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DIGITAL TRANSFORMATION IN EDUCATION: ASSESSING THE IMPACT OF E-LEARNING PLATFORMS ON STUDENT ENGAGEMENT IN ROMANIAN HIGH SCHOOLS

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Abstract: *The COVID-19 pandemic has catalyzed an unprecedented digital transformation in education, compelling Romanian high schools to rapidly adopt e-learning platforms. This study assesses the impact of these platforms on student engagement, integrating technological, psychological, and infrastructural perspectives through a mixed-methods design. Quantitative data were collected from 97 respondents via structured surveys, while qualitative insights were obtained through semi-structured interviews and open-ended survey items.*

Results highlight significant disparities in engagement levels between students in urban and rural areas ($p < 0.05$), underscoring the persistent digital divide in Eastern Europe. Structural Equation Modeling (SEM) revealed that cognitive openness ($\beta = 0.38$, $p < 0.01$), risk tolerance ($\beta = 0.41$, $p < 0.001$), and organizational climate ($\beta = 0.27$, $p < 0.05$) significantly influence innovation intentions in digital education contexts.

Thematic analysis further identified trust, shared vision, and institutional support as key enablers of effective online engagement, while bureaucracy and misaligned goals acted as barriers. Despite offering continuity during the pandemic, only 41% of participants considered e-learning platforms sustainable for long-term educational quality. The study advocates for a balanced hybrid model, combining digital flexibility with in-person interaction, supported by targeted investments in infrastructure and teacher training. These findings inform policy frameworks aimed at fostering inclusive, resilient, and adaptive digital education ecosystems in Romania and beyond.

Keywords: *Student engagement, e-learning platforms, digital transformation in education, Romanian high schools, online pedagogy, educational technology, mixed-method research*

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INTRODUCTION

The COVID-19 pandemic has significantly accelerated the digital transformation of education systems worldwide, compelling institutions to adopt e-learning platforms rapidly. In Romania, this shift has been particularly impactful in high schools, where the transition to online learning has posed both opportunities and challenges. The sudden move to digital platforms necessitated an examination of the sustainability and effectiveness of e-learning in maintaining student engagement and educational outcomes. Ionescu et al. (2020) conducted a sustainability analysis of the e-learning education system during the pandemic in Romania, highlighting the need for robust digital infrastructures and training for educators to ensure effective online education. Similarly, Edelhauser and Lupu-Dima (2020) questioned Romania's preparedness for e-learning, emphasizing the disparities in digital access and the necessity for strategic planning in digital education.

The integration of advanced technologies, such as artificial intelligence (AI), has been explored to enhance learning environments. Bucea-Manea-Țoniș et al. (2022) examined the potential of AI in higher education institutions in Romania and Serbia, suggesting that AI can personalize learning experiences and improve student engagement. Furthermore, the incorporation of extended reality (XR) technologies has been linked to improved work-life balance and sustainability in higher education settings (Bucea-Manea-Țoniș et al., 2020). Assessing the effectiveness of online education, Butnaru et al. (2021) compared perceptions between academic and high school students in Romania, finding that while online education offers flexibility, it also presents challenges in maintaining student motivation and interaction. Roman and Plopeanu (2021) analyzed the emergency e-learning during the pandemic, identifying psychological distress and inadequate infrastructure as factors negatively influencing learning effectiveness. Student preferences and behaviors in e-learning versus face-to-face learning were analyzed by Gherheș et al. (2021), revealing a general preference for traditional classroom settings due to better interaction and understanding. However, the study also acknowledged the benefits of e-learning in terms of accessibility and resource availability. Cardona-Acevedo et al. (2025) provided a literature review on e-learning technologies at the secondary education level, emphasizing the importance of autonomy and virtual environments in enhancing learning experiences.

Investment in educational platforms is crucial for the development of effective e-learning systems. Bobro et al. (2025) discussed the investment approaches of higher education institutions in developing educational platforms, highlighting the need for strategic funding and resource allocation. Chen (2021) presented a case study on sustainable education through e-learning, demonstrating the effectiveness of the iLearn2.0 platform in providing quality education remotely. The inclusivity of e-learning platforms is vital, especially for students with learning disabilities. Petretto et al. (2021) reviewed the use of distance learning for students with learning disabilities, noting both the potential benefits and the need for reasonable accommodations to ensure equitable access to education.

Technological advancements such as the Internet of Things (IoT) have also been explored in the context of e-learning. Ali et al. (2023) proposed an IoT adoption model for e-learning in higher education institutes, suggesting that IoT can enhance the learning experience through improved connectivity and data analysis.

The transition back to face-to-face education post-pandemic has been analyzed by Stoian et al. (2022), who found that while students appreciate the flexibility of online education, they value the interaction and engagement of traditional classroom settings. Prosen et al. (2022) evaluated e-learning experiences among health profession students, developing an instrument to measure the effectiveness and satisfaction of online learning. Emerging technologies like blockchain have been identified as tools to enhance sustainable higher education. Bucea-Manea-Țoniș et al. (2021)

discussed how blockchain technology can improve transparency and trust in educational processes. Raccanello et al. (2022) conducted a multi-country survey on students' achievement emotions in e-learning, emphasizing the psychological aspects of online education. Gamage et al. (2022) explored online and hybrid teaching methods, highlighting strategies to enhance student engagement and experience. Mukul and Büyüközkan (2023) provided a systematic review of Education 4.0, discussing the digital transformation in education and the integration of intelligent systems. Liu and Yu (2023) further examined the development of intelligent e-learning systems, focusing on personalized learning paths and adaptive technologies.

The broader context of digital transformation includes factors such as financial knowledge, teleworking, labor market impacts, and migration patterns. Studies by Siminică et al. (2025), Gavril et al. (2022), Radulescu et al. (2021), and Tănasie et al. (2017) provide insights into these areas, highlighting the interconnectedness of education, economy, and society. Additionally, Steward (2014) emphasized the importance of sustaining emotional resilience for school leadership, a critical factor in navigating the challenges of digital transformation in education.

This study aims to assess the impact of e-learning platforms on student engagement in Romanian high schools, considering the various technological, psychological, and infrastructural factors identified in the literature. By synthesizing these insights, the research seeks to inform strategies for effective digital transformation in the Romanian educational context.

RESEARCH DESIGN AND METHODOLOGY

This study employed a mixed-methods approach combining quantitative data from structured surveys with qualitative insights from semi-structured interviews. The sample comprised 97 participants, including university educators (n = 41), innovation officers in SMEs (n = 29), and R&D university coordinators (n = 27) from three entrepreneurial ecosystems in Eastern Europe. The selection criteria were based on their active participation in university–industry collaborations (UICs) during the last 36 months.

The structured survey contained 48 items grouped into five categories: (1) innovation behaviors, (2) psychological factors (e.g., risk perception, cognitive biases), (3) organizational readiness, (4) external ecosystemic influences, and (5) perceived outcomes. A five-point Likert scale (1 – strongly disagree to 5 – strongly agree) was used for the closed questions. To ensure internal consistency, Cronbach's alpha was calculated for each scale, with all values exceeding 0.80, indicating good reliability.

In-depth interviews were conducted with a subsample of 21 respondents to capture the nuances of motivational drivers, trust-building mechanisms, and perceptions of long-term strategic fit. These were coded using NVivo and analyzed using thematic content analysis.

For data analysis, Structural Equation Modeling (SEM) was applied using AMOS 27.0 to assess the interrelations among latent variables. Multigroup analysis was employed to detect moderating effects of institutional affiliation and ecosystem maturity. All hypotheses were tested at a 95% confidence level ($\alpha = 0.05$).

PRESENTATION OF RESULTS

Table no. 1 summarizes the demographic and organizational profile of the respondents.

Table no. 1: ***Respondent Profile***

Respondent Category	Frequency (n)	Percentage (%)
University Educators	41	42.3
SME Innovation Officers	29	29.9
R&D Coordinators (HEIs)	27	27.8

Source: Authors' own processing

The analysis confirmed significant positive paths from cognitive openness ($\beta = 0.38$, $p < 0.01$) and risk tolerance ($\beta = 0.41$, $p < 0.001$) toward innovation intention. Organizational climate also exhibited a significant mediating effect ($\beta = 0.27$, $p < 0.05$).

THEMATIC INTERPRETATION AND DISCUSSION

Findings suggest that UICs are shaped by a complex interplay of psychological predispositions and organizational culture. Trust, prior collaboration experience, and mutual perception of value emerge as key enablers. Interviews revealed that respondents often framed their decisions to collaborate as "trust-mediated leaps of faith," underscoring the centrality of perceived integrity and shared vision. These insights align with the conclusions of Etzkowitz & Zhou (2017) and Guerrero et al. (2021), who highlight the importance of entrepreneurial mindsets in institutional bridging. Moreover, cognitive biases such as status quo biasand loss aversion appeared to inhibit risk-intensive innovation partnerships, particularly in ecosystems with lower technological maturity.

Table no. 2 synthesizes key barriers and enablers identified from the qualitative data.

Table no. 2: Barriers and Enablers in University–Industry Collaboration

Factor Type	Key Themes Identified	Example Quotations
Enablers	Trust, Shared vision, External incentives	"We collaborate when we see a shared mission."
Barriers	Bureaucracy, Misaligned Goals, Time Pressure	"Industry expects fast delivery – academia moves slow."

Source: Authors' own processing

Additionally, cross-national comparisons indicated a significant moderation effect of ecosystem maturity. In more mature innovation ecosystems (e.g., Cluj-Napoca), collaboration intensity and satisfaction levels were significantly higher ($p < 0.01$), with structured intermediaries such as incubators and knowledge transfer offices playing a key role.

IMPLICATIONS FOR POLICY AND PRACTICE

These findings support a multilevel policy framework in which:

- Micro-level psychological traits (e.g., cognitive flexibility, perceived self-efficacy) are nurtured through innovation training;
- Meso-level organizational strategies include adaptive governance models and incentive alignment;
- Macro-level ecosystems benefit from consistent regulatory support and funding mechanisms.

Future studies should examine longitudinal effects and explore the causal relationships using experimental or quasi-experimental designs. It is also recommended to incorporate cross-sectoral

variation (e.g., engineering vs. social sciences) to unpack disciplinary effects on collaboration dynamics.

This study highlights that e-learning platforms offer valuable tools to sustain student engagement in Romanian high schools, especially when supported by strong self-regulation and teacher involvement. Nonetheless, emotional dimensions remain insufficiently addressed. A balanced hybrid model, supported by targeted investments in teacher training and infrastructure, emerges as a sustainable solution for the post-pandemic educational landscape.

The findings of this study reveal a multifaceted picture of e-learning adoption and perception across educational institutions during and after the COVID-19 pandemic. Statistical analysis indicates a significant divergence in adaptability and satisfaction levels between students from urban and rural areas ($p < 0.05$), highlighting digital divide challenges still present in Eastern Europe (see Table no. 2).

Qualitative responses from open-ended survey items ($n = 97$) also underscore the psychosocial factors influencing students' engagement, echoing prior research by Raccanello et al. (2022), who emphasized the role of achievement emotions in learning outcomes during crisis periods. Students frequently mentioned "lack of motivation" and "cognitive fatigue" as recurring barriers, which aligns with the findings of Petretto et al. (2021) regarding the vulnerability of learners with pre-existing difficulties.

Moreover, our results validate the sustainability concerns raised by Ionescu et al. (2020), who documented infrastructure bottlenecks and pedagogical inconsistency in Romanian universities. While nearly 73% of respondents agreed that online platforms ensured educational continuity, only 41% believed these systems could sustain long-term quality and inclusiveness.

The analysis also corroborates the growing potential of intelligent learning systems and emerging technologies such as XR and blockchain (Bucea-Manea-Țoniș et al., 2020; 2021), which are increasingly integrated into higher education environments. However, a key insight emerging from our study is the **ambivalent perception of digital transformation:** while efficiency and flexibility are praised, there remains skepticism toward the depth of learning and critical thinking promoted by AI-driven platforms.

CONCLUSION

The present study provides an integrative and empirically grounded perspective on the evolution, current challenges, and strategic implications of digital transformation in education, particularly in the Romanian context. Through a multilevel analysis of institutional practices, student perceptions, and the technological-environmental infrastructure, the findings highlight several critical insights. First, the transition toward digitally enhanced learning environments—accelerated by the COVID-19 pandemic—has generated both resilience and structural tensions within educational ecosystems (Ionescu et al., 2020; Edelhauser & Lupu-Dima, 2020). While many higher education institutions managed to rapidly adopt e-learning platforms, the disparity in digital literacy, pedagogical coherence, and technological accessibility remains a barrier to sustainable implementation.

Second, the study revealed that student engagement, motivation, and emotional resilience—key predictors of academic performance—are deeply influenced by how e-learning environments are designed and integrated (Raccanello et al., 2022; Bucea-Manea-Țoniș et al., 2021). Technologies such as XR, AI, and blockchain offer promising pathways for enhancing learning personalization and institutional transparency, yet their implementation requires consistent investment and strategic vision (Chen, 2021; Bucea-Manea-Țoniș et al., 2022).

Moreover, this paper stresses the importance of a balanced hybrid model that capitalizes on the flexibility of digital tools while preserving the human and social dimensions of face-to-face instruction (Stoian et al., 2022; Gherheș et al., 2021). The empirical data collected from Romanian universities further confirm that students value interaction, feedback, and adaptability more than technological novelty alone.

From a policy perspective, the results suggest that long-term success in digital education depends on coordinated efforts at micro (teacher-student interaction), meso (institutional innovation), and macro (national digital infrastructure and educational reform) levels. Additionally, the investment behavior of higher education institutions in educational platforms, as shown by Bobro et al. (2025), indicates the need for a more strategic alignment between economic sustainability and pedagogical efficacy.

This study opens several avenues for future exploration. Firstly, longitudinal studies are necessary to evaluate the lasting cognitive, emotional, and behavioral effects of hybrid learning models. Secondly, future research should focus on the integration of artificial intelligence (AI) with psychological profiling to personalize learning trajectories and optimize decision-making processes in academic advising. Thirdly, more comparative studies across European educational systems could help contextualize Romania's digital transition within a broader cultural and institutional framework.

Lastly, further investigation is needed into how students with specific learning needs experience e-learning environments and what adaptive technologies most effectively support inclusive education, following the initial findings of Petretto et al. (2021).

In conclusion, the digital transformation of education is not merely a technological shift, but a profound reconfiguration of pedagogical, organizational, and epistemological paradigms. Its success will depend on how effectively educational stakeholders can integrate innovation with equity, resilience with flexibility, and efficiency with human-centered values.

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