The educational divide in UE regions: linking technological advancement to socioeconomic outcomes

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Abstract

The primary objective of this report is to assess the influence of technological development in various European regions on their education levels, quantified through the Education Index, which we derived from multiple variables related to the educational attainment of each region.
Following this, we conducted a detailed analysis of the disparities in education levels across different European regions by examining their correlation with GDP per capita, corruption levels, employment rates, and NEET (Not in Education, Employment, or Training) rates. This comprehensive approach provides insights into the intricate relationship between technological advancement and educational outcomes, as well as their broader socioeconomic implications.

Contents

1. Introduction

Education and technology stand at the forefront of the European Union's strategic objectives for fostering sustainable growth, social cohesion and economic resilience. Recognizing the transformative power of these two pillars, the EU has set ambitious targets within its broader frameworks, such as the Europe 2020 strategy and the Digital Education Action Plan, to ensure that all member states can leverage education and technology as catalysts for regional and national development.

The Europe 2020 strategy, launched in 2010, explicitly aims to enhance the quality and accessibility of education across the Union, targeting a reduction in early school leaving rates to below 10% and an increase in tertiary education attainment to at least 40% among young adults **[1]**. These goals underscore the EU's commitment to developing a highly skilled workforce capable of adapting to the demands of a rapidly evolving global economy. Parallel to these educational objectives, the Digital Education Action Plan (2021-2027) reinforces the EU's dedication to improving digital skills and infrastructure, recognizing the critical role that technology plays in both individual empowerment and regional competitiveness **[2]**. Within this context, the relationship between education and technology becomes increasingly significant.

The current study leverages the Regional Competitiveness Index (RCI) 2022 dataset, curated by the European Commission, to investigate the specific relationship between the Education Index and Technology Readiness across 234 European regions. The RCI dataset provides a detailed assessment of various dimensions of regional performance, the Education Index, derived from the available data, and Technology Readiness serving as key indicators for this analysis.

By focusing on these dimensions, this analysis offers insights into the ways in which education and technology are interlinked. The findings have important implications for policymakers and stakeholders, who are increasingly focused on enhancing educational systems and technological infrastructures to support sustainable growth and development.

On the other hand, this report aims to explore the multifaceted relationship between education and various socio-economic factors. We examine how education influences and is influenced by key economic indicators such as GDP per capita, corruption and employment rates. By analysing the data, we seek to identify patterns and correlations that shed light on the main differences between regions belonging to different levels of education.

In summary, this study seeks to deepen our understanding of the critical connections between education and technology while elucidating the correlations between education and various socio-economic indicators. As the European Union works towards achieving its 2030 targets, comprehending the synergies between education and technology will be essential for ensuring that all regions can both contribute to and benefit from the Union's collective progress.

2. Data

The dataset underpinning this analysis is the *Regional Competitiveness Index (RCI) 2022*, curated by the European Commission. This extensive dataset offers a comprehensive assessment of regional competitiveness across Europe, incorporating a diverse range of indicators, recorded between 2018 and 2021, that reflect the multifaceted nature of economic, social and innovative performance in various regions.

Specifically, the RCI 2022 dataset comprises 68 distinct indicators that span across 234 different EU regions, providing an in-depth view of each region's competitive standing. These indicators cover different critical areas, namely:

- **Institutions** captures the quality of governance, the integrity of public services, and the strength of legal protections, reflecting how people experience and perceive corruption, justice, and the efficiency of institutions in their daily lives.
- **Macroeconomic stability** reflects the economic health of a country, including how much its government saves or borrows, the returns on its bonds, its debt relative to GDP, and its overall financial position with the rest of the world.
- **Infrastructure** shows how many people can be easily reached within 1.5 hours by road or rail from a neighbourhood, and also reveal the daily flow of passenger flights connecting different areas.
- **Health** captures important aspects of public health and safety, such as how many lives are lost in road accidents, how long people can expect to live in good health, the rate of infant deaths, and the standardized rates of cancer, heart disease and suicide for those under 65.
- **Basic education** reveals how many 15-year-olds are falling behind in reading, math, and science, showing where extra help and improvements in education might be needed to boost their skills.
- **Higher education and lifelong learning** paints a picture of educational attainment and accessibility: they show how many young adults have earned higher degrees, how engaged adults are in lifelong learning, the number of students who leave education early, how easily people can reach a university by car and the proportion of older adults who haven't advanced beyond lower secondary education.
- **Labour market efficiency** offers a glimpse into the job market, revealing how many people are employed across different sectors, the level of job-seeking among the unemployed and how well our economy performs per work hour. They also shed light on gender gaps in employment, the struggles of young people not in education or work, the demand for jobs that's not being met and the proportion of temporary workers.

- **Market size** offers a snapshot of economic health, showing how household incomes measure up to the EU average, how GDP compares across regions and the potential market size relative to the EU's population.
- **Technological readiness** highlights our digital landscape, showing how many households have broadband, how often people shop online, and the reach of high-speed internet in different areas. They also reflect the level of digital skills compared to the EU average, the proportion of businesses that handle online orders and how well-connected enterprises are to various broadband technologies.
- **Business sophistication** gives a snapshot of the economy, showing how much of the workforce and economic value come from sectors like finance, real estate, and professional services. They also highlight the extent to which small and medium-sized businesses are engaging in innovation and adopting new strategies, with their performance measured against the EU average.
- **Innovation** paints a picture of innovation and intellectual activity, showing how many patents are filed per million people, the proportion of the workforce involved in creative and knowledge-driven jobs and the volume of academic publications per capita. They also highlight how much regions invest in research and development, the percentage of people with advanced education working in science and tech roles and the extent of employment in tech-intensive industries. Additionally, they capture the number of trademarks and design applications relative to regional economic output and the impact of new innovations on sales.

By offering such a detailed overview, the dataset enables a thorough exploration of how different factors contribute to regional competitiveness and helps identify key areas for policy intervention and strategic development.

In the discussed dataset, not all the variables were utilized to reach our purposes. The focus was selectively narrowed to key indicators that provide a detailed measure of two different dimensions: education and technology. The following paragraphs offer a more detailed description of the chosen variables.

2.1 Variables considered under the educational dimension

The educational dimension encompasses a variety of indicators that measure different aspects of education, from basic literacy and numeracy skills to higher education and lifelong learning opportunities. Here's a detailed summary of what the educational dimension includes:

- **Low achievement in reading (15-year-olds):** this indicator measures the percentage of 15-year-old students with reading proficiency at level 1a or lower, reflecting critical literacy challenges at a foundational level.
- **Low achievement in maths (15-year-olds):** this variable assesses the percentage of 15-year-olds performing at or below level 2 in maths, highlighting regions with potential deficiencies in fundamental mathematical skills.
- **Low achievement in science (15-year-olds):** similar to the other two, this measures science proficiency at the lower end of the scale, identifying areas where science education may need bolstering.
- **Higher educational attainmen**t: represents the percentage of the population aged 25-34 with tertiary educational attainment, indicating a region's success in promoting higher education.
- **Lifelong learning**: measures the percentage of the adult population (25-64 years) that participated in lifelong learning activities within four weeks of the survey, illustrating ongoing educational engagement.
- **Early school leavers**: this metric tracks the percentage of 18-24-year-olds who have only achieved lower secondary education at most, offering insight into dropout rates.
- **University accessibility**: calculated as the average share of the population able to reach a university main site or campus within 45 minutes by car, this indicator evaluates accessibility to higher education facilities.
- **Lower-secondary completion only**: shows the percentage of individuals aged 25-64 who have completed at most lower secondary education, highlighting the basic educational level within the adult population.

These variables provide a comprehensive overview of the educational landscape, from basic education to lifelong learning opportunities, revealing both strengths and areas needing attention in regional educational systems.

2.2 Variables considered under the technological dimension

The technological dimension in the dataset encompasses several indicators that determine the extent of technology adoption and digital infrastructure across European regions. The indicators used are the following:

- **Households with broadband access**: this indicator measures the share of total households with broadband access, reflecting the penetration of fundamental internet services crucial for modern living and digital participation.
- **Individuals buying over the internet last year**: this metric tracks the percentage of individuals who ordered goods or services over the internet for private use in the last 12 months. It highlights the population's engagement with e-commerce, which is an indicator of digital consumer behavior and internet usability.
- **Access to high-speed broadband**: represents the percentage of the population living in a Local Administrative Unit (LAU) where broadband speeds of at least 100 Mbps are available. This indicates the availability of high-speed internet services critical for advanced digital activities and is a key factor in regional digital competitiveness.
- **Individuals with above-basic overall digital skills**: this variable assesses the digital proficiency of individuals, converted to an index relative to the EU average in 2021. An index value of 100 represents the EU average, indicating the level of digital skills necessary to effectively engage in a technology-driven environment.
- **Enterprises having received orders online (at least 1%):** measures the percentage of enterprises that have received at least one percent of their orders online. This metric applies to enterprises with at least ten employees and provides insight into how businesses are integrating e-commerce into their operations.
- **Enterprises with fixed broadband access:** this indicator quantifies the percentage of enterprises that have access to fixed broadband, whether through xDSL technologies, cable networks upgraded for internet traffic, or other broadband technologies. It reflects the degree to which businesses are equipped with the necessary digital infrastructure to support various operational and communication needs.

Together, these variables offer a comprehensive look at the technological infrastructures, capabilities and adaptation within regions, aiming to enhance digital readiness and technology-driven growth.

3. Methodologies

3.1 Data Preparation

In the process of preparing the dataset for the construction of a composite indicator for education, particular attention was given to the management of missing values and the treatment of outliers, ensuring the robustness and reliability of our results **[3]**.

On one hand, addressing missing values is essential for maintaining the integrity of the dataset. Incomplete data can lead to biased estimates and reduce the efficiency of the analyses. To tackle this, we utilized the Multiple Imputation by Chained Equations (MICE) method. The MICE algorithm is a robust imputation technique that involves multiple iterations to fill in missing data. It creates several different plausible imputations by modelling each missing data point as a function of other available data in the dataset. Each missing value is replaced with a set of plausible values that represent the uncertainty around the true value.

This process generates multiple completed datasets, allowing for comprehensive statistical analysis that accounts for the uncertainty inherent in the imputation process.

By using the MICE algorithm, we ensure that the imputed values maintain the statistical properties of the original data, providing a sound basis for subsequent analysis. For instance, the value for "Early school leavers" in Burgenland, which was originally missing, was imputed using this method.

On the other hand, to address the issue of outliers – data points that deviate markedly from other observations and can skew the results – we implemented the technique of Winsorization on variables exhibiting significantly skewed distributions. Specifically, distributions characterized by absolute skewness greater than 2 and kurtosis exceeding 3.5 were modified. Winsorization involved adjusting the extreme values to reduce the influence of outliers. For instance, in the variable *Low achievement in reading (15-year-olds),* which displayed a kurtosis of 3.7238502, the Winsorization process adjusted values by setting the lowest and highest 5% of the data to the 5th and 95th percentiles, respectively. This method effectively reduces the impact of outliers by limiting the range of the data and brings the distribution closer to normality, thereby stabilizing variance and making statistical analysis more reliable.

Through these data preparation steps – imputation of missing values through the MICE algorithm and Winsorization of outliers – we ensured that the dataset was well-suited for developing a reliable and meaningful composite indicator for education. These procedures not only enhance the quality and usability of the data but also bolster the credibility of the analysis, providing a solid foundation for subsequent evaluative and predictive assessments in the educational and technological readiness domains.

3.2 The Education Index

The Education Index was developed to provide a comprehensive measure of the educational performance obtained through the mean of the considered variables. Those variables were firstly normalized to ensure comparability and then adjusted in order to consider their inherent negative implications **[4]**.

The normalization of variables was done using the Min-Max scaling technique. This method adjusts the data to a common scale, specifically a 0 to 1 range, enhancing the comparability across different educational metrics. By calculating the minimum and maximum values for each variable across the dataset, each score is transformed based on its relative position between these two integrating points. This normalization is crucial for diverse data into a single, coherent index, as it mitigates the effects of varying scales and units of measurement among the variables.

Concerning the variables that negatively impact the index – where higher values indicate undesirable outcomes – an inversion was necessary in order to align them with the index's goal of higher scores reflecting better educational outcomes. For instance, variables such as low achievement rates in reading, maths and science, early school leavers and lower-secondary completion only are inverted by subtracting each value from 1. This reversal transforms the data so that higher values now signify better, ensuring that all variables contribute performance positively to the index.

Once all variables are normalized and appropriately adjusted, they are integrated into a composite Education Index. This is achieved by calculating the average of the normalized scores of the education, thus providing a holistic measure of the region's educational landscape.

By employing rigorous data normalization techniques and careful consideration of variable impacts, the Education Index serves as a robust tool for understanding and improving educational outcomes across diverse regions.

3.3 Linear Model

To explain the Education Index using variables related to technological levels, we adopted a linear regression model based on a systematic approach to data preparation and analysis.

Initially, we normalized the independent variables related to the technological readiness so that the region with the highest value for each variable was scaled to 1, while the region with the lowest value was set to 0, as we did for the educational variables. This normalization ensured comparability across variables and facilitated a more intuitive interpretation of the results.

Subsequently, we calculated the linear correlation between the education index and the technological variables. The observation of high levels of linear correlation indicated that a linear regression model would be the most appropriate choice given the circumstances. We then incorporated all available independent variables related to technological levels into the model to capture the full range of influences on the education index.

To refine the model, we employed the stepwise selection method using the step function to determine if excluding any covariates would improve the model's performance. The final model, however, confirmed that the inclusion of all independent variables yielded the best results, as indicated by the Akaike Information Criterion (AIC). This suggests that the comprehensive inclusion of technological variables is crucial in accurately modelling the Education Index.

4. Results

4.1 The Education Index

The Education Index, developed through the analysis of educational indicators, serves as a critical tool for evaluating and comparing educational performance across EU regions. This index reflects a comprehensive measure of the educational landscape, integrating aspects such as literacy rates, higher education attainment, and lifelong learning opportunities.

A higher Education Index suggests that a country has a well-developed educational system, where individuals are more likely to have access to quality education, leading to higher literacy rates and improved social outcomes. Conversely, a lower Education Index often points to systemic issues such as inadequate educational infrastructure, economic constraints or social inequalities, which can hinder the overall development of a region.

The map shown in figure 1 illustrates the Education Index across various regions in Europe, highlighting significant disparities in educational outcomes across the European Union. The index values are color-coded, with green shades representing higher education levels and red shades indicating lower education levels.

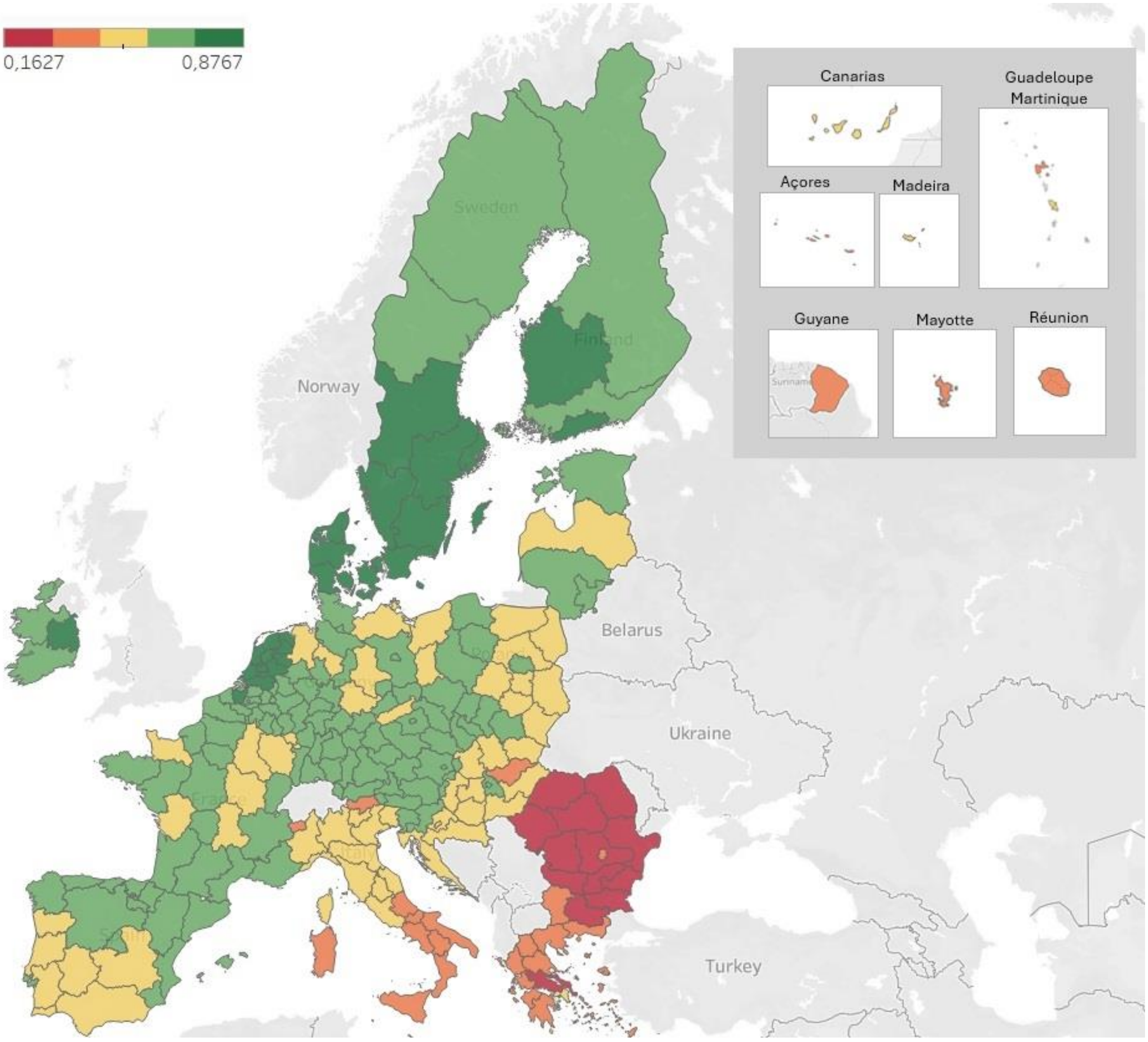

FIGURE 1 – EDUCATION INDEX ACROSS DIFFERENT EU REGIONS

The map clearly shows that **Northern European countries** such as Sweden and Finland exhibit the highest Education Index scores. These regions are depicted in dark green, suggesting a strong educational infrastructure, high literacy rates and widespread access to quality education. Finland, in particular, is well-known for its exemplary education system, which emphasizes equal opportunity and produces consistently high student performance. Finland's success can be attributed to its emphasis on equal educational opportunities, which is evident in its policy of providing free education from preschool to university. The commitment of these Northern European nations to education is further reflected in their substantial public investment in education, with both Finland and Sweden spending a significant percentage of their GDP on education, respectively 6% and 6.3% compared to the countries belonging the Organisation for Economic Co-operation and Development (OECD) average 5.0%, ensuring that all citizens have access to high-quality learning opportunities **[5]**.

Moreover, **Western European countries**, including Germany, France, Belgium, also perform well, mostly represented in green to yellow hues. This indicates generally high educational standards with some regional variations. Areas closer to economic hubs and large cities tend to have better education outcomes, while more rural areas might slightly underperform in comparison. Nonetheless, education in Western Europe remains robust, supported by substantial public investment and well-developed educational policies.

In contrast, **Southern European countries** like Spain, Italy, Greece, and Portugal are marked with orange and yellow colors, indicating lower scores on the Education Index. The lower performance in these regions may be attributed to various factors, including economic disparities, higher levels of unemployment and, in some cases, challenges in public education funding. Greece, in particular, shows significant regional variation, with some areas severely lagging behind, possibly due to the lingering impacts of the financial crisis. For instance, Eurostat data highlights that these countries have some of the highest youth unemployment rates in Europe, with Greece and Spain often exceeding 30% in recent years **[6]**. The Organisation for Economic Co-operation and Development (OECD) has pointed out that schools in less affluent areas often struggle with inadequate funding, which can lead to larger class sizes, outdated materials and insufficient support for students **[7]**.

These factors collectively contribute to the lower performance of Southern European countries on the Education Index, highlighting the complex interplay between economic conditions, public policy, and educational outcomes.

Eastern European countries, including Romania, Bulgaria and parts of the Balkans, are predominantly shaded in red, signifying the lowest Education Index scores across the EU. These regions face significant educational challenges, often related to economic difficulties, limited access to resources, and lower government spending on education. Data from the World Bank shows indeed that public expenditure on education as a percentage of GDP is significantly lower in Eastern European countries. Romania, for example, allocates around 3.7% of its GDP to education, compared to the European Union average of 4.9% **[8]**.

Finally, **Central European nations** like Poland, Czechia, and Hungary exhibit a mix of yellow and light green shades, indicating mid-range scores on the Education Index. These countries have made significant progress in improving their education systems over recent decades but still face challenges, particularly in rural areas where access to high-quality education may be more limited.

Moreover, analysing the top and bottom EU regions (figure 2 and figure 3) based on the Education Index provides a vivid contrast in educational performance and highlights regional disparities in educational opportunities and outcomes.

Region	Education Index
Hovedstaden (DK)	0.877
Stockholm (SE)	0.865
Utrecht (NL)	0.844
Sydsverige (SE)	0.828
Helsinki-Uusimaa (FI)	0.827

FIGURE 2 - TOP 5 EU REGIONS

Regions like Hovedstaden (DK) and Stockholm (SE), with education indices of 0.877 and 0.865 respectively, exemplify the impact of effective educational policies. In Hovedstaden, strong performance is evident in the not-low achievement of students under 15 years old in reading (0.95), maths (0.86) and science (0.74), alongside impressive figures for higher educational attainment (0.87) and lifelong learning (0.74). Similarly, Stockholm demonstrates solid outcomes in reading (0.86) and maths (0.76) among students under 15, supported by exceptional scores in lifelong learning (1.00 - which means that is the best one in EU) and higher education attainment (0.91).

Other regions, such as Utrecht (NL), Sydsverige (SE) and Helsinki-Uusimaa (FI), also demonstrate high educational standards, with indices of 0.844, 0.828, and 0.827 respectively. Utrecht's high values in higher education attainment (0.81) and re-engagement of early school leavers (0.84), along with Sydsverige's significant score in lifelong learning (0.98) and Helsinki-Uusimaa's focus on reducing underachievement in science (0.89) among students under 15 years old and ensuring university accessibility (0.97), highlight their commitment to fostering educational excellence.

Region	Education Index
Yugoiztochen (BG)	0.163
Severozapaden (BG)	0.166
Sud-Est (RO)	0.191
Nord-Est (RO)	0.194
Yuzhen tsentralen (BG)	0.206

FIGURE 3 - BOTTOM 5 EU REGIONS

On the other hand, regions such as Severozapaden (BG) and Nord-Est (RO), with education indices of 0.166 and 0.194 respectively, reflect challenges in their educational systems. In Severozapaden, low performance is notable in higher educational attainment (0.153) and lifelong learning (0.011), with a low value of enterprises having fixed broadband access (0.13), limiting digital opportunities. Similarly, Nord-Est struggles with poor results in reading and maths among students under 15 years, achieving minimal lifelong learning engagement (0.052) and facing a high rate of early school leavers (0.362).

Other regions, like Yugoiztochen (BG) and Sud-Est (RO), also face difficulties, with education indices of 0.163 and 0.191 respectively. Yugoiztochen has extremely low lifelong learning participation (0.005) and struggles with low higher educational attainment (0.217). Meanwhile, Sud-Est (RO)'s focus on addressing underachievement in science is critical, as it shows a significant gap in university accessibility (0.462), reflecting broader systemic issues in these regions' commitment to enhancing educational outcomes.

Understanding the Education Index is essential for policymakers, educators, and development agencies as it provides insights into the effectiveness of educational systems and highlights areas that require targeted interventions. By analysing the Education Index across different regions, disparities in educational access and quality can be identified, enabling to design and to implement policies that promote educational equity and contribute to the broader goals of economic development and social progress.

The map reflects a broader trend in Europe, where educational outcomes are generally stronger in the wealthier, more developed northern and western regions, while southern and eastern areas struggle with lower education levels.

The contrast in education quality between Eastern and Western Europe highlights the pressing need for reforms and increased investment in the education sector. Addressing these disparities is crucial for ensuring equitable access to education and for fostering social and economic development across the European Union.

The educational gap not only reflects broader socio-economic inequalities but also poses a significant barrier to achieving the EU's goals of cohesion and integration.

4.2 Technological impact on education

To quantitatively evaluate the impact of technological readiness on the Education Index, a regression model was constructed, revealing the pivotal role technology plays in shaping educational outcomes.

The selection of variables, shown before, encompasses various dimensions of technological integration and usage, ensuring a comprehensive analysis. The results of the regression analysis unequivocally demonstrate a robust positive correlation between technological factors and educational performance across different regions, underscoring the critical influence of technological advancement on education.

The regression coefficients, which are detailed in the table below, provide clear insights into the relationship between technology and education:

Variable	Coefficient
Intercept	0.13465
Households with broadband access	0.09930
Individuals buying over internet in the last year	0.27136
Access to high-speed broadband	0.04811
Individuals with above-basic overall digital skills	0.04170
Enterprises having received orders online (at least 1%)	0.06606
Enterprises with fixed broadband access	0.20840

FIGURE 4 – COEFFICIENTS OF THE REGRESSION MODEL

Analysing more precisely the table, two different considerations can be done:

- **Broadband Access and Online Engagement (first three variables):** the most pronounced positive effects on the Education Index are attributed to variables related to internet access and digital engagement by both individuals and businesses. This suggests that not only the access to the internet is crucial, but active participation in the digital economy is vital for educational advancement. For instance, regions where a higher percentage of individuals purchase goods online or where there is greater broadband penetration tend to exhibit better educational outcomes.
  Notably, the high coefficient for *Individuals buying over internet in the last year* (0.27136) indicates that this variable has a disproportionately large impact on educational outcomes compared to other factors. Since all variables in the model are normalized, the magnitude of the coefficients directly reflects the relative importance of each factor, allowing us to draw meaningful comparisons. Therefore, the large coefficient highlights the importance of digital engagement and online participation, as purchasing goods online reflects digital literacy and confidence in using technology. Individuals who actively engage in online commerce are likely to possess the digital skills necessary to access educational resources, interact with digital platforms and participate in remote learning environments. The significance of this variable underscores that access alone is insufficient – active digital engagement is a key driver of educational success.
  This trend is particularly evident in Northern European countries such as Finland, Sweden, and Denmark, which have consistently ranked among the highest in both the Education Index and digital readiness. For example, according to Eurostat, Finland boasts a broadband penetration rate of over 95% and has implemented comprehensive digital literacy programs that integrate ICT (Information and Communication Technology) into the national curriculum from early education levels **[9]**.
- **Digital Literacy and Business Technology (last three variables):** positive coefficients associated with digital skills and business technology readiness imply that regions with higher levels of digital competence and more technologically advanced businesses experience superior educational outcomes. This finding indicates that educational success is closely linked to the broader technological ecosystem, encompassing both individual digital capabilities and business readiness to embrace technology.
  The strong coefficient for *Enterprises with fixed broadband access* (0.20840) suggests that business-level digital readiness contributes significantly to educational success. The normalization of the variables ensures that this coefficient, like the others, reflects the relative impact of business technology on educational outcomes, providing a clear comparison across different factors. Hence, the high coefficient highlights the interconnectedness between the technological infrastructure of businesses and educational outcomes, as enterprises with reliable internet access foster an environment that enhances digital literacy within the workforce and the community at large. When businesses are technologically equipped, they contribute to creating a digitally competent workforce, which, in turn, supports educational achievement. Additionally, regions with digitally advanced enterprises generate a stronger demand for skilled labour, incentivizing education systems to focus on producing graduates who are proficient in digital skills.
  For instance, Denmark's "National Digital Strategy" has significantly contributed to creating a digitally competent workforce, which in turn supports educational achievement **[10]**.

However, while Northern European countries have made significant strides in leveraging technology to enhance educational outcomes, Southern European regions face several challenges. The disparity in digital infrastructure and skills between the North and South of Europe is stark. For instance, in regions like Southern Italy, Greece, and parts of Spain, broadband access remains limited, with penetration rates often below 70% **[11]**. This digital divide directly impacts educational performance, as students and educators in these regions lack the necessary resources to fully participate in the digital economy. Furthermore, digital literacy levels are generally lower in these areas, exacerbating the difficulties in integrating technology into educational systems.

A major issue in Southern European regions is the limited investment in digital infrastructure and education. In many NUTS regions of Southern Europe, public spending on education and digitalization initiatives is lower compared to their Northern counterparts. For example, public expenditure on education as a percentage of GDP in Greece was only 3.9% in 2021, compared to 7.0% in Sweden **[12].** This underinvestment leads to a lack of access to modern educational technologies, which hampers efforts to improve educational outcomes.

In conclusion, the regression analysis reinforces the imperative for targeted investments in both technological infrastructure and human capital. By focusing on both technology and digital literacy, policymakers can foster educational systems that are resilient, adaptable, and capable of thriving in the digital age. Such strategies are fundamental to ensuring that educational improvements are sustainable and equitably distributed across all regions, particularly in those areas currently lagging behind in digital readiness.

4.3 Other considerations

To gain a deeper understanding of the structural characteristics of countries based on their Education Index, we conducted a series of scatterplot analyses.

These visualizations compare the education index against several critical indicators that reflect the overall welfare of a nation.

Specifically, we examined the relationship between educational attainment and key factors such as GDP per capita (intended as the average of the values recorded between 2018 and 2020), corruption levels (recorded in 2021), employment rate in 2021 (excluding the agricultural sector) and NEET (Not in Education, Employment, or Training) rate (intended as the average of the values recorded between 2019 and 2021). By juxtaposing the education index with these diverse metrics, we aimed to uncover potential correlations and insights that could illuminate how educational outcomes influence, and are influenced by, broader socioeconomic conditions.

- **GDP per capita**

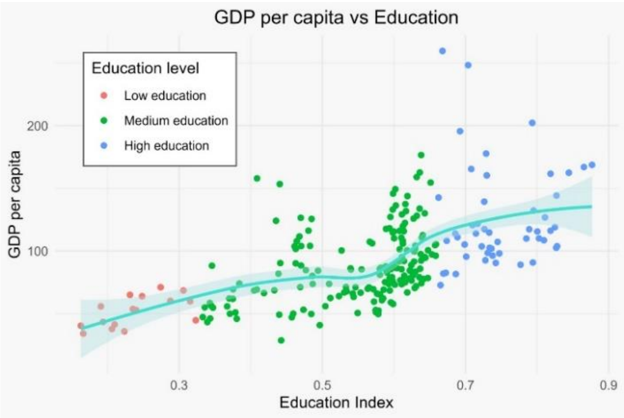

FIGURE 5 - GDP PER CAPITA AND EDUCATION INDEX

The scatter plot in figure 5 visualizes the relationship between GDP per capita and Education Index across different regions, categorized into low, medium, and high education levels. Each point on the plot represents a specific region, with its position determined by GDP per capita on the vertical axis and the corresponding educational index on the horizontal axis.

The data is color-coded to differentiate between regions with low education (red), medium education (green), and high education (blue).

A clear trend emerges as the education level increases: regions with higher education indices tend to have a higher GDP per capita, as evidenced by the upward slope of the trend line.

Despite the positive association between education and GDP per capita, there are notable exceptions worth highlighting.

For instance, Mayotte, the region with the lowest GDP per capita (28.68), achieves a medium education index of 0.442, deviating from the general trend that associates lower GDP per capita with lower educational attainment. 0.442 is a crucial threshold below which we can find the first and the fourth

Italian region for GDP per capita: Provincia Autonoma di Bolzano/Bozen (with a GDP per capita equal to 153.42 and an education index equal to 0.440) and Valle d'Aosta (with a GDP per capita equal to 124.13 and an education index equal to 0.435).

On the other hand, Luxembourg, which boasts the highest GDP per capita (259.660), has an education index of 0.668. This figure, while relatively high, falls significantly short of the highest education index recorded - 0.887 in Hovedstaden, Denmark. This stark contrast in Luxembourg makes it clear that GDP per capita is far from being solely dependent on the level of education.

- **Corruption**

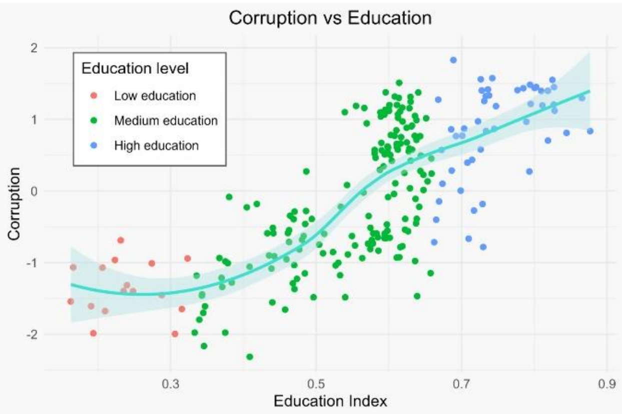

FIGURE 6 - CORRUPTION AND EDUCATION INDEX

The scatter plot shown in figure 6 illustrates the relationship between the Education Index and perceived corruption levels across various EU regions (note that, concerning the variable Corruption, higher values represent the better situations).

As the Education Index increases, there is a noticeable trend where regions with higher educational attainment tend to experience lower levels of corruption, as indicated by the downward slope of the trend line in the lower range of the education index.

However, as the education index moves toward higher values, the corruption index initially shows a slight increase before stabilizing, highlighting a more complex relationship.

This trend suggests that while higher education levels are generally associated with reduced corruption, other factors may influence this relationship at different stages of educational development.

- **Employment rate (excluding agriculture)**

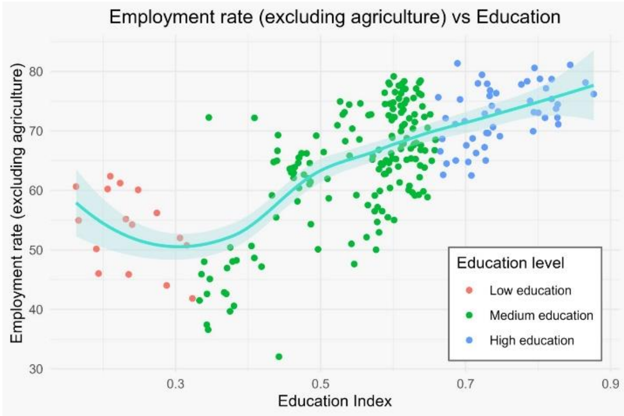

FIGURE 7 - EMPLOYMENT RATE AND EDUCATION INDEX

The scatter plot in figure 7 illustrates the relationship between the Education Index and the employment rate (excluding agriculture) across various EU regions.

As in the previous visualisations, there exists a positive correlation between the two variables: the plot reveals a general trend where regions with higher education indices tend to have higher employment rates. Interestingly, the plot suggests that regions with medium education levels exhibit a wider range of employment rates, while those with high education levels tend to cluster around higher employment rates.

Moreover, the scatter plot offers insightful observations within the employment rate range of 60 to 65. In this interval, we observe the coexistence of regions with both low and high education levels, a finding that underscores the complex dynamics at play.

Specifically, within this employment rate range, there are five regions classified under low education - four from Bulgaria and one from Romania. Simultaneously, this same range includes four regions categorized as having high education levels: one from Belgium (Brussels), two from Spain and one from Ireland.

This overlap suggests that similar employment rates can be achieved under significantly different educational conditions. The presence of both low and high education regions within this employment band challenges the assumption that higher education levels universally correspond to higher employment rates, indicating that regional economic, social and policy factors may also play pivotal roles in shaping employment outcomes.

Furthermore, if we were to assess the efficiency of educational systems based solely on skill mismatch, it becomes evident that both the low-education regions and the high-education regions in this employment rate range prepare students equally well for entering the local labor market.

This observation challenges the assumption that higher educational attainment automatically leads to better employment outcomes, highlighting the complex interplay between education and regional employment dynamics.

- **NEET rate**

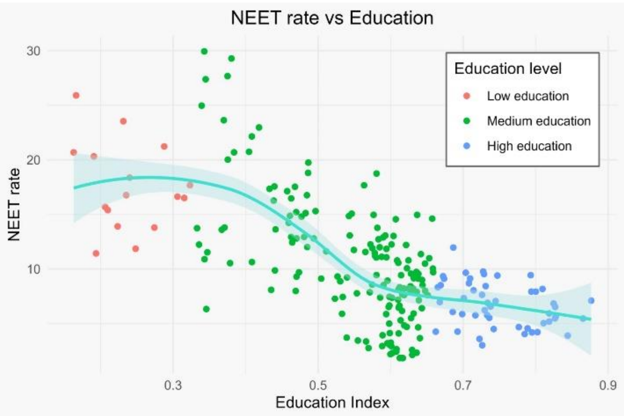

FIGURE 8 - NEET RATE AND EDUCATION INDEX

The plot in figure 8 depicts the negative relationship between the Education Index and the NEET (Not in Education, Employment, or Training) rate across various EU regions.

This inverse relationship, highlighted by the downward-sloping trend line, suggests that regions with better educational outcomes tend to have fewer individuals who are not engaged in education, employment, or training. The plot further illustrates that regions with high education levels consistently report the lowest NEET rates, emphasizing the critical role of education in reducing the prevalence of youth disengagement across regions.

5. Conclusions

This report uncovers the impact that technological advancement has on education across diverse EU regions. As the analysis unfolded, it became evident that regions equipped with more sophisticated digital infrastructures are not just better prepared for the future but are already reaping the benefits through enhanced educational outcomes. This observation reinforces the idea that the embrace of technology and the cultivation of digital skills are not merely supportive elements but foundational pillars in the architecture of modern educational systems.

Moreover, the interplay between education and broader socio-economic factors emerges with clarity. Higher education levels tend to align with greater economic prosperity, lower corruption, and improved employment rates, painting a picture of how education serves as both a reflection of and a trigger for a region's overall well-being. Yet, there are some exceptions, reminding us that the relationship between education and socio-economic conditions is nuanced and multifaceted.

As we look to the future, there is a rich landscape for further exploration. Delving deeper into the quality of education in the context of technological evolution could reveal new insights, particularly if we consider factors like public investment in educational technology and the equitable distribution of digital resources. Additionally, tracing the temporal shifts in the relationship between technology and education may offer a more detailed understanding of how we can bridge regional disparities and cultivate inclusive growth across Europe.

The story of education and technology is far from complete, and this report serves as a stepping stone toward a deeper, more nuanced understanding of this relationship.

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