Economic Perspectives on Artificial Intelligence and the Digital Transformation of Education. A Case Study on Estonia

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Abstract
This paper delves into the integration of artificial intelligence within Estonia's education system, showcasing the country's global reputation for digital innovation. Utilising the method of the case study and the method of document analysis, we explore not only the practical outcomes, challenges, and strategies related to the adoption of artificial intelligence in the Estonian education system but also its economic implications. The research highlights artificial intelligence's potential to lead to cost efficiencies and economic benefits for the education sector. Furthermore, we address the critical issue of fostering artificial intelligence literacy among students, schools, and universities, pinpointing data privacy and ethical considerations as key areas of concern. The strategies implemented by educational institutions to mitigate these challenges and promote a comprehensive understanding of artificial intelligence are also discussed. In conclusion, the paper underscores artificial intelligence's transformative potential in reshaping education, offering guidance for other nations and academic entities aiming to successfully integrate artificial intelligence-based technologies. Emphasis is placed on the importance of a supportive policy framework and a solid ethical foundation to navigate the complexities of artificial intelligence adoption and ensure responsible use, while also considering the economic impact on the educational ecosystem and the labour market at large.

1. Introduction

The swift progress in technology has facilitated significant improvements across all sectors, with education being a prominent recipient of these advancements. Artificial intelligence has significantly transformed various aspects of society, exerting a profound influence on individuals' everyday routines, professional endeavours, and educational frameworks.

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The country of Estonia is widely acknowledged for its notable technical expertise and forward-thinking approach to incorporating artificial intelligence into its education system. Consequently, it serves as a subject of analysis for the case study that this article brings forward. This study explores the practical consequences of incorporating artificial intelligence into education, including the potential economic advantages such as cost effectiveness and the ability to respond to changes in the labour market. Additionally, it discusses the obstacles and difficulties that arise in the process. Moreover, this research delves into the strategic approaches employed by Estonia in leveraging artificial intelligence, providing valuable insights that can be applied on a worldwide scale.

This paper serves a twin purpose: firstly, to illustrate the transformative impact of artificial intelligence on education, and secondly, to advocate for the establishment of robust legal and ethical frameworks that facilitate the integration of these changes. This study contributes to the existing body of research by providing a comprehensive framework for countries and companies to adhere to when deploying artificial intelligence, ensuring its responsible and advantageous utilisation for economic purposes.

2. Review of the scientific literature

Artificial intelligence (AI) has the potential to tackle some of the most pressing issues in today's education, revolutionise teaching and learning methods, and expedite progress. However, the rapid pace of technological advancement brings with it numerous risks and challenges that have, thus far, outpaced discussions on policies and regulatory frameworks.

Chen, Chen and Lin (2020) note that artificial intelligence pertains to the advancement of machines possessing a certain degree of intelligence. As per their statements, these machines are capable of emulating human-like functions, encompassing cognitive processes, learning, decision-making, and adaptability to the surrounding environment. Consequently, certain distinctive features and principles emerge as fundamental in the context of AI. Intelligence, or the machine's capacity to exhibit a certain level of intellect and carry out a diverse array of functions and abilities akin to those of humans, emerges as a pivotal characteristic of AI.

The integration of artificial intelligence into education heralds a significant shift with far-reaching economic consequences. This literature review critically examines scholarly discourse on the subject, emphasising the economic dimensions of artificial intelligence's educational impact.

The education sector is likely to be heavily impacted by AI, making it one of the domains that could experience significant AI-driven changes. Timms (2016) makes an interesting observation, emphasising the formidable capabilities of artificial intelligence and its potential to deeply affect various sectors of society. It is already integrated and utilised within the field of education, contributing to enhancements across different aspects. Within the context of the narrative and framework proposed by Chassignol *et al.* (2018), it becomes clear that AI has been applied in education, particularly in roles related to administration and teaching, subsequently influencing and making an impact on students' learning.

AI-driven education is becoming increasingly significant as educational needs undergo transformation. This evolution encompasses crucial elements such as intelligent pedagogy, ground-breaking virtual learning experiences, data analysis, and predictive capabilities. In a study by Chen, Chen and Lin conducted in 2020, the authors outlined essential use cases for integrating AI into the realm of education, along with the key technologies that support them, as detailed in Table 1. According to their findings, intelligent educational systems offer timely and customised guidance and feedback to both educators and students. These systems are crafted to enhance educational value and efficiency by leveraging various computational technologies, particularly those associated with machine learning, which closely align with statistical models and cognitive learning theories, findings previously described by Rus *et al.* (2013).

Table 1. Scenarios of AI Education and related techniques

Scenarios of AI education	AI-related techniques
Assessment of students and schools	Adaptive learning methods and personalised learning approaches, academic analytics
Grading and evaluation of papers and exams	Imagine recognition, computer-vision, and a prediction system
Personalised, intelligent teaching	Data mining, or Bayesian knowledge interference, intelligent teaching systems, and learning analytics
Smart school	Face recognition, speech recognition, virtual labs, A/R, V/R, hearing, and sensing technologies
Online and mobile remote education	Edge computing, virtual personalised assistants, and real-time analysis

Source: Chen, Chen and Lin, 2020

Ahmad *et al.* (2021) delve into artificial intelligence's transformative potential in education, particularly its capacity to surmount barriers to educational access and foster innovative pedagogies. The emergence of social robots, intelligent tutoring

systems, and smart learning environments are identified as key artificial intelligence applications that enhance interactive learning. The study calls for empirical research to substantiate the efficacy of artificial intelligence in education and its wider implications for the learning ecosystem.

Ocaña-Fernandez, Valenzuela-Fernandez and Garro-Aburto (2019) highlight the urgency for education institutions to adapt to the information society's demands by integrating artificial intelligence. They posit that artificial intelligence's capacity to provide personalised learning experiences is crucial, necessitating the development of digital competencies. The authors argue for the adoption of artificial intelligence-driven programmes to meet contemporary educational challenges, emphasising the role of digital literacy in preparing students for the future labour market.

Popenici and Kerr (2017) explore artificial intelligence's nascent role in academia, acknowledging its limitations in understanding complex human interactions but noting its growing proficiency in supporting educational infrastructure. They advocate for a nuanced appreciation of artificial intelligence's capabilities and a strategic approach to its application in education.

In another vein, UNESCO (2019) underscores the value of incorporating AI technologies in education to empower human potential and protect human rights, fostering effective cooperation between humans and machines in various aspects of life, learning, and professional development, all while promoting sustainable progress. In conjunction with partners and international organisations, the organisation seeks to fortify its leadership role in the realm of AI in education.

During the International Forum on AI and Education in 2022, participating countries presented their national strategies, which emphasised the active integration of AI into their education systems (UNESCO, 2022). They also highlighted the challenges associated with current technologies, the need for stronger evidence of their effectiveness, the significant role of the corporate sector, and investment in driving AI integration in education. These contributions underscored the importance of promoting extensive international and intersectoral collaboration and opportunities for reflection to better understand the implications of AI integration in education. Additionally, they accentuated the necessity for forward-thinking strategies to prevent AI adoption from perpetuating inequalities. The key to successfully navigating this transformation lies in the design and implementation of unbiased AI systems that are responsible for addressing the needs of all educators and learners. This approach has the potential to elevate education and humanity to new heights.

Collectively, these studies underscore the need for a robust economic analysis of artificial intelligence in education. They suggest that artificial intelligence's role

extends beyond pedagogical enhancement to include economic benefits such as cost savings and labour market readiness.

The policy implications arising from these studies are significant. Policymakers must consider how artificial intelligence integration aligns with broader economic objectives, such as workforce development and innovation promotion. The findings also highlight the importance of continued investment in artificial intelligence research within the educational sector to ensure that its deployment is economically sound and beneficial for all stakeholders.

3. Research methodology

To attain a comprehensive understanding of the influence of artificial intelligence on the education system, we employed two qualitative research approaches: the case study method and the document analysis method.

Document analysis is a method that entails a systematic review and assessment of diverse document types, aimed at extracting important and relevant information. It also involves a comprehensive examination of individual pieces of text, aiming to pinpoint recurring themes across various texts. The utilisation of this approach is essential for attaining a more profound insight into the broader context pertaining to our study's subject matter. In our research, we conducted a comprehensive exploration by scrutinising a variety of documents. Through this method, our research managed to lay a strong groundwork in the existing knowledge base and concurrently identify congruent perspectives.

The use of the case study method provides an in-depth investigation into a particular real-world situation. In the context of our research focused on economic perspectives on artificial intelligence and the digital transformation of education, employing the case study method has allowed us to investigate and understand the performance of one of the best education systems in Europe and the good practices implemented in this regard. Our attention was directed towards the high-performing Estonian education system. Being interested in the Estonians' unified and well-structured education system that commences in early childhood and extends beyond regular school hours, we studied the implications related to the digitization of education along with the challenges it brings, and we consider that our findings have the potential for global application.

Considering the objectives of this paper: on the one hand, to illustrate the impact of AI on education, and on the other, to support the creation of strong legal and ethical structures that enable the incorporation of these transformations, the research methodology and approaches presented above are fitting for the purpose of this study.

4. Results and discussion

Estonia has achieved the creation of a digital society over the past two decades and is well-known for its success in e-governance. The government's efforts to attract tech investments include the e-Residency programme, and they are also investing in protecting national intellectual property and data from cyber threats by utilising blockchain technology and establishing a "digital embassy" in Luxembourg, actions described on the national *e-Estonia.com* online platform.

Regarding the Estonian education system, pre-school education in Estonia is designed to accommodate children between the ages of 18 months and seven years, with a primary focus on fostering individual growth and development. The government is responsible for developing educational curricula for pre-school institutions, and successful completion of these curricula is officially accredited to facilitate the smooth transition to primary education.

In Estonia, it is compulsory for students to complete a nine-year programme of comprehensive basic education, which includes the possibility of home-schooling as an alternative option. The curriculum has been strategically developed to fulfil the criteria of general education and provide students with the necessary skills and knowledge to pursue diverse educational trajectories, such as general secondary education, vocational training, or immediate integration into the labour market.

The higher education system in Estonia is structured into three levels: bachelor's, master's, and doctorate degrees. Additionally, there are certain integrated programmes available in specialised sectors such as medicine and engineering. In the higher education landscape of the country, universities possess a considerable degree of autonomy. This is further complemented by a diverse array of both public and private institutions, among which the University of Tartu stands as the largest (K12academics.com, 2023).

The implementation of artificial intelligence in the Estonian education system has resulted in several practical outcomes, thereby establishing the country as a frontrunner in the realm of educational innovation.

The ProgeTiger programme is an educational effort implemented by the Estonian government with the objective of providing instruction in information and communication technology (ICT) to students in grades 1 through 12. The programme encompasses a wide range of topics, including software utilisation, programming, and robotics. This programme is an integral component of Estonia's comprehensive initiative to include digital literacy and skills into its educational framework, guaranteeing that the younger generation is adequately equipped to

navigate a future where digital proficiency is of growing importance (Education Estonia, 2021).

From an economic standpoint, initiatives such as ProgeTiger hold considerable importance for multiple reasons. The nation of Estonia is taking proactive measures to cultivate a workforce that possesses the necessary information and communication technology skills to effectively participate in the digital economy. This is achieved by providing kids with ICT education from a young age. This phenomenon has the potential to foster a more vibrant labour market, characterised by an ample pool of individuals with the requisite skills and qualifications for employment in high-tech businesses and sectors driven by innovation.

Education programmes that prioritise the development of digital skills are crucial for cultivating innovation and enhancing productivity. As students acquire the ability to effectively interact with technology in innovative ways, it is probable that they will make valuable contributions to enhancing productivity and fostering the creation of novel products and services upon their entry into the professional realm.

Moreover, the presence of a highly educated and technologically proficient workforce has the potential to draw foreign direct investment in sectors that rely on technology and knowledge. Organisations frequently want to establish their operations in countries characterised by a robust talent pool of prospective employees possessing sophisticated digital competencies.

The enhancement of economic resilience can be facilitated by the digitalization of education, exemplified by initiatives such as ProgeTiger. Estonia mitigates its susceptibility to economic shocks that could impact conventional businesses by enhancing the diversity of its population's skill set.

Moreover, the potential for long-term economic growth is anticipated to be positively influenced by the early acquisition and utilisation of digital skills. As these individuals progress in their educational journey and transition into other professional domains, they possess the capacity to incorporate digital solutions into a wide range of organisational procedures, thereby enhancing operational effectiveness and fostering expansion.

The ProgeTiger initiative, thus, signifies a deliberate allocation of resources towards enhancing Estonia's human capital with the anticipation of substantial long-term economic advantages. This is consistent with the nation's established status as a frontrunner in the digital realm and demonstrates a progressive stance towards educational policies that may serve as a blueprint for other nations.

Notwithstanding these achievements, the incorporation of artificial intelligence into the realm of education presents several challenges. The ethical implications

surrounding the integration of artificial intelligence in the field of education give rise to concerns pertaining to bias, discrimination, and the digital divide. Estonia has demonstrated a proactive approach to addressing these concerns by prioritising the development of AI teaching tools that are geared to promote inclusivity and fairness. This entails the surveillance of data sets that may contain biases, which in turn could result in disparities in learning opportunities and results.

One further obstacle pertains to the maintenance of a current curriculum and the enhancement of instructors' competencies in response to the swiftly progressing domain of artificial intelligence.

To tackle these difficulties, Estonia has devised several measures. Aiming to ensure that teachers possess the requisite skills and knowledge to effectively instruct in an AI-enhanced educational setting, professional development initiatives have been implemented (UNESCO Institute for Lifelong Learning, 2014). The government has also made efforts to enhance the information technology infrastructure in educational institutions, thereby ensuring that all students have equitable access to essential technological resources.

Infrastructure investment plays a crucial role in ensuring that educational institutions possess the requisite technology infrastructure to effectively incorporate artificial intelligence, thereby mitigating the digital divide.

Another technique to address the challenges is stakeholder engagement, which refers to facilitating the participation of parents, students, and educators in dialogues pertaining to the involvement of artificial intelligence in the field of education with the aim of cultivating collective comprehension and addressing apprehensions through collaborative efforts.

The promotion of continuous study on the effects of artificial intelligence in the field of education is also very important, with the aim of consistently informing policymaking and implementation.

Data privacy presents an additional ethical consideration. To adhere to the General Data Protection Regulation (GDPR) and other privacy regulations, Estonia has implemented measures to assure compliance, given the significant volume of personal data being processed by AI systems. This entails obtaining informed consent from both students and parents for the purpose of data gathering, ensuring transparency regarding the utilisation of collected data, and adopting strong cybersecurity protocols.

The emergence of new technologies, particularly artificial intelligence and the internet of things, has likewise raised concerns about legal regulations and standardization. The challenge lies in the fact that these technologies, especially

artificial intelligence, are significantly more complex and far-reaching than e-governance. It is essential to formulate comprehensive political and economic strategies that extend beyond e-governance before defining legal standards, as Chounta *et al.* (2022) conclude. Estonia has demonstrated a proactive approach in formulating legislation and regulations to effectively tackle problems related to data privacy, thereby establishing a model for the appropriate handling of educational data within the context of artificial intelligence.

In terms of policy, the Estonian government has been faced with the task of managing the establishment of a regulatory structure that fosters innovation while safeguarding the concerns of all parties concerned. This encompasses the establishment of criteria for ensuring the quality of data, the development of algorithms employed in educational environments, and the promotion of transparency in artificial intelligence systems. Policies should also consider the long-term ramifications of artificial intelligence on the labour market, ensuring that the education system maintains its ability to adapt to forthcoming technological changes.

Moreover, the transition towards a digital economy requires ongoing financial commitment to both education and technology, imposing a substantial economic burden. The careful evaluation of the costs associated with technological progress in relation to the advantages it offers continues to be a crucial deliberation for policymakers.

Conclusions

In summary, the incorporation of artificial intelligence into Estonia's education system acts as a testimony to the country's commitment to technological advancement and stands as a model for worldwide educational restructuring.

The utilisation of the case study and document analysis methods in this article has shed light on the many effects of artificial intelligence in the field of education. These effects encompass a wide range of aspects, including the improvement of learning processes and the introduction of economic efficiency. The results emphasise the relevance of incorporating AI literacy into contemporary education as a core element, hence emphasising the significance of formulating strategic policies and ensuring ethical supervision.

As Estonia traverses these domains, its encounters provide vital insights on the prudent assimilation of AI, underscoring the imperative for strong privacy safeguards and ethical principles. The insights presented in this paper shed light on Estonia's approach, offering guidance for other countries and institutions seeking to harness the potential of artificial intelligence. By doing so, they can cultivate an

education system that not only adjusts to, but also foresees, the requirements of the future job market.

The economic ramifications are evident: with the allocation of resources towards artificial intelligence and digital literacy, Estonia is not only undertaking educational reforms but also strategically positioning its economy to prosper in the digital era.

References

Ahmad, S.F., Rahmat, M.K., Mubarik, M.S., Alam, M.M. and Hyder, S.I. (2021) 'Artificial Intelligence and Its Role in Education', *Sustainability*, 13(22), 12902. doi: https://doi.org/10.3390/su132212902

Chassignol, M., Khoroshavin, A., Klimova, A. and Bilyatdinova, A. (2018) 'Artificial intelligence trends in education: A narrative overview', *Procedia Computer Science*, 136, pp. 16-24. doi: https://doi.org/10.1016/j.procs.2018.08.233

Chen, L., Chen, P. and Lin, Z. (2020) 'Artificial Intelligence in Education: A Review', *IEEE Access*, 8. doi: https://doi.org/10.1109/ACCESS.2020.2988510

Chounta, I.A., Bardone, E., Raudsep, A. and Pedaste, M. (2022) 'Exploring Teachers' Perceptions of Artificial Intelligence as a Tool to Support their Practice in Estonian K-12 Education', *International Journal of Artificial Intelligence in Education*, 32, pp. 725-755. doi: https://doi.org/10.1007/s40593-021-00243-5

e-Estonia (no date) *Home page*. Available at: https://e-estonia.com/ (Accessed: 14 October 2023).

Education Estonia (2021) *ProgeTiger Programme*. Available at: https://www.educationestonia.org/progetiger/ (Accessed: 03 October 2023).

K12academics.com (2023) *Education in Estonia*. Available at: https://www.k12academics.com/Education%20Worldwide/education-estonia (Accessed: 08 October 2023).

Ocaña-Fernandez, Y., Valenzuela-Fernandez, L. and Garro-Aburto, L. (2019) 'Artificial Intelligence and its Implications in Higher Education', *Propósitos y Representaciones*, 7(2), pp. 536-568. doi: https://doi.org/10.20511/pyr2019.v7n2.274.

Popenici, S.A.D. and Kerr, S. (2017) 'Exploring the impact of artificial intelligence on teaching and learning in higher education', *Research and Practice in Technology Enhanced Learning*, 12, 22. doi: https://doi.org/10.1186/s41039-017-0062-8.

Rus, V., D'Mello, S., Hu, X. and Graesser, A. (2013) 'Recent advances in conversational intelligent tutoring systems', *AI Magazine*, 34(3).

Timms, M.J. (2016) 'Letting artificial intelligence in education out of the box: Educational cobots and smart classrooms', *International Journal of Artificial Intelligence in Education*, 26(2), pp. 701-712. doi: https://doi.org/10.1007/s40593-016-0095-y

UNESCO (2019) *How Can Artificial Intelligence Enhance Education?* Available at: https://en.unesco.org/news/how-can-artificial-intelligence-enhance-education (Accessed: 16 October 2023).

UNESCO (2022) *International forum on AI and education: Steering AI to empower teachers and transform teaching*. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000386162?locale=en (Accessed: 18 October 2023).

UNESCO Institute for Lifelong Learning (2014) *Estonia: Lifelong Learning Strategy 2020*. Available at: https://uil.unesco.org/document/estonia-lifelong-learning-strategy-2020-issued-2014 (Accessed: 16 October 2023).