A COMPARATIVE ANALYSIS BETWEEN THE QUALITY OF EDUCATION AND DIGITAL COMPETENCIES IN CENTRAL AND EASTERN EUROPE (CEE)

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Abstract

This article investigates the post-2020 evolution of education quality and digital competencies in Central and Eastern Europe (CEE) in the wake of the abrupt shift to online and hybrid learning during the COVID-19 pandemic. We triangulate comparative evidence from PISA 2022, the Digital Economy and Society Index (DESI)/Digital Decade monitoring, the EU Digital Education Action Plan (2021–2027), and the DigComp/DigCompEdu frameworks to map cross-country disparities in infrastructure, teachers' digital readiness, and institutional capacity. Findings indicate partial convergence across several indicators—particularly connectivity and digital public services—yet reveal persistent gaps in basic digital skills, pedagogical integration of technology, and equitable access, with the southeastern EU subregion lagging behind. Urban–rural divides, uneven curriculum implementation, and insufficient large-scale teacher upskilling remain binding constraints. Methodologically, we offer a structured regional snapshot, then contrast Romania's trajectory with EU averages, and synthesize lessons from the United States and China to highlight similarities (connectivity versus capability paradox) and differences (scale, governance, and industrial digitalization). Policy analysis emphasizes the need for people-centric investments that complement infrastructure: standardized DigComp-aligned assessments, micro-credentials for students and adults, robust teacher training pipelines, and outcome-based funding tied to actual technology use in schools, firms, and public services. We argue that narrowing foundational skill deficits (especially among youth, rural communities, and older adults) is a precondition for translating connectivity into sustained improvements in learning outcomes and productivity. The paper concludes with a practical roadmap that prioritizes equity-oriented delivery, sector-linked upskilling, and consolidated

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governance to accelerate convergence within CEE and position the region for the EU's 2030 Digital Decade targets.

Keywords: Digital skills; DigComp / DigCompEdu; DESI / Digital Decade; PISA 2022; Central and Eastern Europe (CEE); Education quality; Digital divide.

JEL Classification: I21, I28, J24

1. Introduction

The recent years, especially after the COVID-19 pandemic created an intense, emulation, boosting the digital education all around the world. Even if, previously, digital education was recognized, the level of formal recognition of it was highly heterogeneous, leaving the national authorities to allow it or not, entirely or partially. After 2020, most of the educational systems abruptly shifted from classical face to face interactions to an online or hybrid instructional process, highlighting the need for new adapted national and institutional strategies, together with teachers' digital competences. It was a quick and, sometimes, a very costly transition, exposing the strengths and the weaknesses of each and every national educational system. Europe was not different. The overnight change due to the pandemic shutdown, especially in early 2020, forced an immediate shift, changing all the optional digital tools and skills, from recommended to mandatory requirements, for an optimal and effective educational process, all across Europe. In Central and Eastern Europe, particularly, the results of this change have been shaped mostly by three interacting forces: *the pre-existing gap or convergence of the quality of education in comparison with the Europe average*, *the pace of new digital infrastructure rollout*, and *the capacity of teachers and educational institutions to adopt the technology from the pedagogically perspective*.

From the methodological point of view, this article compares evidence and data collected from some recognized monitoring instruments and policy frameworks to assess where CEE stands, after 2020, versus the EU median, on both education quality and digital competencies. The key resources which guided this analysis refer to ***OECD/PISA 2022*** assessment[6], the ***European Commission's Digital Economy and Society Index (DESI 2022[7])***, the ***EU's Digital Education Action Plan (2021–2027[8])***, ***DigCompEdu[9]***, and a recent World Bank working paper on digital skills topic.[10]

[6] https://www.oecd.org/en/publications/pisa-2022-results-volume-i_53f23881-en.html
[7] https://digital-strategy.ec.europa.eu/en/policies/desi
[8] https://education.ec.europa.eu/focus-topics/digital-education/actions
[9] https://digcompedu.net/statistici/
[10] https://thedocs.worldbank.org/en/doc/a607bb6e3b76d2be0f3db8db34dcf73e-0140022025/related/3EDU-WP-14-Digital-skills-development.pdf

2. Regional snapshot after 2020: infrastructure, access capabilities and digital skill readiness

After just two years from the pandemic crisis, DESI's 2022 Report documented notable progress across the EU, concerning the broadband connectivity availability and the 5G rollout, with strong improvements concerning the fixed high-capacity networks. But this general positive image was just an overall evaluation for the entire EU region. The gaps are also mentioned in the same report, suggesting that the disparities among EU areas are more than serious. If Finland, Denmark, the Netherlands and Sweden continued to maintain the EU leadership in term of digitalization, other member state like Italy or Greece, despite their initial lack of appetite for digitalization, improved their ranks substantially, by implementing constant investments and reinforcing their national political focus on digital. However, there are still member states, like Romania and Bulgaria, were the digital skill appetite for implementation remained among the lowest scores, at the beginning of 2022.

Specifically, while 87% of the EU population (aged 16-74) used the internet regularly during the pandemic, perhaps forced by the lockdown restrictions, only 54% possessed in fact a minimum set of basic digital skills. The problem to be mentioned is that last year, based on the published data, still a large part of the EU population is not reporting to have and to use the most basic digital skills, even if, though most present jobs, such digital skills are required as mandatory.[11]

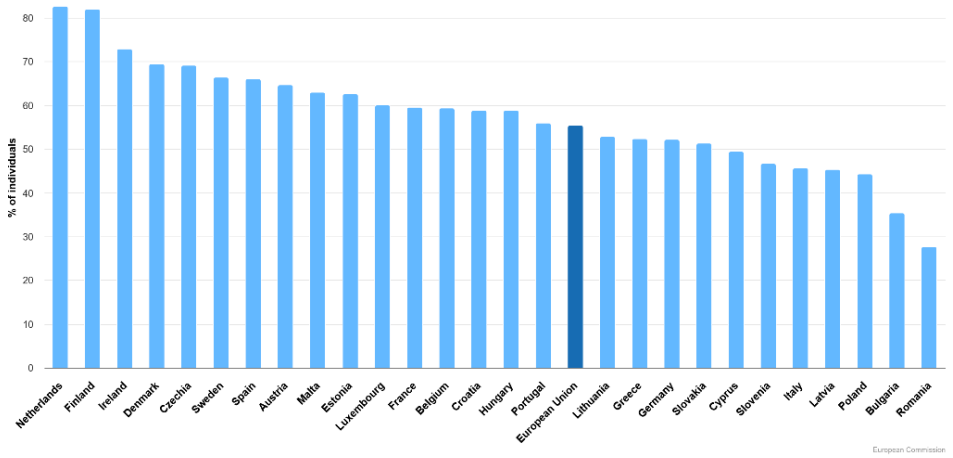

Figure 1. DESI 2025- basic digital skills within EU[12]

[11] https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/charts/desi-indicators?period=desi_2025&indicator=desi_dsk_bab&breakdown=ind_total&unit=pc_ind&country=AT,BE,BG,HR,CY,CZ,DK,EE,EU,FI,FR,DE,EL,HU,IE,IT,LV,LT,LU,MT,NL,PL,PT,RO,SK,SI,ES,SE

[12] https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/charts/desi-indicators?period=desi_2025&indicator=desi_dsk_bab&breakdown=ind_total&unit=pc_ind&country=AT,BE,BG,HR,CY,CZ,DK,EE,EU,FI,FR,DE,EL,HU,IE,IT,LV,LT,LU,MT,NL,PL,PT,RO,SK,SI,ES,SE

The topmost characteristics to be mentioned here were the general shortage of ICT specialists available on the EU during 2020 and up to 2024, with an inversion trend in the last months, completed with the traditional gender imbalance issue, with only 19% of ICT female specialists in areas like technology and engineering.

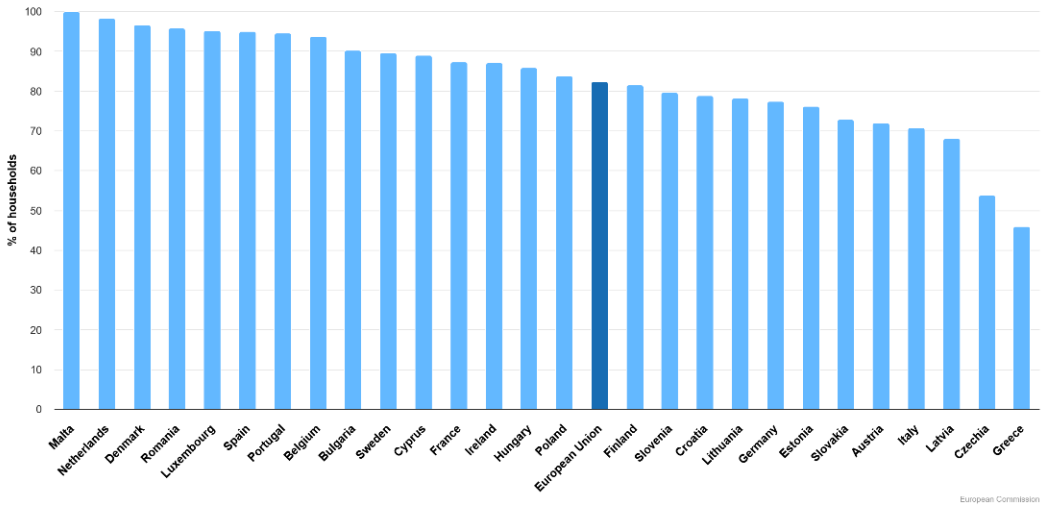

Figure 2. Fixed Very High-Capacity Network (VHCN) coverage[13]

Describing the broadband connectivity, while the EU has reported full coverage of broadband, in fact, only 70% of households can benefit from performant broadband connectivity, with a reported large gap between rural and urban areas, and important differences across nations. For example, if countries like Luxembourg, Denmark, Spain, or the Netherlands are reporting an almost full coverage, in Greece, only 1 in 5 households have access to fixed broadband connectivity. In the same time, countries like Estonia, even if is being reported as one of the best performers in digital services implementation and education based on digital tools, is not among the forerunners, while Romania, one of the poorest performers in the same area of analyses places on the fourth position, proving its inability to use available infrastructure resources.

Based on these facts, we need just to mention one more aspect, namely that, when Covid stroked, only 55% of SMEs reported at least a basic level in the adoption of digital technologies[14]. Sweden and Finland have the most digitalized business environment with

[13] https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/charts/desi-indicators?period=desi_2025&indicator=desi_vhcn&breakdown=total_pophh&unit=pc_hh&country=AT,BE,BG,HR,CY,CZ,DK,EE,EU,FI,FR,DE,EL,HU,IE,IT,LV,LT,LU,MT,NL,PL,PT,RO,SK,SI,ES,SE

[14] Eurostat, European Union survey on ICT usage and e-commerce in enterprises

reported values around 86% and respectively 82% of their SMEs, while Romania or Bulgaria declared among the lowest rates of having a basic level of digital intensity.

Fortunately, things are changing, and the latest reports and ranks, covering the last four years, are showing us a different image.

But despite all the undertaken initiatives at EU level, the most recent analysis underlines some previous expressed concerns, outlining Europe need to improve its regional and international leadership in digital technologies, knowing that the international market proves to be a very dynamic one, with major players and competitors like US and China. As result, the full potential of the Single Market, from the ICT perspective, remains unleashed. Furthermore, more than 80% of the technologies and services demanded all over EU are designed and produced abroad, in third countries, while the presence of European ICT companies among the world's leading players is still minimal.

Another perspective of the same conclusion is offered by the 2022 PISA results, showing again a very heterogenous mix of systems all over the EU. While some national education systems, like the Estonian one, remains among Europe's top examples, other member states, mainly from the south-eastern EU area, reported notable declines compared with the pre-pandemic years. The results also exposed severe equity gaps and strong interdependences between the national wellbeing and development progress and scholar population' digital competences, suggesting that the gaps cannot be diminished in the absence of strong and sound economic growth and development.

This also means that the pressure applied by the European authorities on each and every national education policy maker, especially in the lowest ranked member states, needs to be constant, otherwise the perspective of economic development stalls, human capital formation disruptions, together with future risk of brain-drain phenomenon and social fragmentation cannot be ignored or even avoided, causing even more important problems to EU responses toward international challenges on its own role as regional leader.

3. Comparative patterns across EU - convergence, divergence, and inequality

As already presented, the available data reports show two facts. Firstly, after accession, the new member states reported accelerated improvements in certain digital indicators, mainly because some new opportunities were available to them due to the new membership and, secondly, the post pandemic opportunities, among them the investments financed by each and every national Recovery & Resilience plans caused faster year-to-year improvement in certain digital indicators, demonstrating a catch-up dynamics.

Despite overall convergence, large gaps are still evidenced within member states and among them. Urban versus rural disparities, advantaged versus disadvantaged educational systems,

socio-economic inequalities among similar family patterns in different EU regions persist and continue to shape gaps in actual digital competence and learning outcomes, despite direct or indirect EU efforts.

The overall quality in national educational systems around member states split Europe into two major categories. Countries that combined clear infrastructure investment with curricular adjustments and human force training reported more educational value acquired through technology implementation. On the other side, all member states, where infrastructure was enhanced but teacher support was absent or minimal, reported some improvements but with overall effects and quality below the forerunners.

Recent adoption of the Artificial Intelligence, changing patterns in offering services from classical ways towards on-cloud delivery, and the large implementation on big data analysis by the business environment has improved the overall national educational systems' appetite for embedding more and more digital competencies, however, EU remains reliant on external providers, making us quite vulnerable to other competitors, like US or China.

With only half of Europeans (55.6%) reporting a basic level of digital competences, we remain vulnerable, while technology advances in other regions, making us mole like users and not creators or innovators of these new skills and technologies, The digital transformation, present all around the world, intensified vulnerabilities and inequalities, raising concerns about our capabilities to adequately tackle the international context.

The latest Digital Decade Policy Programme (DDPP)[15] mentions recent improvements across Europe concerning digitalization of public services or basic 5G coverage compared with previous years, but, at the same time, highlights the gaps and the lack of advancements, still present, despite the numerous efforts made to address them.

The Estonian example can be mentioned in this context as among one of the best reported all-around Europe. Its long-term digital strategy is known even before 2020. Estonia is also appreciated for having a public administration strongly based on online communication interfaces with the public, being a performer in what we call e-government. Advanced e-government services, constant investment in digital-ready educational system, constant specialized training for teachers and other categories involved in delivering educational services, resulted in relative resilience during COVID 19 pandemic and created premises for a rapid return, without the educational process being affected in a particularly serious way.

On the other hand, Romania and Bulgaria scored lower compared with EU average in general and Estonia's performances in particular. Policy responses, especially since 2021, have included targeted some specific investments, mainly recovery & resilience allocations for digital and education infrastructure, but with no translation into consistent pedagogical

[15] https://digital-strategy.ec.europa.eu/en/policies/2025-state-digital-decade-package

competence, the generated results do not show any significant improvements, placing us at the end of the list.

For EU decision makers, overall raising of both education quality and digital competencies remains an objective to be addressed in the next months or years. Furthermore, the present of these already mentioned disparities between the west and the east will not ease the process.

Future financing programs to be launched at the EU level need to address in this context, both the hardware/servicing area and the professional development of these new competences for teachers and trainers. The metrics used in evaluating the achieved results need also to be adapted in a way to better evaluate the skill acquisition reported by the trained personnel. Embedding digital competencies across subjects during the educational process rather than treating them as an isolated subject will create a real integrative and formative digital environment, capable of being properly assessed.

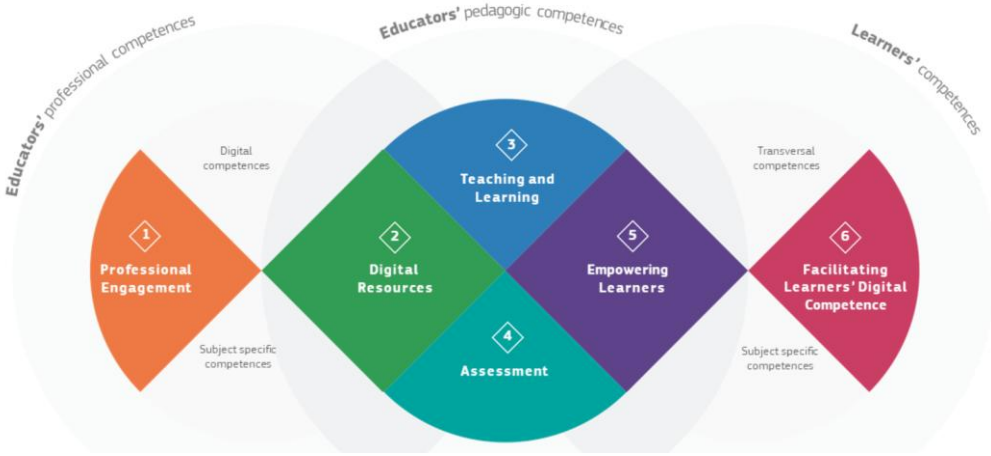

Figure 3. DigCompEdu-digital competences and the educational process[16]

The future investments in communication infrastructure need to address more the rural areas and the socio-economically disadvantaged regions, especially in the eastern area of the EU, because the lack of profitability makes these regions to be left somehow behind the urban areas. Or in the absence of good infrastructure, chances for the digital skill dissemination and quality education improvement lags.

[16] https://joint-research-centre.ec.europa.eu/digcompedu_en

4. Digital skills statistics in Romania

The diffusion of digital technologies across sectors has elevated ICT competencies - from basic digital literacy to advanced professional skills - into core determinants of productivity, inclusion, and resilience. The EU's *Digital Decade policy*[17] makes this explicit through two flagship 2030 targets: at least 80% of adults with basic digital skills and 20 million employed ICT specialists, with marked progress on gender balance. Recent monitoring shows the EU is well short of both targets, underscoring the urgency of large-scale skilling and reskilling programs across Member States.

Following the accelerated transformations in the post-pandemic years, Romania still remains significantly below the EU average in terms of basic digital skills, despite notable progress in connectivity and substantial allocations from the National Recovery and Resilience Plan (PNRR). According to the *Digital Decade 2024* report[18], only 27.7% of Romanian citizens aged 16–74 possess basic digital skills (EU average: 55.6%), while the share of ICT specialists in total employment stands at 2.6% (EU average: 4.8%). Despite exceptional fixed fiber coverage, Romania's lag in human capital indicators continues to constrain the returns to connectivity, e-government, and business digitalization.

Romania has committed substantial public resources (notably through the PNRR[19]) to digital transformation, with ~21.8% of the plan fostering the digital transition (investments in cloud government, interoperability, connectivity in "white zones," and digital skills initiatives). The gap between infrastructure and people-centric capabilities, however, persists, making equity-oriented training and coherent governance of skills policies pivotal.

This section provides a detailed analysis across three levels: secondary education, higher education, and the active workforce (aged 18–64), with a particular focus on territorial and demographic disparities, as well as on the corrective measures currently being implemented [1].

4.1 Romania vs. the EU: the structure of disparities

4.1.1 Basic digital skills and the new DSI 2.0 measurement

Eurostat's Digital Skills Indicator (DSI 2.0), grounded in the DigComp framework, underpins EU-level estimates of "basic digital skills." The 2.0 revision modernized items and improves robustness of cross-country comparisons. On this measure, Romania's 27.7%

[17] https://digital-strategy.ec.europa.eu/en/policies/europes-digital-decade?source=post%3A7544337119316214 26
[18] https://digital-strategy.ec.europa.eu/en/factpages/romania-2024-digital-decade-country-report
[19] https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/country-pages/romanias-recovery-and-resilience-plan_en

rate signals a large structural gap relative to the EU mean (55.6%) and the Digital Decade's 80% target.

4.1.2 ICT specialists, graduates, and gender

In 2024, Eurostat estimates that ~5.0% of EU workers are ICT specialists (>10 million people), whereas Romania stands at ~2.8% (from 2.6% in 2023), still among the lowest in the Union (only Greece is comparable). Notably, Romania's female share among ICT specialists is relatively high for the EU (about 27%), suggesting potential to scale inclusive pipelines if volume constraints are addressed[20].

On education supply, Eurostat's statistical overview of ICT education for 2024 indicates strong employment rates of ICT-educated individuals EU-wide and gradual gains in women's representation, yet cross-country variation remains pronounced. Romania has historically produced a sizeable cohort of ICT graduates relative to its population, but transition into domestic ICT employment is shaped by outward mobility and regional labor market dynamics[21].

4.1.3. Territorial and demographic divides

Urban–rural divides are salient across the EU and especially pronounced in Romania. EU evidence shows systematically lower above-basic digital skills outside cities; for 2023, internet access remains slightly lower in rural areas, and the largest gap concerns content creation skills. Romanian analyses consistently report lower skills attainment in rural communities, compounding social exclusion risks.

Complementary assessments (World Bank technical assistance and recent Romanian commentary on the Digital Decade) highlight low adult learning participation, stark age and education gradients, and rural disadvantages, despite targeted measures (e.g., library-based digital hubs) financed under PNRR.

4.1.4. Policy capacity and governance

Recent EU monitoring and independent reviews point to implementation risks: fragmented governance, weaker targets than EU benchmarks (including on skills), limited stakeholder engagement, and delays. The 2026 revision of the national Digital Decade roadmap is a

[20] https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20250708-2
[21] https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=673722

critical opportunity to consolidate leadership, adopt credible interim milestones, and integrate outcome-based funding for skills[22].

4.2 Romania vs. the United States: different baselines, similar structural challenges

4.2.1 Measurement caveats

Romania's EU metrics (DSI 2.0 "basic digital skills," share of ICT specialists) are not directly comparable to the United States' principal sources, which rely on OECD-PIAAC (literacy, numeracy, adaptive problem-solving) and a growing body of digital equity diagnostics (e.g., National Skills Coalition, FCC[23] CEDC). Thus, comparisons should be interpreted as triangulations rather than like-for-like[24] [2].

4.2.2 Adult competencies and digital demand

The PIAAC 2023 cycle shows U.S. adults score near the OECD average in literacy but below average in numeracy and adaptive problem solving; about 28% of adults are at Level 1 or below in literacy and 34% at or below Level 1 in numeracy—indicators of foundational skill constraints that interact with digital readiness[25].

On the demand side, a landmark analysis finds 92% of U.S. job postings require digital skills, while roughly one-third of workers lack foundational digital competencies [3] - evidence of a sizable "last-mile" skills gap despite near-universal connectivity. U.S. policy is mobilizing significant Digital Equity Act and broadband funds to close these divides, with emphasis on work-based and community-based upskilling.

4.2.3 Where Romania stands relative to the U.S.

Connectivity vs. capabilities: Both countries exhibit a paradox - high or improving connectivity coexisting with foundational skills gaps. Romania's gaps are larger on EU's DSI 2.0, whereas the U.S. shows broad demand-pull from employers that outpaces the supply of digitally capable workers.

[22] https://www.crpe.ro/wp-content/uploads/2025/10/CRPE-Romanias-Digital-Decade-2030-Roadmap-Building-coherence-collaboration-and-accountability.pdf
[23] https://www.fcc.gov/sites/default/files/cedc-innovation-access-wg-digital-upskilling-report-06152023.pdf
[24] https://www.oecd.org/en/publications/survey-of-adults-skills-2023-country-notes_ab4f6b8c-en/united-states_427d6aac-en.html
[25] https://primarynewssource.org/wp-content/uploads/427d6aac-en.pdf

Labor market composition: The U.S. ICT labor market is significantly larger and more diversified; however, Romania's relatively high female share within ICT roles could inform inclusive design of U.S. pathways, while the U.S. experience with workforce-employer partnerships offers a template for Romania's adult upskilling.

Adult learning systems: U.S. institutions (community colleges, workforce boards) provide scalable platforms for short-cycle digital credentials; Romania's policy architecture could adapt analogous mechanisms (micro-credentials mapped to DigComp, modular courses delivered via libraries, schools, and SMEs) already envisaged in national plans.

4.3. Romania vs. China: contrasting scale, state capacity, and measurement

4.3.1 Data limitations and what can be compared

China does not report DSI 2.0-equivalent "basic digital skills." Public sources emphasize the scale of the digital economy, infrastructure leadership, and state-backed initiatives to raise digital literacy and industrial digitalization. Academic syntheses juxtapose China's national literacy campaigns with the EU's Digital Decade, noting progress alongside persistent urban–rural divides. Consequently, comparisons focus on system capacity and outputs, not like-for-like skill rates[26] [4].

4.3.2 Systemic features relevant to skills

Digital economy scale and infrastructure: China's digital economy reached ~RMB 56.1 trillion in 2023 (~44% of GDP), underpinned by the world's largest fiber and mobile broadband networks and rapidly expanding computing power—conditions that create vast demand for digital skills and pervasive exposure to digital services.

Industrial digitalization and workforce: MIIT reports continued growth in software revenues and the establishment of hundreds of "intelligent digital demonstration factories," signaling state-driven diffusion of advanced ICT across manufacturing. Such programs are typically accompanied by large-scale, employer-embedded training.

Talent formation: International rankings (e.g., IMD World Talent) show steady improvement in China's talent competitiveness, tied to increased education spending and the ability to tap large cohorts, though regional disparities persist and external comparability is debated[27].

[26] https://www.carecprogram.org/uploads/Mr.-Gang-Zhu-Deputy-Director-International-Economic-and-Technical-Cooperation-Center-Ministry-of-Industry-and-Information-Technology.pdf
[27] https://global.chinadaily.com.cn/a/202409/27/WS66f6693aa310f1265a1c54c2.html

4.3.3 Where Romania stands relative to China

Romania's advantage lies in its EU governance framework (DigComp, DSI 2.0, Digital Decade targets) and access to EU funding mechanisms. China's advantage lies in scale, tight policy coordination, and industrial policy instruments that accelerate digitalization in firms. For Romania, feasible lessons from China include: (i) sector-specific (manufacturing, health, public administration) digital upskilling tied to technology deployments; (ii) regional "demonstration" sites that integrate infrastructure, software, and training; and (iii) robust data systems to monitor skill attainment and usage. Translating these to the EU setting requires adherence to EU standards on privacy, transparency, and open labor markets.

5. Root causes of Romania's disparities

In our vision, we consider that the following four elements are the most important and relevant for explaining the current disparities between Romanian population groups, regarding the ICT level of knowledge.

1. Late start and policy discontinuities: Repeated administrative turnover and fragmented governance have hampered policy continuity and execution in digital skills, even as capital investments (fiber, cloud government) moved forward.
2. Education system performance: OECD reviews underline persistent foundational learning deficits (as seen in PISA) and low participation in adult learning, which depress the absorptive capacity for ICT upskilling later in life[28].
3. Territorial inequities: Rural–urban disparities in income, schooling, and service access translate into digital skills gaps, despite improving connectivity; "last-mile" social infrastructure (training venues, mentors, employer demand) remains thin in rural counties[29].
4. Labor market structure: A relatively small ICT-intensive sector (by employment share) and the international mobility of Romanian ICT graduates constrain domestic pathways, even as the female share among ICT specialists is a notable strength to build upon[30].

[28] https://www.oecd.org/en/publications/education-and-skills-in-romania_594cbb5d-en.html
[29] https://ec.europa.eu/eurostat/statistics-explained/index.php?oldid=656908
[30] https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20250708-2

5.1 High school level considerations and statistics

Youth data points to a paradox: heavy use of social platforms coupled with low levels of digital literacy. In 2023, only 46% of 16–24 year olds in Romania had basic digital skills (the lowest rate in the EU; EU average: 71%). At the same time, Romania had the highest TikTok penetration in the EU (~47% of the population with an account), which highlights that digital "consumption" does not equate to skills [5].

In standardized assessments, analyses of digital literacy in the Baccalaureate (2020–2022) show statistically significant differences: girls score better than boys, and students from rural areas score significantly lower than those from urban areas; correlations with other tests are of medium intensity, suggesting that digital literacy is associated with overall academic performance. The *Brio Digital Literacy Report* (2022) confirms these disparities and insists on regional differences in digital literacy among students [6] [7].

Structural factors:

- Curriculum: the cross-curricular integration of DigComp in high school is uneven; mandatory "digital skills" modules are poorly standardized at the national level.
- Resources & connectivity: rural–urban gap in access to equipment and quality Internet (although Romania excels at FTTP as an infrastructure, educational use remains suboptimal) [1]
- Teacher training: recent plans announce the training of ~100,000 teachers in digital skills through the PNRR, but require monitoring for scaling and quality [8]

The implication of the above statements is clear - without a coherent "mix" between infrastructure, curriculum and teacher training, exposure to platforms does not transform competence. Interventions should aim for systematic DigComp assessment in high school and differentiated support for rural areas.

5.2 University-level considerations and statistics

At the university level, Romania has high shares of ICT graduates and a relatively good presence of women in ICT, aspects highlighted in the Digital Decade reports; however, generic digital literacy among non-ICT students remains heterogeneous. DESI/DDPP data indicate that ~72% of adults do not have basic digital skills (2022–2024), which also implies the non-ICT university population, especially in the transition to the labor market [9].

Universities have accelerated e-learning platforms and administrative digitalization post COVID, but the mandatory transversal digital skills module is often optional or local.

Analyses on the body of high school students (Baccalaureate candidates) and on the transition to university suggest that the rural-urban gap is "transported" to the university environment, affecting the ability to capitalize on advanced digital resources [6].

Improvement directions:

- Systematic introduction of micro credentials in digital skills for all domains (data literacy, AI literacy, cyber hygiene).
- Partnerships with industry for applied projects that validate DigComp competencies (e.g.: PNRR collaborations, government cloud, interoperability) mentioned in the national DDPP targets.
- Integrating DigCompEdu model assessments at the program level, not just in ICT faculties/schools.

5.3 Considerations and statistics at the level of the active labor force (18–64 years)

The workforce profile reflects the most acute shortage. In 2024–2025:

- Basic skills: 27.7% of the population (16–74) – representative indicator for 18–64 – have minimal digital skills (EU: 55.6%).
- ICT specialists: 2.6% of employees (EU: 4.8%).
- Lifelong learning: adult participation 4.9% (EU: 10.8%), which slows down systemic upskilling/reskilling [10].
- Disparities: only 21% of rural residents have basic skills; at 65–74 years old, 6.17% (EU: 28.19%), highlighting the need for "last mile" programs and human support for public digital services.

In the labor market, employers increasingly require digital and AI skills even in non-IT roles, but only ~40% of employees regularly use digital tools; AI adoption in companies remains the last in the EU, despite increasing demand and workplace training initiatives. In parallel, Romania has made visible steps in the digitalization of public services (government cloud, ROeID, e-invoicing), but the benefits on civic and corporate skills are materializing gradually, requiring digital literacy campaigns and UX simplifications for broad adoption [11] [1] [12].

Among the relevant interventions correlated with the above issues we can mention, for example, The Digital STARs program (World Bank) aims to train 100,000 citizens by 2026, transforming 1,135 libraries into skills hubs; the approach targets vulnerable groups and

reduces territorial inequalities. For the 60+ population (and their families), Erasmus+ DigitalScouts initiatives confirm the need for support networks and community "digital mentors", complementary to formal courses.

6. Priority directions for Romania (with EU-level alignment)

- Make DigComp the lingua franca of lifelong learning

  Adopt and scale a national DigComp-aligned certification (micro-credentials at basic, intermediate, advanced levels) across schools, adult centers, libraries, and employer academies; link to hiring and wage supplements in public administration and SMEs.

  This aligns with EU Digital Decade targets and leverages DSI 2.0 for measurement.

- Target the equity gap where the marginal gains are largest

  Prioritize rural counties, older workers (45–64), and low-educated adults with community-based delivery (public libraries as digital hubs, mobile labs, school-based evening programs), building on PNRR investments already earmarked for "white zones" and local hubs.

- Tie training to actual technology adoption in firms and agencies

  Couple grants for cloud/AI/data adoption by SMEs with mandatory digital upskilling hours and outcome audits; replicate China's "demonstration factory" logic in an EU-compliant manner through regional digital sandboxes and shared trainers.

- Strengthen governance and accountability

  Consolidate a single ownership point for digital skills (cross-ministerial unit), publish annual outcomes (attainment, usage, wage effects), and align national milestones with the EU's cooperation cycle; address critiques regarding weak targets and fragmented execution.

- Expand work-based learning pathways

  Borrow from U.S. practice: employer partnerships, short-cycle credentials embedded in jobs, and sectoral training funds; link to tax incentives for firms documenting skill gains and productivity effects.

Taking into account all the considerations we have emphasized previously, we think that a realistic successfully implemented roadmap for Romania should show how success would look like by reaching the following landmarks:

- Foundational skills: Raise the share of adults with basic digital skills to the EU average trajectory (mid-40s percent by 2028 on DSI 2.0) with credible year-on-year increases, on a path toward ≥60% by 2030, acknowledging the distance to the EU's 80% headline.
- ICT specialists: Lift Romania's share toward ≥3.5–4.0% of employment by 2030 through retention of graduates and sectoral expansion, while preserving or improving the female participation advantage.
- Equity: Narrow the rural–urban gap in above-basic skills by at least one-third relative to 2023 baselines, verified via Eurostat regional indicators and national microdata.
- System integration: Full operationalization of DigComp-aligned credentials in secondary, tertiary, and adult learning; outcome-based funding tied to usage (e.g., eID, e-health, tax filing) and workplace application (e.g., ERP, cloud, AI tools) to ensure skills translate into practice.

Cross-country comparison of "digital skills" is complicated by divergent definitions and instruments. EU's DSI 2.0 is behavior-based and DigComp-aligned; OECD-PIAAC assesses cognitive competencies (literacy, numeracy, adaptive problem solving) rather than digital behaviors; China emphasizes economic scale and industrial digitalization with fewer internationally harmonized skills indicators in the public domain. Accordingly, the comparative statements above triangulate across multiple sources and should be read with these caveats in mind.

Nevertheless, ff we continue to compare Romania's situation to its main geographically relevant entities – EU, USA and China – we can list the following takeaways:

- Romania vs. EU: Romania's principal challenge is foundational (basic digital skills) and structural (low ICT employment share), not infrastructure. EU frameworks provide clear targets and monitoring, but national execution must accelerate and be equity-focused.
- Romania vs. U.S.: The U.S. balances vast demand for digital skills with significant foundational deficits across adults. Romania can draw on U.S. models of work-based digital upskilling, while the U.S. can learn from Romania's female representation in ICT roles.
- Romania vs. China: China's scale and state coordination speed diffusion of advanced ICT; Romania should adapt the sector-based and demonstration-site logic to EU norms, using PNRR and cohesion funds to ensure the people side (skills) matches infrastructure and software roll-outs.

7. Conclusions and policy directions

In order to start fixing the current issues as fast as possible we discern three elements that Romania can implement on a fast pace approach – each one addressing a different target group:

1. High school level: national standardization of DigComp assessments, sustained teacher training (monitored by quality indicators), and dedicated resources for rural areas (infrastructure + content).
2. University level: cross-curricular micro credentials in data/AI literacy, partnerships with industry for competency validation, and program-level DigCompEdu audits.
3. Workforce level: incentives for upskilling (digital vouchers, tax deductions for training), onboarding campaigns for digital public services, and local hubs (libraries, "one stop shops") for basic skills.

Without accelerated growth in digital skills in the 16–24 and 18–64 segments, Romania risks widening the gap with the EU average even if the network/hardware infrastructure remains competitive (FTTP/VHCN). Focusing on quality of use (not just access) becomes a priority for educational and economic convergence.

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References

[1] KRALj Lidija - *Romania: a snapshot of digital skills (05.08.2024)*. https://digital-skills-jobs.europa.eu/en/latest/briefs/romania-snapshot-digital-skills. Last access: 2025-11-11

[2] Misheva G. - *Digital Skills Indicator 2.0: Measuring Digital Skills across the EU*. https://digital-skills-jobs.europa.eu/en/inspiration/resources/digital-skills-indicator-20-measuring-digital-skills-across-eu. Last access: 2025-11-10

[3] Bergson-Shilcock A., Taylor R., Hodge N. - *Closing the Digital Skill Divide*. https://nationalskillscoalition.org/resource/publications/closing-the-digital-skill-divide/. Last access: 2025-11-11

[4] Wang, C., d'Haenens, L. (2025). Report-Based Interpretation of 2024 Digital Literacy and Skills in China and the EU: Status, Differences, and Future Directions. In: Tomczyk, Ł. (eds) New Media Pedagogy: Research Trends, Methodological Challenges, and Successful Implementations. NMP 2024. Communications in Computer and Information Science, vol 2537. Springer, Cham. https://doi.org/10.1007/978-3-031-95627-0_1

[5] Iliescu D., Airinei M – *Report on students' digital literacy level in Romania*. May 2022, UIPath Foundation. https://uipathfoundation.com/wp-content/uploads/2025/04/State-of-the-Nation-May-2022.pdf. Last access: 2025-11-11

[6] Grigorescu, A., Fontanella, B., Pasnicu, D., Uleia, M.C., Lincaru, C., Tudose, G. (2025). Basic Education and Basic Digital Skills Insights for Romania & Italy. In: Dima, A.M., Badarinza, C. (eds) Innovative Approaches in Economics, Leadership, and Technology. ICESS 2024. Springer Proceedings in Business and Economics. Springer, Cham. https://doi.org/10.1007/978-3-031-86989-1_7

[7] https://lemonews.com/en/article/cresterea-somajului-in-randul-tinerilor-si-cerintele-angajatorilor-in-materie-de-competente-digitale-qbus6b. Rising Youth Unemployment and Demand for Digital Skills in Romania. Last access: 2025-11-10

[8] Meirosu R., Palarie T.A. – *Report of the Erasmus+ Project "DigitalScouts: Enhancing the Digital Literacy and Participation in Europe"*. https://digitalscouts.eu/wp-content/uploads/2023/09/DigitalScouts_National_Report_Romania.pdf. Last access: 2025-11-10

[9] Ernst I. - *Romania's young population has lowest digital skills but highest TikTok adoption rate*. https://www.romania-insider.com/romania-youth-digital-skills-tiktok-adoption-2024. Last access: 2025-11-10

[10] Dumitrescu R. - *Only a quarter of Romanians had basic digital skills in 2023, report shows*. https://www.romania-insider.com/romanians-basic-digital-skills-2023-report. Last access: 2025-11-10

[11] WorldBank Romania - *Romania Digital Skills RAS*. https://edskills.org/RAS%20Digital%20Skills_final%20presentation.pdf. Last access: 2025-11-10

[12] https://europroject.org.ro/uploads/Digital%20Decade%20Country%20Report%202023%20Romania.pdf. Digital Decade Country Report 2023. Last access: 2025-11-10

Bibliography

Bergson-Shilcock A., Taylor R., Hodge N. - Closing the Digital Skill Divide. https://nationalskillscoalition.org/resource/publications/closing-the-digital-skill-divide/. Last access: 2025-11-11

Dumitrescu R. - Only a quarter of Romanians had basic digital skills in 2023, report shows. https://www.romania-insider.com/romanians-basic-digital-skills-2023-report. Last access: 2025-11-10

Ernst I. - Romania's young population has lowest digital skills but highest TikTok adoption rate. https://www.romania-insider.com/romania-youth-digital-skills-tiktok-adoption-2024. Last access: 2025-11-10

Grigorescu, A., Fontanella, B., Pasnicu, D., Uleia, M.C., Lincaru, C., Tudose, G. (2025). Basic Education and Basic Digital Skills Insights for Romania & Italy. In: Dima, A.M., Badarinza, C. (eds) Innovative Approaches in Economics, Leadership, and Technology. ICESS 2024. Springer Proceedings in Business and Economics. Springer, Cham. https://doi.org/10.1007/978-3-031-86989-1_7

Iliescu D., Airinei M – Report on students' digital literacy level in Romania. May 2022, UIPath Foundation. https://uipathfoundation.com/wp-content/uploads/2025/04/State-of-the-Nation-May-2022.pdf. Last access: 2025-11-11

Kralj L. - Romania: a snapshot of digital skills (05.08.2024). https://digital-skills-jobs.europa.eu/en/latest/briefs/romania-snapshot-digital-skills. Last access: 2025-11-11

Meirosu R., Palarie T.A. – Report of the Erasmus+ Project "DigitalScouts: Enhancing the Digital Literacy and Participation in Europe". https://digitalscouts.eu/wp-content/uploads/2023/09/DigitalScouts_National_Report_Romania.pdf. Last access: 2025-11-10

Misheva G. - Digital Skills Indicator 2.0: Measuring Digital Skills across the EU. https://digital-skills-jobs.europa.eu/en/inspiration/resources/digital-skills-indicator-20-measuring-digital-skills-across-eu. Last access: 2025-11-10

Wang, C., d'Haenens, L. (2025). Report-Based Interpretation of 2024 Digital Literacy and Skills in China and the EU: Status, Differences, and Future Directions. In: Tomczyk, Ł. (eds) New Media Pedagogy: Research Trends, Methodological Challenges, and Successful Implementations. NMP 2024. Communications in Computer and Information Science, vol 2537. Springer, Cham. https://doi.org/10.1007/978-3-031-95627-0_1

WorldBank Romania - Romania Digital Skills RAS. https://edskills.org/RAS%20Digital%20Skills_final%20presentation.pdf. Last access: 2025-11-10

https://europroject.org.ro/uploads/Digital%20Decade%20Country%20Report%202023%20Romania.pdf. Digital Decade Country Report 2023. Last access: 2025-11-10

https://lemonews.com/en/article/cresterea-somajului-in-randul-tinerilor-si-cerintele-angajatorilor-in-materie-de-competente-digitale-qbus6b. Rising Youth Unemployment and Demand for Digital Skills in Romania. Last access: 2025-11-10

https://www.oecd.org/pisa

https://digital-strategy.ec.europa.eu/en/policies/desi

https://education.ec.europa.eu/focus-topics/digital-education/actions

https://joint-research-centre.ec.europa.eu/digcompedu_en

https://thedocs.worldbank.org/en/doc/a607bb6e3b76d2be0f3db8db34dcf73e-0140022025/related/3EDU-WP-14-Digital-skills-development.pdf