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AI-Driven Inclusion in Romanian Preuniversity Education: A Mixed-Methods Study

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Abstract: This study investigates how artificial intelligence (AI) and digital transformation shape inclusion and equity in Romania's preuniversity education system. Using a sequential explanatory mixed-methods design, we surveyed 362 teachers, school leaders, and support staff across eight development regions (January-March 2025), followed by 22 semi-structured interviews with educators, students (including learners with special educational needs), counsellors, digitalization coordinators, and inspectorate representatives (April-May 2025). We introduce the Inclusive AI-Transformation Nexus for Romania (IATN-RO), which integrates four interdependent domains – Access Infrastructure, Adaptive Intelligence, Justice and Governance, and Relational Support Systems – under the principles of Agency, Accountability, and Alignment. Quantitative analysis validated two composite measures: the Inclusive Integration Index (III-RO) (α = .82–.90) and the Equity Outcomes Composite (EOC-RO) (α = .88). III-RO was strongly correlated with EOC-RO ($r = .52$, $p < .001$) and remained a significant predictor in regression models controlling for location, funding, and school level ($\beta = .39$, $p < .001$). AI governance maturity independently predicted equity outcomes ($\beta = .31$, $p < .001$), while general AI usage intensity was not significant ($\beta = .08$, $p = .11$). Professional Learning Ecosystems mediated the III-EOC relationship (indirect effect = 0.10, 95% CI [0.05, 0.17]), and connectivity constraints moderated implementation effects ($\beta\_interaction = -.11$, $p = .03$). Thematic analysis revealed five recurring patterns: the centrality of human mediation, transparency as trust, co-design with students and parents, inclusive improvisation in resource-poor settings, and the negotiation of algorithmic tensions. Overall, the findings show that equity depends on institutional capacity, governance, and relational support rather than the volume of AI tools. Policy recommendations address ethics, infrastructure, teacher training, and inclusive orchestration within Romanian legislative and infrastructural realities.

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Introduction

The rapid integration of artificial intelligence (AI) into educational environments has intensified long-standing debates about whether technological innovation reduces or reinforces structural inequities. In Romania's preuniversity system, which encompasses primary, secondary, and high school levels, the adoption of digital tools accelerated sharply during the COVID-19 pandemic. This shift was accompanied by targeted investments through initiatives such as PNRR, Digitaliada, CRED, and ministerial programs focused on electronic gradebooks, online learning platforms, and teacher training in digital competencies. These developments have created new avenues for personalization, accessibility, and alternative pedagogical practices, while simultaneously exposing enduring disparities tied to infrastructure, connectivity, teacher readiness, and socioeconomic precarity.

Recent research and national policy reports emphasize that students in rural communities, areas marked by high poverty, and those with special educational needs are disproportionately affected by fragmented digital access and inconsistently resourced implementation efforts (Twesigye, 2020). While AI holds the potential to strengthen inclusive practices through differentiation, speech-to-text supports, automated feedback, and early intervention mechanisms, its impact depends less on the technical availability of tools and more on the local orchestration of their use. In line with scholars positioning educational technologies as socio-technical systems shaped by governance structures, pedagogical cultures, human agency, and policy contexts (Facer & Selwyn, 2021; Williamson & Eynon, 2020), this study conceptualizes Romanian schools not as passive recipients of technology but as active mediators of equity outcomes.

The investigation is structured around two core hypotheses. The first is that identical AI features – such as adaptive feedback, automated evaluation, or translation support – can produce markedly different outcomes depending on infrastructural conditions, teacher oversight, data provenance, and inclusion-oriented school policies. The second hypothesis is that institutional capacity for inclusive orchestration, understood as the alignment of AI and digital resources with principles of accessibility, participation, and relational support, may exert a stronger influence on equity outcomes than the extent of AI use alone.

The study advances the field in three interrelated ways. At the conceptual level, it introduces the Inclusive AI-Transformation Nexus for Romania (IATN-RO), which maps the intersections among digital transformation, governance, accessibility, and human relations in preuniversity contexts. Empirically, it presents a sequential explanatory mixed-methods study conducted exclusively in Romania, through which two constructs – the Inclusive Integration Index (III-RO) and the Equity Outcomes Composite (EOC-RO) – are validated and examined through regression and mediation analyses. Practically, it offers design heuristics and policy checkpoints intended to support responsible, equity-centred AI implementation across diverse Romanian school profiles, including under-resourced and rural environments.

Three research questions structure the investigation. The first explores the relationship between AI-related practices and digital transformation on one hand, and equity outcomes – such as access, participation, inclusion, and assessment fairness – on the other, within the Romanian preuniversity system. The second examines which forms of institutional capacity, governance mechanisms, and professional learning most effectively support inclusive implementation. The third interrogates how teachers, students, and support specialists negotiate AI use in practice and which mechanisms mitigate emergent inequities.

To address these questions, a national mixed-methods design was employed. A survey of 362 participants assessed AI governance maturity, inclusive digital practices, professional development conditions, and perceived equity outcomes. This was followed by semi-structured interviews with 22 participants, which provided nuanced insights into how inclusion is mediated in practice through AI and digital tools at both classroom and institutional levels.

The article proceeds by first contextualizing AI implementation, digital transformation, and inclusive education in Romania. It then introduces the IATN-RO framework, followed by a detailed account of the methodology and ethical considerations. Subsequent sections present quantitative and qualitative findings, synthesize insights, and discuss their implications. The analysis culminates in governance and policy recommendations and concludes with proposed directions for future research.

1. Literature Review

Digital transformation in Romanian preuniversity education has unfolded primarily in response to two systemic drivers: the need to transition to remote learning during the COVID-19 pandemic and the strategic investments mandated through initiatives such as PNRR, CRED, ROSE, and Digitaliada. Although the Ministry of Education has advanced digitization through policy documents and targeted funding measures, implementation has varied significantly across regions. Research indicates that urban schools, particularly those in county capitals, have experienced more rapid adoption of digital platforms – such as Google Classroom, Microsoft Teams, Adservio, and Kinderpedia – and have benefitted from infrastructure advancements to a greater extent than schools in rural and small-town contexts.

European frameworks, notably the Digital Education Action Plan 2021-2027 and the DigCompEdu model, have influenced the national approach to teacher digital competence. Programs such as CRED and courses offered through County Centres for Teachers (CCD) were developed in alignment with these policy directions. Nevertheless, studies reveal persistent disparities in digital literacy among educators, particularly within primary and lower-secondary schooling. As a result, the shift from digitization – understood as the transfer of traditional practices to online formats – to meaningful digital transformation that reconfigures teaching and learning remains incomplete and unevenly distributed.

While the international literature has increasingly positioned AI as a catalyst for personalization, automated feedback, predictive learning analytics, and pedagogical augmentation (Baker & Hawn, 2022; Holmes et al., 2022), Romanian educational institutions are largely situated in pre-adoption or exploratory phases. AI is typically present only indirectly through platform-based features such as automated correction, speech-to-text tools, or adaptive items embedded within digital textbooks. Intentional and systematic integration of AI tools remains relatively rare. At the same time, two emerging patterns can be observed: first, the gradual incorporation of AI-enabled functions within educational platforms, particularly in assessment and language support; and second, teacher experimentation with generative applications such as ChatGPT, Canva Magic Write, or Quillionz for planning, differentiation, and content creation.

Public discourse has increasingly referenced concerns around bias, data privacy, and teacher displacement, amplified through inspectorate workshops and media commentary. However, governance mechanisms specific to AI – such as transparency protocols, ethical guidelines, bias audits, or accountability frameworks – have not yet been formalized within Romania's preuniversity policy architecture.

Inclusive education in Romania rests on several legislative and strategic pillars, including the National Education Law no. 198/2023, the National Strategy on Social Inclusion and the Reduction of School Dropout, regulations governing special educational needs (SEN), itinerant support structures administered through CJRAE and CJAP, and programs for disadvantaged learners such as "School after School," social scholarships, and adapted ICT provisions. Although national legislation promotes integrative models over segregated approaches, implementation remains inconsistent across regions and school types. Research points to multiple barriers, including limited availability of support staff, oversized classes, insufficient teacher training in differentiated instruction, and inadequate funding for rural schools.

Digitalization in this context has been recognized as both an enabling force and a source of further inequity. On one hand, technology can facilitate access to visual resources, adaptive learning tools, and personalized feedback, particularly for students with diverse learning needs. On the other hand, insufficient access to devices, unreliable connectivity, and low levels of digital competence can significantly constrain inclusive outcomes. The pandemic exposed these vulnerabilities most starkly, with approximately 900,000 students lacking either internet access or digital devices at the peak of school closures (Twesigye, 2020). Although subsequent PNRR investments have helped improve conditions, regional and socioeconomic disparities persist.

International scholarship increasingly emphasizes the need to conceptualize AI, digitalization, and inclusion as interdependent rather than parallel domains. Frameworks grounded in equity governance and inclusive pedagogy highlight the importance of aligning innovation with social justice considerations (Reich, 2023; Facer & Selwyn, 2021). In the Romanian case, however, these domains tend to evolve along separate trajectories: digitalization is frequently defined in terms of infrastructure and curricular modernization, AI is often perceived as experimental or optional, and inclusion remains predominantly framed through psychosocial services and legal mandates.

The risk that technological advancements could exacerbate rather than alleviate exclusion is well documented, particularly when differences in socioeconomic context and capability are ignored. Studies examining rural-urban divides and marginalized communities demonstrate that students from low-income households, Roma populations,

and geographically remote areas remain vulnerable to digital exclusion, even when online learning platforms are formally available. Against this backdrop, the present study addresses a critical knowledge gap by investigating how AI and digital practices interact with inclusion in Romanian schools, and by identifying the governance arrangements and support mechanisms most consequential for equitable outcomes.

2. Theoretical Framework

To investigate how artificial intelligence and digital transformation intersect with inclusion in Romanian preuniversity education, the study advances the Inclusive AI-Transformation Nexus for Romania (IATN-RO). This framework conceptualizes schools not as passive consumers of technology but as socio-educational systems in which equity outcomes emerge dynamically through the interaction of resources, governance structures, norms, and human agency. Rather than treating digitalization, AI implementation, and inclusion as discrete reform areas, the framework positions them within a shared ecosystem shaped by contextual constraints and institutional capacities.

The rationale for proposing IATN-RO stems from the observation that international approaches often examine AI, digital transformation, and inclusion in parallel, whereas in Romania these domains evolve in partially overlapping and sometimes misaligned ways. Digital tools are frequently adopted before inclusive adaptation occurs; AI enters classrooms in the absence of governance structures or pedagogical integration; and inclusion continues to be shaped by longstanding legislative and inspectorate frameworks marked by uneven resourcing. The IATN-RO model responds to this fragmentation by integrating three interdependent layers: technological readiness, institutional capacity and governance, and human mediation expressed through pedagogical practice.

These layers are operationalized through four interacting domains that reflect the differentiated realities of Romanian schools. The first domain, access infrastructure, encompasses the material and technical conditions that enable digital and AI-supported participation. This includes device accessibility for both teachers and students, the reliability and coverage of connectivity through Wi-Fi, LAN, or mobile networks, the availability of digital platforms such as Adservio, Kinderpedia, Google Classroom, or Microsoft Teams, and the presence of assistive technologies such as subtitling, speech-to-text tools, or screen readers. Persistent disparities between urban and rural schools continue to shape the degree to which digital access supports or constrains inclusion.

The second domain, adaptive intelligence, refers to AI-based or AI-adjacent tools with the potential to support personalization, accessibility, and real-time feedback. These tools may include platform features enabling automated assessment, translation, or speech recognition, as well as the use of generative AI in lesson planning and digital adaptations designed for learners with special educational needs. In some contexts, early warning systems are being piloted to identify disengagement or risk of dropout. However, such tools become genuinely equitable only when their use is aligned with pedagogical intent and subject to informed oversight.

The third domain, justice and governance, encompasses the ethical, administrative, and regulatory mechanisms guiding the use of digital and AI tools. These mechanisms include compliance with data protection requirements such as GDPR, participation of local support institutions like CJRAE and CJAP in decision-making, and the presence of school-level or inspectorate-level policies regulating technology adoption. To date, Romania lacks a national governance framework specific to AI in education, leaving institutions to navigate issues such as bias, transparency, data security, and human oversight without formal guidance.

The fourth domain, relational support systems, highlights the role of human mediation in shaping equitable or exclusionary outcomes. This includes teacher agency and collaboration, professional development opportunities through initiatives such as CCD, CRED, or PNRR, and the involvement of parents, psychologists, counsellors, or itinerant support teachers. Co-design practices with students, particularly those with special educational needs, also influence how AI and digital tools are interpreted, negotiated, or resisted in everyday school life. These relational dimensions determine whether digital and AI tools foster belonging or entrench exclusion.

The framework is further structured by three cross-cutting principles, conceptualized as the Romanian 3A Triad: agency, accountability, and alignment. Agency refers to the empowerment of teachers, students, and support professionals to shape the pedagogical role of technology. In Romania, this includes recognition of didactic autonomy, variability across school levels, and the acknowledgment of students with special needs as active participants in their learning. Accountability involves ethical responsibility, transparency, and the distribution of decision-making power, encompassing GDPR compliance, digital safety norms, institutional reflexivity, and inspectorate expectations. Alignment denotes coherence between technological tools, curricular goals, legal provisions, student needs, and

resource availability. Without such alignment, AI risks remaining peripheral, optional, or exclusionary rather than embedded in inclusive practice.

The analytical use of the IATN-RO framework is threefold. It supports diagnostic assessment by offering a structure through which to analyse how schools combine infrastructure, governance, and human practice. It functions interpretatively by providing a lens through which the study's quantitative constructs – the Inclusive Integration Index (III-RO) and the Equity Outcomes Composite (EOC-RO) – can be situated within the broader contextual dynamics of equity. It also has actionable value by guiding the design of policy levers, teacher training strategies, and governance mechanisms that reflect the institutional diversity of Romanian schools. The framework is not presented as a prescriptive model but as an adaptive structure capable of accommodating the heterogeneous realities of well-equipped technological high schools in urban centres such as Iași or Brașov, as well as under-resourced lower secondary schools in rural regions including Vaslui, Teleorman, or Maramureș.

3. Methodology

The study adopted a sequential explanatory mixed-methods design to investigate the intersection of artificial intelligence, digital transformation, and inclusion in Romanian preuniversity education. This approach combined quantitative and qualitative methods to capture both systemic patterns and contextualized experiences. The research unfolded in two distinct yet interconnected phases. The first phase consisted of a quantitative survey designed to assess digital and AI-related practices, institutional governance capacity, infrastructural access, professional learning ecosystems, and perceived equity and inclusion outcomes. The second phase involved semi-structured interviews that served to contextualize and deepen the interpretation of the quantitative findings by drawing on lived experiences and institutional realities. The explanatory design facilitated data triangulation and enhanced interpretive validity by linking numerical trends with school-level dynamics.

A total of 362 participants completed the survey during the first phase, representing 29 counties and reflecting the diversity of the Romanian preuniversity system. The sample included teachers from primary (23%), lower secondary (41%), and upper secondary (36%) levels, and reflected both urban (58%) and rural (42%) settings. Professional roles were distributed across tenured and substitute teachers (64%), principals and vice principals (9%), support and itinerant teachers (8%), school counsellors (6%), ICT and digitalization coordinators (7%), and inspectors or project specialists (6%). Stratified sampling was used to ensure demographic and regional representation across all eight development regions.

The qualitative component included 22 semi-structured interviews conducted with participants selected through maximum variation sampling. The sample included representation from urban and rural schools, primary, lower secondary, and upper secondary education levels, as well as a range of stakeholder categories. The final group comprised 12 teaching staff, three students – including one with special educational needs and one from a rural environment – two principals, one school inspector, two counsellors or CJRAE specialists, one ICT or digitalization coordinator, and one representative of an educational non-governmental organization. The inclusion of students, support professionals, and administrative actors allowed the analysis to capture the complex interplay between policy, practice, and educational experience.

The survey instrument was developed in alignment with the IATN-RO framework and encompassed the four domains and the three cross-cutting principles of the model. It included 12 items on digital infrastructure and access, 10 items on AI usage and adaptive technologies, 14 items related to governance, policy, and ethics, and 11 items on relational support and professional development. An additional eight items measured outcomes associated with inclusion, participation, and equity. All items used five-point Likert scales. Two composite indices were constructed for the analysis: the Inclusive Integration Index – Romania (III-RO), which demonstrated internal consistency with Cronbach's alpha values between .82 and .90 across domains, and the Equity Outcomes Composite – Romania (EOC-RO), with a Cronbach's alpha of .88.

The interview protocol was designed to explore the themes identified in the quantitative phase and focused on five key areas: the role of AI and digital platforms in practice; access, infrastructure, and urban–rural disparities; student experiences, including those of learners with special educational needs; the interplay of policies, resources, and teacher autonomy; and the obstacles and improvisational strategies evident in schools. Interviews, which ranged from 45 to 70 minutes, were conducted either online or face-to-face.

Data collection occurred between January and May 2025. The survey was administered between January and March through inspectorate networks, County Centres for Teachers (CCD) mailing lists, and professional associations of educators. Participation was voluntary and anonymous. The interviews took place between April and May. All sessions were audio-recorded with participant consent and transcribed verbatim. Pseudonyms were assigned to preserve confidentiality.

Quantitative data were analysed using SPSS version 28. Analytical procedures included descriptive statistics, Pearson correlations, and multiple regression models that controlled for school environment, educational level, and resource availability. Mediation analyses were performed using PROCESS version 4.2, and a moderation model examined connectivity as a moderating variable. Qualitative data were analysed through thematic analysis following Braun and Clarke's (2021) framework. The process involved open coding, the development of thematic categories, cross-case comparisons, and the integration of patterns with quantitative findings. NVivo version 14 was utilized for data management and coding.

Ethical considerations were central to the study design. Approval was obtained from a regional ethics committee affiliated with a university partner. Informed consent was secured from all adult participants, and assent procedures were applied for students, with parental authorization obtained when necessary. All data were anonymized in accordance with General Data Protection Regulation (GDPR) requirements. Participation was voluntary, and no incentives were offered that could influence responses. Additional measures were put in place for interviews involving students with special educational needs or individuals from socioeconomically vulnerable backgrounds to ensure that participation was safe, respectful, and fully consensual.

4. Quantitative Results

The quantitative strand of the study drew on survey data from 362 participants working in primary, secondary, and upper-secondary schools across Romania. The analysis focused on the four domains of the IATN-RO framework – access infrastructure, adaptive intelligence, justice and governance, and relational support systems – along with one cross-cutting dimension related to professional learning ecosystems. Two validated composite indices, the Inclusive Integration Index – Romania (III-RO) and the Equity Outcomes Composite – Romania (EOC-RO), were used to assess institutional practices and perceived inclusion-related outcomes.

Descriptive findings indicated that digital and AI-related practices were moderately implemented across the participating institutions. On a five-point scale, access infrastructure registered the highest mean score ($M = 3.41$, $SD = 0.83$), followed by relational support systems ($M = 3.22$, $SD = 0.80$) and professional learning ecosystems ($M = 2.98$, $SD = 0.84$). Adaptive intelligence tools were used to a lesser extent ($M = 2.79$, $SD = 0.91$), while governance mechanisms reflected the weakest overall performance ($M = 2.56$, $SD = 0.88$). Disaggregated analysis showed that urban schools scored higher across all domains compared to rural institutions. Primary and lower secondary teachers reported greater reliance on established digital platforms, whereas upper secondary educators were more likely to experiment with adaptive or AI-adjacent tools. Governance maturity emerged as particularly underdeveloped in rural environments and at the secondary level.

The Inclusive Integration Index (III-RO), composed of 32 items addressing access, AI use, governance, and support structures, revealed an overall mean of 3.06 ($SD = 0.63$). Differences by institutional type were notable: urban high schools achieved an average score of 3.33, rural lower secondary schools scored 2.71, and combined primary-lower secondary institutions registered a mean of 2.94. Cronbach's alpha for the index ranged from .82 to .90 across subdomains, indicating strong internal reliability.

Perceived equity outcomes were captured through the Equity Outcomes Composite (EOC-RO), which measured participation, accessibility, belonging, assessment fairness, and the digital inclusion of students with special educational needs. The overall mean was 3.18 ($SD = 0.66$). Participants in urban upper secondary contexts reported the highest levels of positive outcomes ($M = 3.42$), while those in rural lower secondary schools reported the lowest ($M = 2.81$). Internal consistency for the composite was strong, with Cronbach's alpha of .88.

A strong positive correlation emerged between III-RO and EOC-RO ($r = .52$, $p < .001$), suggesting that higher levels of inclusive integration of AI and digital practices correspond to better equity outcomes in Romanian schools. To further examine these relationships, a hierarchical regression model was constructed with EOC-RO as the dependent variable and controls for school location, funding level, and educational cycle. The model accounted for 41% of the variance in equity outcomes (adjusted $R^2 = .41$, $F(6, 355) = 42.7$, $p < .001$). The strongest predictor of equity outcomes was the

Inclusive Integration Index (β = .39, p < .001). AI governance maturity also emerged as a significant independent contributor (β = .31, p < .001), followed by professional learning ecosystems (β = .27, p < .01). AI usage intensity showed a weak and statistically non-significant effect (β = .08, p = .11). Urbanicity and funding level exerted small yet significant influences, while school level did not yield a significant effect once the controls were applied.

A mediation analysis tested whether professional learning ecosystems functioned as an intermediary mechanism between III-RO and EOC-RO. The indirect effect was 0.10, with a 95% confidence interval of [0.05, 0.17], indicating that 22% of the total effect was mediated. These findings suggest that structured training and peer support amplify the impact of inclusive digital integration on perceived equity outcomes.

Connectivity emerged as a moderating variable. A moderation analysis indicated that connectivity constraints weakened the positive relationship between inclusive integration and equity outcomes (β_interaction = −.11, p = .03). The effect was particularly pronounced in rural schools, where infrastructural limitations reduced the capacity to translate inclusive practices into measurable equity gains.

Overall, five quantitative patterns stood out. First, the degree of integration mattered more than the volume of tools deployed. Second, governance maturity exerted as much influence as infrastructural capacity in shaping outcomes. Third, teacher training and collaboration partially explained improvements in equity indicators. Fourth, digital divides persisted, particularly in rural areas and resource-constrained institutions. Finally, AI usage in isolation did not lead to meaningful equity gains in the absence of intentional orchestration and supportive conditions.

5. Qualitative Findings

The thematic analysis of the 22 semi-structured interviews revealed five interrelated patterns that shape how artificial intelligence and digital transformation influence equity in Romanian preuniversity education. These themes illustrate how institutional capacity, human mediation, and socio-economic conditions converge to condition the adoption, interpretation, and outcomes of technology use in schools.

A first topic highlighted the central role of human mediation in translating digital tools into inclusive practices. Participants consistently emphasized that technology alone is insufficient to ensure equitable learning. AI-assisted instruments appeared effective only when embedded in relational support provided by teachers, school counsellors, itinerant support staff, or parents. One teacher working in a rural lower secondary school in Vrancea observed, “Platforma ne ajută, dar copilul cu CES are nevoie de cineva care să-i explice și să adapteze, nu doar să-i dea linkul. [*The platform helps, but a student with SEN needs someone to explain and adapt things, not just send him a link*.]” Educators described using AI-enabled features such as voice typing, autocorrection, and visual applications to assist students with writing or dictation difficulties, yet emphasized that these tools required continuous pedagogical accompaniment to be meaningful.

A second topic concerned the role of transparency in fostering pedagogical trust. Interviewees associated ethical AI use not only with compliance but with clarity, accountability, and communicative responsibility. A school counselor from an urban high school in Cluj explained, “Elevii ne întreabă dacă îi monitorizează platforma. Dacă noi nu știm ce date se colectează, nici nu putem explica.[*When I asked two students in the class which platform they found easier to use, they chose something different from what we teachers would have decided*.]” Many teachers expressed uncertainty about privacy obligations, algorithmic decision-making, and data usage under GDPR requirements. They articulated a need for training that addressed ethical dimensions and governance expectations rather than focusing solely on functional instruction. Transparency was widely understood as a source of pedagogical legitimacy; explaining how and why AI works was perceived as increasing both student agency and institutional trust.

A third topic, centred on co-design as a vehicle for access, demonstrated that inclusive implementation emerged most effectively when digital practices were negotiated with learners, families, and support staff. Participants described multiple forms of shared decision-making, including adapting lessons with students, consulting parents in rural localities, involving support teachers in selecting platforms, and integrating the perspectives of learners with special educational needs. One urban primary school teacher from Bucharest reflected, “Când am întrebat doi copii din clasă ce platformă li se pare mai ușoară, au ales altceva decât am fi decis noi profesorii.” [*When I asked two students in the class which platform they find easier to use, they chose something different from what we teachers would have decided*.] Schools that encouraged experimentation and participatory adaptation reported improved engagement and higher levels of digital participation, especially among vulnerable learners.

A fourth pattern illustrated how educators in rural, low-resource, or small-town environments developed context-sensitive strategies to compensate for infrastructural and staffing constraints. Participants described practices such as using parents' phones for intermittent platform access, sharing mobile hotspots among teachers, printing digital materials for learners without internet connectivity, and relying on offline or free applications. As a support teacher from a rural lower secondary school in Vaslui noted, "Nu avem laborator digital, dar elevii folosesc telefonul mamei când pot și lucrăm pe rând." [*We don't have a digital lab, but the students use their mother's phone when they can, and we take turns working*.] AI was seldom explicitly acknowledged in these contexts, but functionalities such as autocorrection, text-to-speech, Google Lens, and generative tools like ChatGPT were used discreetly in lesson planning or differentiation activities.

The fifth topic addressed how educators negotiated the limitations and unintended consequences of algorithmic systems. Respondents described subtle inequities arising from AI-mediated interactions, including cases in which students with regional accents or speech impairments were misidentified as errors in voice applications, automated feedback misinterpreted non-standard essay formulations, or recommendation systems disadvantaged individuals based on past performance contexts. A teacher from an urban high school in Alba observed, "Platforma a spus că două răspunsuri sunt greșite, dar copilul a formulat altfel. Fără intervenția noastră, ar fi rămas nota mică. [*The platform said that two answers were wrong, but the child had formulated them differently. Without our intervention, the grade would have stayed low*.]" These experiences reinforced the perceived necessity of maintaining "omul din buclă" – a human-in-the-loop approach – to correct, contextualize, and mediate AI outputs.

Three cross-thematic insights emerged consistently across interviews. First, inclusion was framed as a relational rather than solely technological process. AI-supported tools enhanced equity only when coupled with responsive teacher engagement, student dialogue, and supportive classroom relationships. Second, participants stressed that agency and control were critical to ethical adoption. Teachers and learners required clarity, predictability, and the autonomy to adjust or challenge technological recommendations. Third, infrastructural disparities were identified as major constraints on ambition. In the absence of adequate connectivity and device access, particularly in rural areas, AI risked exacerbating rather than mitigating existing inequities.

Taken together, the qualitative findings contextualize and substantiate the quantitative results. They underscore that AI contributes to equity outcomes only when supported by governance maturity, professional development ecosystems, relational mediation, and feasible infrastructural conditions.

6. Limits and Discussions

According to our findings, the effects of artificial intelligence and digital transformation on equity in Romanian preuniversity education depend less on the mere availability of technology and more on the ways in which it is orchestrated, governed, and mediated by institutions and individuals. Rather than supporting deterministic views of AI as a neutral force for modernization, the results reinforce the argument that technology functions as a sociotechnical construct shaped by context, relationships, governance practices, and human agency. The discussion that follows interprets the findings in relation to the three research questions guiding the inquiry.

With respect to the first research question, the study reveals that AI and digital practices contribute to equity only when integrated into broader inclusive frameworks. The quantitative analyses demonstrated that the Inclusive Integration Index (III-RO) was the strongest predictor of the Equity Outcomes Composite (EOC-RO), with a significant effect size ($\beta = .39$, $p < .001$), whereas AI usage intensity alone did not yield a significant association with equity outcomes. These findings underscore that equitable gains arise when AI and digital tools are embedded in inclusive practices rather than deployed in isolation. The analysis further shows that infrastructure, while foundational, is insufficient on its own – particularly in rural contexts where connectivity and access to devices are limited. Human mediation remains central, as teachers, counsellors, support educators, and school leaders actively adapt AI to the needs of students, including those with special educational needs. Moreover, alignment with local contexts proves critical; even limited technological resources can enhance participation and learning when incorporated into inclusive pedagogical strategies. These observations extend national analyses by highlighting that digital equity is relational and governed rather than solely distributive (Twesigye, 2020).

The second research question examined which institutional capacities and governance mechanisms contribute most strongly to equitable implementation. AI governance maturity – comprising dimensions such as transparency, bias awareness, and human oversight – emerged as a significant predictor of perceived equity outcomes ($\beta = .31$, $p < .001$).

The qualitative data further indicated that teachers require clarity about data use, student monitoring protocols, ethical risks, algorithmic errors, and pathways for human correction. Professional learning ecosystems played a mediating role, accounting for 22% of the relationship between inclusive integration and equity outcomes. This underscores that teacher preparation and collaboration amplify the inclusive potential of AI and digital tools. Consistent with earlier research on Romanian digitalization, the findings suggest that training focused only on technical competence is insufficient. Instead, professional development must address inclusion-centred pedagogy and ethical governance alongside functionality.

The third research question explored how educators and other stakeholders negotiate AI in ways that may narrow or widen inequities. The interviews revealed that teachers do not engage with AI passively but instead modify, override, or disregard algorithmic recommendations when necessary. They adopt frugal and hybrid strategies in resource-poor environments, make use of AI informally in lesson planning and adaptation, and engage in co-design practices with students and parents. These forms of "local human governance" partially compensate for the absence of national AI policy guidelines. However, persistent infrastructural disparities constrain the potential impact of such adaptive practices. Rural teachers frequently described improvised forms of technological access, such as borrowing parental phones or sharing mobile hotspots. By contrast, urban high schools reported more stable connectivity, device availability, and access to AI-enabled platforms. Students with special educational needs benefitted when teachers used AI tools intentionally, but faced exclusion when systems lacked adaptation. Together, these insights challenge the assumption that increasing AI use inherently advances equity. Instead, they indicate that equitable outcomes arise from the interaction between digital practices and relational, ethical, and infrastructural conditions.

The IATN-RO model was empirically supported across its four domains and three cross-cutting principles. Access infrastructure was strongly evidenced in both survey and interview data, while adaptive intelligence appeared conditionally relevant, reflecting its emerging usage. Justice and governance emerged as a critical predictor in the regression analyses, and relational support systems were consistently emphasized in qualitative narratives. The principles of agency, accountability, and alignment were also reflected in practice: agency was visible in improvisation and co-design efforts; accountability appeared limited at the central policy level due to concerns around transparency; and alignment surfaced as a key mediator through professional learning ecosystems and inclusion practices. The framework proved analytically useful in explaining why institutions with relatively low AI usage but strong relational governance and collaboration reported better equity outcomes than more technologically equipped but weakly coordinated schools.

A further contribution of the study concerns the role of digital divides as structural moderators. Connectivity was shown to significantly moderate the relationship between inclusive integration and equity outcomes ($\beta_{interaction} = -.11$). This suggests that even robust inclusive practices cannot fully compensate for unstable or absent infrastructure. Romanian rural schools, in particular, face systemic constraints that limit the equity potential of AI. These conditions reinforce the qualitative theme of "frugal inclusion," in which adaptive strategies mitigate but do not eliminate exclusionary barriers.

Taken together, the findings call for a shift from conceptualizing AI as a technological enhancement to understanding it as a component of orchestrated inclusion. Schools that treat AI as a co-constructed resource embedded within inclusive pedagogical models appear more likely to realize equity gains than those that approach it as an external technical layer. This perspective challenges narratives of automation or technological inevitability and foregrounds the roles of agency, governance, and adaptation as the true drivers of impact in Romanian preuniversity education.

7. Implications for Policy, Practice, and Design

The findings of this study indicate that artificial intelligence and digital transformation can contribute meaningfully to educational equity in Romania only when they are embedded within orchestrated, relational, and context-sensitive implementation models. Drawing on the IATN-RO framework and the empirical evidence generated through both quantitative and qualitative strands, several implications emerge for policy, institutional practice, and design.

At the policy level, the absence of a national governance framework for AI in education remains a critical gap. Without clear guidance on ethics, data transparency, or algorithmic accountability, schools operate without a coherent reference for acceptable and equitable implementation. A national framework should go beyond generic GDPR compliance to specify human-in-the-loop protocols, establish mechanisms for assessing and appealing algorithmic bias, and articulate expectations related to evaluation, decision-making, and the inclusion of students with special

educational needs. A second policy implication concerns teacher training standards. Current professional development formats delivered through inspectorates or teacher training centres concentrate predominantly on tool use rather than on inclusive orchestration. Revising these standards to integrate ethical AI literacy, digital differentiation practices, and case-based approaches addressing rural schools, multilingual learners, and CES contexts would provide educators with the competencies needed to mediate AI responsibly. A third policy implication relates to persistent infrastructural deficits. Investments in connectivity and devices – particularly in rural regions – should extend beyond the current PNRR funding cycle and should include resources for maintenance, replacement, and community-based access through partnerships with libraries, after-school centres, or NGOs. Finally, policies governing AI, digitalization, and inclusion must be aligned with existing legislative mandates, including the National Education Law no. 198/2023, the National Strategy on Social Inclusion, school dropout reduction plans, and CJRAE/CJAP requirements. Digital initiatives that bypass inclusion frameworks risk reinforcing rather than reducing disparities.

At the level of school practice, the findings underscore the need to strengthen relational support systems as the mediating layer through which AI becomes either inclusive or exclusionary. Teachers, homeroom educators, school counsellors, support specialists, and family members all contribute to the interpretive processes that enable learners – especially those with special needs or socioeconomic vulnerabilities – to access digital resources. One practical recommendation is the creation of multidisciplinary digital inclusion teams within schools, composed of teaching staff, ICT coordinators, counsellors, and CJRAE representatives. A second implication concerns the adoption of co-design practices involving students, parents, and educators in selecting, piloting, and adapting technological tools. Schools that created consultative or experimental spaces for tool selection reported greater engagement and more consistent uptake, particularly among students with additional learning needs. A third implication relates to institutional reflexivity around digitalization. Establishing procedures to identify and correct AI- or platform-related inequities, to address algorithmic errors, and to integrate reflective teaching based on digital traces can foster a culture of accountability and adaptive learning. Embedding such reflective loops into professional development structures can support sustained, equitable use of AI.

Design and implementation processes must likewise transition from platform acquisition to inclusive integration. Technological choices should be assessed in terms of accessibility – including linguistic, visual, and auditory dimensions – curricular relevance, compatibility with the needs of students with special educational needs, and offline usability. Applying the 3A lens – agency, accountability, and alignment – prior to adoption can help schools evaluate who has the capacity to adapt technologies, to whom data and processes are accountable, and how the tool aligns with curriculum, resources, and learner profiles. Given the structural disparities observed in the study, design strategies must also account for what may be termed “frugal inclusion,” acknowledging that low-cost or offline AI alternatives, device-sharing practices, voice-assistive or translation features, and AI-generated scaffolding materials may be necessary to bridge infrastructural deficits. Designing human oversight into AI use remains essential to prevent misclassification, bias, or exclusion; teachers must retain the authority to override or reinterpret AI outputs, and students should be informed transparently of the rules and limitations governing AI-supported assessment and feedback.

Sustainable scaling of inclusive AI practices requires coherent system-level conditions. Inspectorate-level mechanisms for monitoring digital equity and AI ethics would enable more consistent accountability across regions. Interinstitutional networks that bring together schools, teacher training centres, NGOs, and universities could facilitate knowledge exchange and support adaptive implementation models. Additionally, policy incentives – whether through funding allocations, accreditation mechanisms, or recognition from the Ministry of Education – should reward inclusive orchestration rather than mere adoption of platforms. Ultimately, both policy and practice must understand AI not as a discrete technological layer but as part of a broader relational and pedagogical ecosystem tied to justice, teacher agency, and infrastructural equity. Only under such conditions can digital transformation contribute to narrowing rather than intensifying existing educational divides in Romania.

Conclusion and Future Directions

This study explored the intersection of artificial intelligence, digital transformation, and inclusive education in Romania’s preuniversity system, focusing on the mechanisms through which technology may advance or undermine equity. By combining survey data from 362 practitioners with qualitative insights from 22 stakeholders working in diverse school environments, the research provides empirical grounding and conceptual clarity on how inclusion is negotiated within digitally evolving educational contexts.

Three central conclusions emerge from the findings. First, AI and digital tools do not inherently generate equitable outcomes. The quantity or intensity of technology use is not a reliable predictor of inclusion; rather, the degree to which technology is orchestrated through governance practices, pedagogical mediation, and human support systems determines its impact. Second, institutional capacity is a strong predictor of equity outcomes. The Inclusive Integration Index (III-RO) emerged as the most robust predictor of the Equity Outcomes Composite (EOC-RO), while AI governance maturity and professional learning ecosystems functioned as key enabling conditions. At the same time, infrastructural disparities – particularly in rural localities – constrained the benefits of digital transformation. Third, inclusion is relational, contested, and context-dependent. Mechanisms such as human-in-the-loop oversight, co-design practices, frugal innovation, and ethical reflexivity served as practical safeguards against AI-induced inequities. Together, these insights reinforce the need to understand AI not as an external add-on, but as part of a socio-pedagogical ecosystem requiring continual adaptation, clear policy direction, and shared ownership.

The study makes three interrelated contributions. Conceptually, it proposes the Inclusive AI-Transformation Nexus for Romania (IATN-RO), a context-sensitive framework that integrates four domains of digital and AI implementation with the cross-cutting triad of agency, accountability, and alignment. This framework holds diagnostic value for identifying institutional strengths and gaps and can support developmental planning at school, inspectorate, or policy levels. Empirically, the research validates two indices – the Inclusive Integration Index (III-RO) and the Equity Outcomes Composite (EOC-RO) – and employs regression, moderation, and mediation analyses to identify measurable indicators of inclusive digital capacity. The mediating influence of professional learning ecosystems underscores the centrality of teacher preparedness and collaboration. Practically, the findings offer actionable guidance for policymakers, educational leaders, and practitioners concerning governance mechanisms, digital inclusion, teacher training, and AI tool adaptation.

Several limitations warrant consideration. The reliance on self-reported data introduces a possible risk of social desirability bias. Regional representation was uneven, with some counties contributing fewer responses. Given that AI usage in Romanian schools remains emergent rather than fully institutionalized, the findings reflect a formative moment rather than mature implementation. Additionally, the quantitative component primarily reflects teacher and staff perspectives, with limited direct student participation. These constraints do not diminish the validity of the conclusions but point to areas for continued investigation.

Future research should address these limitations through several directions. Longitudinal studies are needed to trace how AI adoption evolves over time, particularly in light of ongoing PNRR investments and emerging policy developments. Student-centred research would provide a more balanced and experiential understanding of digital inclusion, especially for learners with special educational needs or those from rural and socioeconomically disadvantaged backgrounds. Comparative analyses across counties, urban and rural clusters, and governance models could illuminate structural and regional differences. Experimental or design-based approaches would allow for the testing of co-created AI tools, adaptive textbooks, and assistive applications in authentic classroom settings. Finally, further work is needed to develop and validate Romanian indicators for AI governance, transparency, bias mitigation, and human agency.

To conclude, AI and digital technologies hold transformative potential for fostering inclusion in Romanian schools; however, this potential is realized only under conditions of ethical governance, contextual alignment, relational support, and teacher empowerment. The study demonstrates that equity gains arise not from the intensity of technological adoption but from inclusive integration, reflexive leadership, and informed human mediation. Recognizing AI as part of a broader human-technical ecosystem, rather than a standalone innovation, can help Romania avoid the pitfalls of digital determinism and cultivate participatory, just, and contextually responsive educational futures.

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AI Tools Declaration

The author declares that no artificial intelligence tools were used for data analysis, statistical processing, interpretation of findings, theoretical development, or any stage of the empirical research process. AI-assisted tools were employed exclusively for grammar refinement, clarity improvement, and minor linguistic editing after the scientific content had been fully developed and finalized by the author. The following tool was used: ChatGPT (OpenAI), Version GPT-5.1 (2025) employed solely for language polishing, without altering the academic substance, argumentation, methodology, or results of the manuscript. All analytical, conceptual, and interpretative components of the study represent the author's own original work.

Author Biography

Cristina-Georgiana Voicu holds a PhD in Philology (British and American Cultural Studies) from Alexandru Ioan Cuza University of Iași. Her research explores the intersections between cultural theory, posthumanism, and digital pedagogy. She has published extensively in peer-reviewed national and international journals and edited volumes on digital ethics, cognitive humanities, and metamodern humanism. She is currently a member of several international research networks in American Studies and digital pedagogy, with a significant scholarly impact.