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THE INFLUENCE OF EDUCATION 4.0 TECHNOLOGIES ON DIGITAL TRANSFORMATION OF HIGHER EDUCATION INSTITUTIONS

Oleksii SHAPOVAL[9] PhD student
https://orcid.org/0000-0003-4478-3193

Abstract: *Higher education institutions are facing the influence of an ongoing digital transformation, which influences all aspects of a modern study process. This paper aims to address this gap by examining how specific Education 4.0 technologies contribute to different levels of digital transformation in higher education institutions through the lens of the SAMR (Substitution, Augmentation, Modification, Redefinition) model. Based on the results of analysis, we summarize a list of observations followed by the main transformational processes associated with the introduction of these technologies in higher educational context. The study focuses on a broader landscape, assessing the main categories discussed in academic literature.*
Key words: *digital transformation, education 4.0, SAMR model, transformation management*

JEL: I23, O33, O32

1. Introduction

The higher education landscape is undergoing constant transformation driven by the latest advancements and integration of emerging technologies. Education 4.0 is one of the latest trends reshaping the traditional paradigms of teaching and learning. Today, higher education institutions are influenced by an ongoing digital transformation in all aspects of the study process. This presents both valuable opportunities and significant challenges for higher education institutions worldwide.

Despite a growing body of research on Education 4.0 and digital transformation in higher education, there remains a paucity of comprehensive frameworks that illustrate the complex interaction between specific technologies and ongoing transformational processes. This paper aims to address this gap by examining the influence of Education 4.0 technologies on the digital transformation of higher education institutions through the lens of the SAMR (Substitution, Augmentation, Modification, Redefinition) model.

The primary objectives of the study are to analyze how specific Education 4.0 technologies contribute to different levels of digital transformation in higher education and to provide practical insights for guiding the digital transformation of higher education institutions.

2. Literature review.

The concept of Education 4.0 has emerged from increasing digitization as a response to the demands of the Fourth Industrial Revolution, also known as Industry 4.0. Originating in Germany in 2011, the goal of the Industry 4.0 model was to promote the country's manufacturing sector as part of a broader high-tech strategy for 2020. Its defining characteristics are a growing number of autonomous cyber-physical systems using sensors to optimize manufacturing processes and reliance on novel technologies such as data analysis, artificial intelligence, and machine learning (Gabriela Pereira Carvalho and Walmir Cazarini 2020). Industry 4.0 relies on the digitization of manufacturing and

[9] oleksii.shapoval@posteo.net, Research Centre for Industrial Problems of Development of NAS of Ukraine

management processes, leading to a growing number of information technology systems with increased complexity.

While the concept of Education 4.0 has been widely discussed by a number of academics and practitioners, one of the most prominent figures in its popularization was futurist Peter Fisk. According to Fisk's vision, Education 4.0 is meant to respond to the needs of Industry 4.0 while taking advantage of the latest technological advancements to promote open, continuous learning and develop skills relevant in the new environment (Fisk 2017).

In an Education 4.0 environment, higher education institutions inevitably face the need to manage transformational processes associated with it. In this context, digital transformation (DT) refers to the integration of digital technologies to enhance various aspects of higher education institutions' operations. It aims to address the challenges posed by rapid technological advancements and changing market demands, leading to a more responsive and effective educational system (Bisri, Putri, and Rosmansyah 2023).

Education 4.0 encompasses several innovative technologies driving digital transformation. In this study, we focus on the following core technologies and their influence on the digital transformation of higher education institutions:

- *Virtual and Augmented Reality* assist teachers in creating immersive, interactive learning experiences that allow students to visualize complex concepts and perform virtual experiments without associated risks. This is especially effective in fields such as medicine, engineering, and design (Paszkiewicz et al. 2021; Salah et al. 2019).
- *Artificial Intelligence* has a wide array of applications for higher education, from personalization of study paths to automating assessments, providing real-time feedback, and augmenting day-to-day activities of both students and teachers (Hemachandran et al. 2022; Okagbue et al. 2023).
- *Internet of Things* technologies' unique feature is their ability to be deeply integrated in the information systems of the institution. They can be used for campus management and security, automating attendance, assisting distance learning, and as part of digital labs (Kesuma, Kesuma, and Taher 2024).
- *Learning analytics* involve the collection and analysis of data related to student learning behaviors and outcomes. This allows educators to gain a deeper understanding of student needs, make data-driven decisions, and identify at-risk students through automated early-warning systems (Mokhtar, Alshboul, and Shahin 2019).
- *Blockchain* allows developing systems with several main properties: immutability, transparency, and traceability. This makes it suitable for such applications as issuing cryptographically signed digital diplomas or certificates, credentials management, and authorship tracking among others (Lutfiani et al. 2021).

3. Theoretical framework.

We use the SAMR framework to assess the impact of transformation technologies described in the previous section. This approach enables a structured overview of the potential of these technologies at different levels of influence and provides a basis for reasoning when considering their introduction into higher education contexts.

SAMR (Substitution, Augmentation, Modification, Redefinition) is a model designed to help educators efficiently integrate technologies into teaching process by "moving up" through the four

levels of teaching with technology. At *Substitution* level, a new technology substitutes the previous one with no functional change (using word processor instead of pen and paper). At *Augmentation* level, the technology provides some functional improvements (using spell checker in a word processor to enhance the essay writing). At *Modification* level, integrating the technology requires a significant redesign of the task (instead of writing individual essays, students collaborate in a shared online document). At *Redefinition* level, the technology leads to the creation of new activities that were not possible before (students making a multimedia presentation to convey their understanding of a topic) (Hamilton, Rosenberg, and Akcaoglu 2016).

4. Analysis and findings.

In our analysis, we evaluate each technology through the lens of SAMR model, considering its application at each individual level. This section presents results of the analysis along with the summary of our findings and their implications for higher education institutions.

Table 1. Summary of the analysis of Education 4.0 technologies using SAMR model

Technology	Substitution	Augmentation	Modification	Redefinition
VR/AR	Replace traditional 2D images and videos with interactive 3D simulations	Use interactive 3D environments to allow students to explore concepts more deeply	Virtual field trips to visit historical sites or dangerous environments safely	New forms of learning experiences through developing collaborative virtual environments
AI	Replace course or program FAQ with a chatbot	Intelligent tutoring system providing personalized feedback and guidance	Adaptive learning platform with adjustable difficulty	Dynamic course contents generated according to student's profile
IoT	Smart ID cards to enter the premises	Automated attendance systems	Automated occupancy tracking for classrooms and study spaces	Smart campuses
Learning analytics	Digital grade books	Interactive course progress dashboards	Collaborative learning analytics	Predictive and early warning systems for identifying at-risk students
Blockchain	Moving digital diplomas to on-chain storage	On-chain course certificates micro-credentials	Automatic credential issuance based on smart contracts	Decentralized Autonomous Universities (DAUs)

Source: Produced by author

Based on the results of evaluation, we make the following observations:

1. At the Redefinition level, VR/AR and AI technologies show the most potential due to their ability to create new learning modes that are otherwise impossible.
2. IoT and learning analytics have significant potential at the Modification and Redefinition levels. This influence can be further enhanced through their combination, creating responsive learning environments and data-driven experiences.
3. The main transformative potential of blockchain technology lies in applications related to how academic credentials are recorded, stored, and verified. Although DAUs present an interesting opportunity at the Redefinition level, implementing this approach in practice may prove to be challenging.
4. Outlined technologies show significant potential when used in combination. For example, data obtained from IoT sensors can be used in learning analytics systems, which, in turn, can employ AI technologies for a more in-depth analysis.
5. Moving towards the Redefinition level, all technologies except blockchain demonstrate significant capabilities for personalizing different aspects of the study process, which is one of the key trends of Education 4.0.
6. The Redefinition stage for all outlined technologies closely aligns with the goals of Education 4.0, emphasizing personalized, flexible, and data-driven learning experiences.

Obtained results highlight a major paradigm shift, indicating an alignment between Redefinition stage of these technologies and the core principles of Education 4.0 paradigm, which presents a number of challenges for higher education institutions.

HEIs need to adapt and reimagine their educational framework to accommodate personalized, flexible, and data-driven experiences, appropriately responding to the changing needs driven by the Industry 4.0 environment. Below is a list of the main processes associated with implementing Education 4.0 digital technologies for higher education institutions:

1. Adapting curricula and study programs to accommodate the growing demand for a more modular, adaptable, and practical study process, including interdisciplinary programs, micro-credentials, nanodegrees, and competency-based models.
2. Increasing investments in technological infrastructure, hardware, and software to support the growing complexity of institutions' IT systems are driven by the digitization associated with the introduction of Education 4.0 technologies.
3. The need for professional development for faculty staff to bridge the digital skill gap allows teachers to efficiently and safely use new technologies as part of the study process. Moreover, this may involve the creation of new roles at the intersection of education and technology.
4. Stronger emphasis on cybersecurity, data governance, and compliance with data protection regulations stems from the increasing volumes of data being stored and processed.

Digital transformation is a complex process that requires a holistic approach. By considering these processes when planning the adoption of Education 4.0 technologies in study contexts, higher education institutions can leverage their advantages while reasonably addressing potential pitfalls.

5. Conclusions.

In this study, we present our findings on the influence of Education 4.0 technologies on the digital transformation of higher education institutions. Providing an introduction to the main technologies

within the Education 4.0 paradigm and laying the theoretical foundation, we assess each through the lens of the SAMR model, outlining their influence on each of the four levels: Substitution, Augmentation, Modification, and Redefinition. Based on the results of the analysis, we summarize a list of observations followed by the main transformational processes associated with the introduction of these technologies in a higher education context. These findings may help us understand the specific implications of digital transformation amid the Education 4.0 paradigm.

The study focuses on a broader landscape of Education 4.0 technologies, assessing the main categories discussed in academic literature. Further research can be conducted to evaluate specific examples or technologies in greater depth, such as large language models, autograders, deep learning, and distributed ledger technology. By applying the same methodology for understanding the influence of specific technologies on the study process, it is possible to develop practical insights and know-hows that can be applied to particular cases, such as introducing a new technology within a course or a study program.

Moreover, the study does not consider intersections between evaluated technologies. As noted in the observations, many of these technologies may provide more value when used in combination. We suggest that deeper research in this direction may produce interesting and valuable results.

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