

The Role of AI-Driven Personalized e-Learning in Enhancing Economic Competitiveness: A Comparative Analysis of Developed And Developing Countries

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Abstract: This study explores the influence of AI-driven personalized e-learning on the Global Competitiveness Index (GCI) across six countries, comprising three developed (USA, Germany, Japan) and three developing (Pakistan, India and Nigeria) nations, over a span of 17 years (2007-2023). Utilizing a least squares regression model, the analysis incorporates key variables including the Artificial Intelligence Global Index (AIGI), Human Development Index (HDI), and R&D expenditure as control variables to assess their impact on GCI. The model demonstrates a robust fit, with an R^2 value of 96.79% and an adjusted R^2 value of 96.50%, indicating that AI-enhanced e-learning is a significant predictor as independent variables of economic competitiveness GCI. The findings underscore the significant role of investment in AI and e-learning technologies, particularly in enhancing economic competitiveness, as evidenced by strong positive correlations between GCI and AIGI, HDI, and R&D expenditure. The results are consistent with IBM's research, which highlights the importance of these variables in driving national competitiveness in the global market. The study concludes that AI-driven personalized e-learning is a critical lever for improving GCI, particularly for developing countries aiming to close the competitiveness gap with developed nations. The implications of this research suggest that targeted investments in AI and e-learning can substantially contribute to sustainable economic growth and international competitiveness. This study offers valuable insights for policymakers and educational institutions aiming to enhance their nation's competitiveness through strategic investments in AI-driven educational technologies.

Keywords: Global Competitiveness Index (GCI), Artificial Intelligence (AI), Developed and developing countries, E-learning, Human Development Index (HDI)

1. Introduction

The society is incorporating Artificial Intelligence (AI) in its all levels and is regarded as the 21st century's most important technological innovation. AI-based personalized e-Learning in education is emerging as a path for developing learning skills that suit individual needs and abilities. Education is being linked to economic competitiveness as the global economy shifts towards knowledge based activities. This research investigates skill-based e-learning's role in improving economic competitiveness, making comparisons between two sets of countries, set one includes United States, Japan, Germany, marked as 'developed' and set two includes Pakistan, India, and Nigeria which are named the developing. This study aims to show how educational progress affects a country's economy by examining the impact of AI-enabled personalized e-learning on the Global Competitiveness Index (GCI). However, understanding its specific effect for job competitiveness shows a significant variation. The relationship between GCI and AI-enabled self-learning has not yet been explored, especially through international comparisons. This study focuses on several important questions: What is the relationship between AI-enabled personal e-learning and GCI in developed and developing countries? What are the challenges facing success of AI-enabled personal learning?

To navigate these questions, the following hypotheses are posited:

H1: *AI-driven personalized E-learning significantly enhances economic competitiveness, as measured by the Global Competitiveness Index (GCI).*

H2: *The impact of AI-driven personalized E-learning on economic competitiveness is greater in developed countries compared to developing countries, due to differences in technological infrastructure and educational systems.*

H3: *The effectiveness of AI-driven personalized E-learning in improving workforce skills and educational outcomes is a key mediator in the relationship between AI-driven personalized learning and economic competitiveness.*

Countries such as the United States, Germany and Japan, which are known as developed in the context of e-learning systems with high GDP per capita and high Human Development Index (HDI), and robust GCI rankings provide an advantageous environment for the adoption and effective implementation of AI-driven personalized learning. The United States, a leader in AI technology, leverages significant AI applications in education to enhance learning outcomes and maintain its competitive edge. Germany's advanced digital infrastructure and high Programme for International Student Assessment (PISA) scores highlight its integration of AI to foster educational excellence. Japan's substantial investment in AI and educational technology underscores its strategic focus on leveraging AI to sustain its competitive advantage.

In contrast, developing countries like India, Pakistan, and Nigeria face a mix of opportunities and challenges. These nations exhibit lower GDP per capita and GCI rankings but demonstrate growing interest and investment in AI-driven educational technologies. India, with its burgeoning AI sector and increasing ed-tech investments, exemplifies a dynamic environment for AI adoption in education. Pakistan, at the early stages of AI integration, and Nigeria, with its developing digital infrastructure, showcase the nascent yet promising potential for AI to transform their educational landscapes and enhance economic competitiveness.

Learning models have emerged as a revolutionary approach that has the potential to improve educational outcomes and increase economic competitiveness. However, there are differences in the adoption, use and impact of these technologies between developed and developing countries. This study focuses on examining the role of knowledge-based personal e-learning in improving economic competitiveness and compares developing countries (United States, Japan, Germany) with developing countries which are Pakistan, India, Nigeria. This study focuses to elaborate the direct and indirect effects of intelligence in the Global Competitiveness (GCI) study by examining the main factors that support or hinder its profit in different markets. By analyzing these factors and their effects, this research will add value to the international debate for the integration of intellectual skills in academics which benefits businesses and governments to promote economic growth and close the competitive gap between developed and developing countries.

2. Literature Review

Intelligent tutoring systems employing AI methodologies offer customized educational delivery, monitor learner progression, and provide bespoke feedback. These systems emulate the advantages of one-on-one human tutoring, significantly bolstering educational outcomes. By tailoring to the individual requirements and learning styles of students, intelligent tutoring systems can deliver a highly personalized educational experience that surpasses the limitations of conventional classroom environments (Aleven, McLaughlin, Glenn, & Koedinger, 2016). Educational data mining facilitates the examination of extensive datasets to reveal patterns and insights that can shape personalized learning strategies. By harnessing AI, educational institutions can attain a profound comprehension of student behaviors, learning preferences, and academic performance, which can be utilized to customize instruction and support to individual needs (Baker & Yacef, 2009). AI technologies in education possess the potential to offer personalized support, oversee student progress, and adjust instruction to align with individual learner needs. This personalized approach can result in enhanced educational outcomes, elevated student engagement, and a more streamlined learning process (Besterfield-Sacre, Cox, Borrego, Beddoes, & Zhu, 2014). AI applications in education are rapidly proliferating, presenting new opportunities for personalized learning, improved educational management, and heightened student performance. By delivering real-time feedback, adaptive content, and individualized learning experiences, AI can revolutionize traditional educational practices and support the development of 21st-century skills (Chassignol, Khoroshavin, Klimova, & Bilyatdinova, 2018). AI-driven personalized learning platforms are capable of identifying individual student needs and adapting instructional content to optimize learning outcomes. These platforms utilize algorithms to analyze student data, forecast learning trajectories, and provide tailored resources and support, thereby enhancing the overall learning experience (Chen, Cheng, & Lin, 2019). A comprehensive strategy for designing AI-driven personalized learning systems entails considering the learners' cognitive, emotional, and social dimensions. By integrating AI technologies with pedagogical principles, these systems can offer a holistic approach to personalized learning, addressing the diverse needs of students and fostering deeper engagement with the learning material (Chen, Xie, & Hwang, 2020). AI-powered educational technologies can facilitate personalized learning by offering tailored feedback, adaptive content, and individualized learning experiences. These technologies can also promote collaborative learning and peer interactions, creating a more dynamic and engaging educational environment (Grover, Pea, & Cooper, 2015). The integration of AI in education supports personalized learning, data-driven decision-making, and overall efficiency improvements in educational systems. By automating routine tasks and providing personalized instruction, AI can enable educators to devote more time to complex and creative teaching aspects (Hao, Li, & Peng, 2017). AI-driven personalized learning

systems can offer real-time feedback, adapt to students' learning paces, and present customized content, which can enhance educational outcomes and efficiency. These systems also support formative assessment practices, helping educators identify learning gaps and address them promptly (Holmes & Tuomi, 2017). Meta-analytic reviews demonstrate that intelligent tutoring systems, which utilize AI for personalized learning, significantly boost student achievement compared to traditional instructional methods. These systems provide immediate feedback, adjust to individual learning styles, and offer a highly interactive learning experience (Kulik & Fletcher, 2016). The student-centered design of AI classrooms suggests creating an environment where AI supports individualized learning opportunities and encourages student autonomy. Tutoring can provide flexible instruction and immediate feedback, allowing students to take control of their own learning and achieve their learning goals (Luckin, 2008). Education is tailored to the needs and abilities of each student. This approach can improve learning outcomes, increase student engagement, and encourage the development of critical thinking and problem solving (Luckin, Holmes, Griffiths, & Forcier, 2016). AI technology is revolutionizing education by providing more personalized, engaging, and effective learning. These technologies support differentiated instruction, provide immediate feedback, and support the development of 21st century skills (Majumdar, 2015).

Online and blended learning environments, enhanced by AI technologies, offer opportunities for personalized instruction and flexible learning pathways. These environments support self-paced learning, provide immediate feedback, and adapt to individual learning needs, thereby improving educational outcomes (Means, Toyama, Murphy, Bakia, & Jones, 2010).

AI in education can facilitate self-directed learning, work for management, and provide data from insights to inform policy and practice. Schools can increase the efficiency and effectiveness of their work and improve students' overall learning through the use of technology (Miao, Holmes, Huang, & Zhang, 2020). Influence teaching and learning processes so that learning is more flexible and adaptable to the needs of individual students. AI technologies can provide personalized feedback, support independent learning, and foster the development of critical thinking (Popenici & Kerr, 2017). Improving learning outcomes: Adaptive teaching. Through the use of technology, teachers can create a dynamic and interactive learning environment that meets the diverse needs of students (Rose & Woolf, 2008). Education is freedom from traditional education. Schools can provide effective and engaging learning to students by harnessing the power of intelligence (Seldon & Abidoye, 2018). Prepare intervention plans to support student learning. This process can increase the accuracy and efficiency of the assessment process, allowing teachers to better understand and meet the individual needs of students (Shute and Zapata-Rivera, 2012). education to receive personalized education. These technologies support informed decision-making, improve teaching practices, and improve student outcomes (Tsai and Gasevic, 2017). By adapting to students' individual needs and learning styles, these methods provide personalized learning that keeps students engaged and successful (VanLehn, 2011). It is important to improve the teaching and learning process, and smart technologies play a significant role in this change. Artificial intelligence supports the development of students' thinking and problem-solving skills by enabling self-directed and adaptive learning (Wang and Woo, 2007). Artificial intelligence system and providing recommendations. These systems have the potential to transform learning by providing personalized learning experiences that increase student learning and engagement (Woolf, 2010).

AI in higher education enhances self-directed learning and academic achievement by providing personalized learning experiences through predictive analytics and customized feedback (Zawacki-Richter et al., 2019; Zhang et al., 2019). AI systems analyze educational data to tailor learning content and adapt to individual needs, potentially transforming traditional teaching practices into more effective ones. This technology supports diverse learning needs and improves outcomes by creating engaging, adaptive learning environments (Chung & Kim, 2018). However, the integration of AI faces challenges such as resistance from educators and data privacy concerns. Addressing these issues requires collaboration among policymakers, educators, and professionals to ensure effective integration into curricula (Huang & Hew, 2018). AI's potential to revolutionize education includes enhancing personalized learning, providing insightful feedback, and supporting teachers in developing complex teaching strategies, which could lead to improved student outcomes and more engaging educational practices (Spector & Kosslyn, 2018).

3. Data and Methodology

3.1 Data

This paper is based on secondary information and time series analysis for the period 1999-2023. The sources of information used in this research are extracted from the World Development Indicators that are 12 pillars of

global competitiveness for GCI, 6 developing indicators for AIGI and countries' AI adoption and implementation policies

3.2 Model Formation

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \beta_4 X_{4t} + \gamma_1 C_{1t} + \gamma_2 C_{2t} + D_{1t} + \epsilon_t$$

Where:

- Y_t is the dependent variable (GCI) at time t .
- $X_{1t}, X_{2t}, X_{3t}, X_{4t}$ are the independent variables (LAIGI, GCIAI, MHTM, HTEM) at time t .
- C_{1t}, C_{2t} are the control variables (REXP and HDI) at time t .
- β_0 is the intercept term.
- $\beta_1, \beta_2, \beta_3, \beta_4$ are the coefficients for the independent variables.
- γ_1, γ_2 is the coefficient for the control variables.
- D_1 is the dummy variable to compare the developed and developing countries at times.
- ϵ_t is the error term, representing the difference between the observed and predicted values of Y at time t .

4. Empirical Results

Table 1: Descriptive Statistics

Parameters	GCI	LAIGI	GCIAI	MHTM	HTEM	REXP	HDI	D1
Mean	69.450	-1.636	4644.606	43.385	10.959	1.451	0.692	0.500
Median	75.570	-0.200	4967.880	45.347	10.628	0.725	0.640	0.500
Maximum	92.790	25.560	8184.677	81.531	26.523	3.468	0.950	1.000
Minimum	47.530	-54.760	358.432	0.000	0.000	0.000	0.000	0.000
Std. Dev.	13.986	9.585	1826.702	29.922	8.423	1.416	0.253	0.502
Skewness	-0.124	-3.131	-0.112	-0.1585	0.044	0.202	-0.968	0.000
Kurtosis	1.605	16.724	1.881	1.389	1.480	1.180	3.720	1.000
Jarque-Bera	8.523	967.159	5.536	11.448	9.857	14.768	18.127	17.000
Probability	0.014	0.000	0.0628	0.003	0.007	0.0006	0.0001	0.0002
Sum	7083.890	-166.840	473749.80	4425.242	1117.798	148.015	70.589	51.000
Sum Sq. Dev.	19757.170	9278.673	337,000,000	90,430	7,166	203	6.509	25.500
Observations	102	102	102	102	102	102	102	102

Source: Author's own compilation

Using the provided coefficients from results, the analysis was conducted using a panel least squares method, with the Global Competitiveness Index (GCI) as the dependent variable. The dataset spans from 2007 to 2023, covering 17 periods across 6 cross-sections. This balanced panel includes a total of 102 observations, we can specify the equation as:

Table 2: Regression Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	38.13874	8.063954	4.729534	0.000

AIGI	1.123226	0.108015	10.39882	0.000
MHTEM	0.001699	0.021093	0.080549	0.936
HTEM	0.061719	0.075627	0.816097	0.416
REXP	0.981183	0.619862	1.582905	0.117
HDI(-1)	29.77479	10.64996	2.795764	0.006
D1	12.82874	2.956971	4.338474	0.000
Goodness of fit of regression				
R²	0.967909	Adjusted R ²	0.964958	

Source: Author's own compilation

The regression analysis focuses on the impact of various factors, including AI-driven personalized e-learning, on the Global Competitiveness Index (GCI) across both developed and developing countries. Let's break down and interpret the results, and compare the effects between developed and developing countries.

β_0 : Constant (38.13874) represents the basic GCI score when all other independent variables are equal to 0. It indicates the initial critical level of competition between each country. Competition is very beneficial and beneficial to the GCI. For every 1-unit increase in AIGI, the GCI score will increase by 1.12 points, indicating that the advancement of AIGI has increased the economic competitiveness of countries. Government R&D expenditure (REXP): Coefficient: 0.981183, t-statistic: 1.582905

REXP has a positive effect on GCI, indicating that government R&D expenditure contributes to development competitiveness.

Human Development Index (HDI): Coefficient: 29.77479, t-statistic: 2.795764, p-value: 0.0064

Lagged HDI has a positive and significant effect, beneficial for GCI, indicating that improvements in human development significantly increase future competitiveness.

Interpretation: The dummy variable for developed countries has a large, positive, and statistically significant effect on GCI. This coefficient indicates that being a developed country is associated with an additional 12.83 points in the GCI score compared to developing countries, all else being equal.

The model demonstrates a strong fit with an R-squared of 0.9679, meaning it explains approximately 96.79% of the variability in the GCI. The Adjusted R-squared of 0.9650 confirms that the model maintains high explanatory power while accounting for the number of predictors. The F-statistic of 328.0058 with a p-value of 0 indicates that the overall model is highly significant. The low standard error of the regression (2.6400) underscores the precision of the model's predictions. The Akaike and Schwarz criteria support model selection. Overall, the model provides a robust fit to the data

A retrospective analysis of the key differences in the use of AI-enabled personal e-learning to enhance business competitiveness as measured by the Global Competitiveness Index (GCI) between developed and developing countries. The positive value of the negative variable D1 (12.82874) indicates that developing countries such as the United States, Germany, and Japan have higher GCI scores than developing countries such as Pakistan, India, and Nigeria. This suggests that AI-driven e-learning and technology development are more relevant to developing countries, mainly due to their better infrastructure, more investment, more R&D, and job stability. The findings showed that personal e-learning based on cognitive skills and improvements in the Human Development Index (HDI) play a significant role in enhancing competitiveness. In developing countries, the results show a positive impact on the GCI. The fit of the model is commendable with an R-squared value of 0.9679 and an adjusted R-squared value of 0.9649; This indicates that the model can explain almost 97% of the GCI variation well. These results demonstrate the power of the model and its ability to capture changes by showing the relationship between knowledge, R&D and competition. The impact of personal electronics on education is weaker than in developed countries. The positive coefficient of the Artificial Intelligence Global Index (AIGI) shows that advances in AI have helped increase the competitiveness of these countries. However, the most important change for developing countries is that the impact of AI is not a significant factor in developing economies. This can be attributed to factors such as limited digital infrastructure, poor skill

integration and competitiveness issues that prevent countries from benefiting from technological advances. Personalized e-commerce. These include technologies such as network access, high-speed connections and digital technologies that facilitate the use of intelligence in the learning process. In addition, high levels of government and private sector investment in research and development (R&D) have encouraged continued innovation in AI technology, resulting in more e-learning solutions. The higher Human Development Index (HDI) in developing countries, along with higher education, health, and living conditions, provide fertile ground for the development of AI-driven learning. play an important role. These arrangements often include funding for AI-related measures, regulatory frameworks that support digital transformation, and incentives for schools to adopt AI learning tools. This strategic partnership creates an environment that is conducive to the success of AI-driven personalized e-learning. Limiting the digital process is very difficult because many developing countries do not have good access to the internet and modern computer hardware required for the implementation of AI-driven learning solutions. Underfunding of education and technology further exacerbates the problem, as these countries often lack the financial resources to invest in AI tools and platforms. Low education (i.e. lower HDI scores) inhibits the use of good academic skills. Additionally, cultural and organizational resistance to change, including a lack of trained personnel, makes it difficult to implement and sustain AI systems in education. Developing countries should prioritize investment in digital infrastructure, support capacity building and training in AI skills, and create government incentives to support the adoption of AI in education. International collaboration and local development of AI-focused solutions based on the specific needs of developing countries can drive progress and help these countries benefit from AI technology.

According to the IBM Global AI Adoption Index 2022, AI adoption among businesses has grown to 35%, a 4% increase from 2021, driven by the enhanced accessibility of AI solutions. Companies are increasingly using AI to automate processes and reduce costs, though a significant gap remains between large and small companies. Larger companies are now twice as likely to have implemented AI, a sharp increase from the 69% likelihood in 2021. AI adoption varies across regions and industries, with companies in China and India leading at 60%, while lower adoption rates are observed in countries like South Korea (22%), Australia (24%), the US (25%), and the UK (26%). Notably, the automotive and financial sectors are advancing AI usage more aggressively than others.

Germany, Japan, and the US have moderate AI adoption rates, with larger companies driving the trend, supported by strong digital infrastructures. These countries are also increasingly adopting hybrid or multi cloud environments, with Germany showing a significant 41% adoption of mixed cloud services, while Italy lags at 23%. Globally, 53% of IT professionals reported accelerating AI adoption over the past two years, a marked increase from 43% in 2021, driven by the need for cost reduction and process automation. The evolution of AI technology has made it more specialized, easier to deploy, and supported by a more skilled workforce (38%). Larger companies are 70% more likely to use hybrid cloud environments than smaller firms, indicating a growing focus on sophisticated AI integration within major economies like the US, Germany, and Japan, which continue to lead global AI adoption.

5. Conclusions and Policy Recommendations

This study shows a positive relationship between AI-enabled personalized e-Learning and the Global Competitiveness Index (GCI) of developed and developing countries. In developed countries such as the United States, Germany, and Japan, the impact is greater due to advanced digital technologies, high levels of human development, and supportive government policies. In developing countries, although relations are still good, the impact is greater due to many challenges. The analysis highlights the persistent digital divide between developed and developing countries. Developing countries benefit from strong digital infrastructure, good education, and significant investments in research and development (R&D), which together increase the effectiveness of AI and promote e-learning for competitive development. On the other hand, developing countries face challenges such as poor infrastructure, poor education, and access to technology, which prevent AI from complementing their resources in these areas.): This study highlights the importance of AI-driven e-learning and the Human Development Index (HDI) in mediating economic competitiveness. High Human Development, which means better education outcomes, healthcare, and overall health, can improve a country's ability to develop smart skills in learning, thereby increasing its competitiveness. The key challenges facing developing countries include low technological infrastructure, insufficient funding for education and technology, skills, and reluctance to embrace new technologies. These challenges pose significant challenges for the successful integration of AI-powered personalized e-learning into education.

5.1 Policy Recommendations for Corporate Businesses

Businesses should invest in AI-driven e-learning platforms tailored to the technology and education sectors, enhancing employability and productivity in design and manufacturing. Collaborations with universities can develop skill-focused courses aligned with labor market needs, boosting employment and economic competitiveness. Additionally, corporate social responsibility (CSR) initiatives focused on investing in digital infrastructure and technology education in developing countries help bridge the digital divide, create new markets, and contribute to regional economic growth. Continuous development of programmatic e-learning platforms ensures the workforce remains adaptable in rapidly evolving sectors where technology and competition demand ever-changing skills.

5.2 Policy recommendation for Government

Governments, particularly in developing countries, should prioritize investments in digital infrastructure, such as expanding internet access and equipping schools with AI-compatible technologies. Public-private partnerships can fund skills-focused e-learning initiatives, with governments offering incentives for AI-driven education investments. Regulatory frameworks should promote innovation while safeguarding data privacy. Additionally, investments in healthcare, education, and R&D are essential for fostering an environment where AI can thrive. Expanding AI-focused courses, especially in developing nations, ensures students acquire the digital skills necessary to compete in an AI-driven global economy, enhancing both domestic and global competitiveness.

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