., & Kotenev, A, (2017). Digital transformation of society: problems entering in the digital economy. *Eurasian Journal of Analytical Chemistry*, 12(5b), 855-873. <https://doi.org/10.12973/ejac.2017.00216a>
- Kong, D.M, Zhang, B.H, Zhang, J, (2022), Higher education and corporate innovation, *Journal of Corporate Finance.*, 72, p. 31, [10.1016/j.jcorpfin.2022.102165](https://doi.org/10.1016/j.jcorpfin.2022.102165).
- Kholiavk N, Popelo O; Melnychenko A; Derhaliuk, M; Grynevych L, (2022), The role of higher education in the digital economy development, *Revista Tempos e Espaços em Educação*, 15 (34), e16773.
- Marino, O., Gutiérrez, J. A., Aguirre, S, (2019). From digital citizen to digital professional. *Kybernetes*, 48(7), 1463-1477.
- Morgan, A., Sibson, R., & Jackson, D. (2022). Digital demand and digital deficit: conceptualising digital literacy and gauging proficiency among higher education students. *Journal of Higher Education Policy and Management*, 44(3), 258-275.
- Oleksiy T, Kyrchata I; Prykhodko O; Berestiana I, (2023), Prospects for integration of Ukrainian higher education institutions into European education area, *International scientific journal "Internauka". Series: "Economic Sciences"*, <https://doi.org/10.25313/2520-2294-2023-5-8947>
- Oliveira, K. and Souza, R, (2021). Digital transformation towards education 4.0. *Informatics in Education*. <https://doi.org/10.15388/infedu.2022.13>
- Romi, M, (2024), Digital skills impact on university students' academic performance: An empirical investigation, *Edelweiss Applied Science and Technology* ISSN: 2576-8484, 8(5), 2126-2141
- Shenkoya, T. and Kim, E, (2023). Sustainability in higher education: digital transformation of the fourth industrial revolution and its impact on open knowledge. *Sustainability*, 15(3), 2473. <https://doi.org/10.3390/su15032473>
- Tiwow, G. (2023). Strengthening the acceleration of digital transformation in developing a digital economy curriculum. *IJITE*, 2(3), 108-117. <https://doi.org/10.62711/ijite.v2i3.130>
- UNESCO report, (2021), *Digital Skills Critical for a Digital Economy*.

- Van Deursen, A. J., & Van Dijk, J. A. (2014), *The Digital Divide Shifts to Differences in Usage*, *New Media & Society*, 16(3), 507-526.
- Yuqing G, Lingyag C, Jianyi L, Kachif I, (2023), Higher education and digital Economy: Analysis of their coupling coordination with the Yangtze River economic Belt in China as the example, *Ecological Indicators*, 154, 110510. <https://doi.org/10.1016/j.ecolind.2023.110510>
- World Economic forum, (2019), the digital skills gap is widening fast: here is how to bridge it, <https://www.weforum.org/stories/2019/03/the-digital-skills-gap-is-widening-fast-heres-how-to-bridge-it/>