

DIGITAL DIVIDE AND TECHNOLOGICAL EXCLUSION: STRATEGIES FOR INCLUSIVE ICT SKILL DEVELOPMENT IN ADULT EDUCATION

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Abstract

These days, there is no doubt that we are marked by rapid technological innovation and pervasive digital integration across socio-economic and educational domains. The persistent phenomenon of the digital divide constitutes a profound barrier to equitable access, participation, and empowerment within knowledge societies.

This article critically examines the multifaceted dimensions of digital exclusion as experienced by adult learners, interrogating the structural, cognitive and socio-cultural impediments. Against this backdrop, the study foregrounds inclusive ICT skill development as a pivotal catalyst for social inclusion, economic mobility, and lifelong learning, thereby underscoring its salience within global and national educational policy frameworks.

Leveraging an interdisciplinary approach that synthesizes theoretical constructs from digital sociology, adult education pedagogy and technology acceptance models, this research situates its empirical inquiry within the Romanian context, drawing on comprehensive data collected at the Bucharest University of Economic Studies alongside extensive bibliographic analyses of international and regional case studies. The article aims to explain the nexus between technological exclusion and broader educational inequities. It is also highlighting how factors such as socio-economic status, age, educational background and geographic location exacerbate disparities in digital competence among adult populations.

Methodologically, the study employs a robust mixed-methods design, integrating quantitative assessments of ICT skill proficiency, access metrics, and participation rates with qualitative insights from semi-structured interviews, focus groups and participant observations within adult learning centers. This holistic analytic framework enables an intricate understanding of the lived experiences and pedagogical challenges faced by digitally marginalized adults.

Findings reveal that comprehensive, context-sensitive strategies—encompassing tailored curriculum design, community engagement, and culturally responsive pedagogies—are instrumental in mitigating technological exclusion and fostering sustainable digital competence development. The research further identifies the transformative potential of leveraging emerging technologies such as mobile learning platforms, gamified instruction, and peer-led digital mentorship.

In addition, the article articulates a strategic framework for inclusive ICT education that integrates technological infrastructure expansion and intersectoral collaboration between governmental bodies, educational institutions, and civil society actors. By foregrounding adult education as a critical arena for bridging the digital divide, the study advances a policy-relevant discourse aimed at fostering digital equity and empowering marginalized communities within and beyond Romania.

In conclusion, this research contributes as a fundamental scholarly perspective on the complexities of digital exclusion in adult education. In addition, it provides empirically grounded and also scalable recommendations for policymakers, practitioners, and researchers committed to advancing inclusive digital overviews. It asserts the idea to reconceptualize adult learning as an inclusive, adaptive, and also technology-empowered process, that is capable of catalyzing socio-economic transformation and reinforcing the foundational outlines of lifelong learning in this digital age.

Keywords: Digital divide and adult education, exclusion and inclusion strategies, inclusive ICT skill development, lifelong learning and digital literacy, socio-educational equity in technology.

1 INTRODUCTION

The digital divide is one of the most relevant structural and sociotechnical problems for adult education in knowledge societies. The literature always stresses that digital exclusion is more than a matter of technological presence/absence and its roots embed in multifaceted social, cognitive and cultural factors which interact in affecting adults' participation, empowerment and lifelong learning pathways

[1–3]. As Selwyn et al. [1].- "Digital access standing alone does not equal digital opportunity. It is the confluence of resources, skills and social capital that mediates meaningful participation in digitally mediated learning environments". This finding highlights the necessary shift of paradigms away from a focus on infrastructure provision and toward framing digital inclusion as a systemic, multifaceted effort (involving pedagogical practice, psychological elements, and policy initiatives).

Structurally, socio-economic status (SES), geographic place of residence and educational achievement appear to be reliable determinants for digital exclusion [2, 4–6]. References Memon and Memon [2] highlight the social divide in terms of access to internet resources as well as the ability to convert access into run-of-the-mill competence, working to accentuate educational inequalities. Similarly, Lopez-Aguado et al. [3] note that adult learners in underserved areas face compounded challenges, including connectivity issues, limited institutional support and social stigma around the use of technology that makes adoption cognitively and socially difficult. Warschauer's influential volume [4] further extends this by arguing that digital inclusion depends on the synchronisation among three mutually dependent dimensions - technology access, skills for using the technology and participating in related social/educational networks. This tripartite model offers a basic way of thinking about how adult learners do or do not gain access to the benefits of ICT - enriched learning.

The cognitive and motivational part of digital capabilities is also important. Empirical evidence suggests that adults' use of ICT is influenced by perceived self-efficacy, previous experience, and motivational orientation [6–8]. Parsons and Hick (2008) contend; 'digital inclusion efforts must use pedagogical principles that foster confidence and motivation as well as learn technology skills.' In parallel, Fang et al. [6] emphasise the role of privilege and social capital in relation to learners' ability to navigate digital spaces with potential programmatic and policy implications. Adult learners who have little or no previous experiences with technology are particularly at risk of suffering from cognitive overload and learned helplessness also in face of digital learning programs, a condition that becomes even worse in marginalized socio-cultural conditions [9,10].

Institutional and policy contexts are another central axis of analysis in the literature. The success of ICT skills development interventions is often facilitated by organizational commitment, leadership support and policy alignment [11–12]. Adam and Dzang Alhassan [9] note that having a holistic digital inclusion programs necessitate coordinated intersectoral actions or strategies, such as integrating government policy, educational infrastructure and the involvement of civil society. In a related work, Spivak et al. [9] highlights the need for institutionalized lifelong learning paths with modular, flexible and context-based programs for adult learners. The failure to embed these can result in 'part-provision, low ratios of participation and inevitably technologically excluded'. Zdjelar and Žajdela Hrustek [10] also show that, even within highly industrialized economies, systemic inertia, under-funding and mis-aligned policy have led to different forms of long-term inequalities: thus drawing attention to the political and administrative aspects associated with digital inclusion. "The need to move entirely from the traditional teaching-learning method of economic-financial sciences toward more interactive and practical methods, based on the preference for experiential learning styles. Incorporation of mentoring and peer learning programs in the curriculum design could enhance skill retention and application of knowledge into practice, emphasising the role of MRCFs as collaborative learning campuses" [11]. In the same vein, Costache (2024) explains how structured internships and mentorship are essential in order to enhance educators' digital and pedagogical competences [12,13]. This relationship is found again in the literature, and there is an important convergence between inclusive pedagogy, cognitive variation and neurodiversity. An inclusive ICT education for adults requires instructional designs that permit individual learning profiles, cognitive styles and cultural backgrounds to be considered [14–17]. Tomczyk et al. [14] argue that older adults are faced with specific learning difficulties such as reduced digital literacy, increased fear of technology and cognitive processing limitations requiring personalized pedagogical strategies. Akinlar et al. [15] take this one step further for migrant and culturally diverse communities by proving that critical pedagogy, and culturally rich instructional approach, helps improve the engagement of students and learning. These studies together confirm that inclusive pedagogy is not only a normative goal, but also an imperative with its practical force to counteract established digital inequities and promote equitable ICT proficiency of adult learners.

The literature also added an understanding that motivation, resilience, and psychological predecessors are interconnected in adult learners' paths within the ICT-mediated environments [18,19]. Raihan et al. [18] highlight that the ability of self-regulation, perseverance and adaptive coping mechanisms can contribute to successful participation in digital learning especially if such posture occurs within social or cognitive disadvantage. Afzal et al. Institutional support structures, such as support, mentorship, PAL schemes and incentives/acknowledgment mediate the impact of motivational dispositions on learning outcomes [22]. This finding is consistent with the results of Pont

and Sweet [20] who suggest that adult learners benefit from a scaffolded, structured intervention which builds technical competence in a gradual way but also increases positively self-efficacy. Significantly, the report of Gorski [21] frames this research within questions of equity, arguing that attention to pedagogical responsiveness to learners' socio-cultural and psychological contexts can help address systemic barriers to digital inclusion. Project-based-learning frameworks show how problems of sustainability (e.g. renewable energy roll-out, waste product handling) can be solved through a participatory problem solving approach [23, 24]. Sustainability is a metaphor for an ability of resilience: "ability of the system to maintain itself, whereas the institution of a variety of external destabilising factors" [25, 26]. Despite such theoretical and empirical progress, however, a number of unsettled questions and controversies remain. First, the debate on what works best in closing the digital divide between technology-based interventions and socio-pedagogical initiatives is still alive [5, 27, 28]. Whereas some studies have focused on the delivery of hardware, software and connectivity, others propose that mere provision of infrastructure is inadequate if cognitive skills development has not been addressed in parallel, motivation has not been scaffolded and culture has not been localized [29,30]. Second, the assessment of adult digital competence is still debated, scholars have proposed multidimensional evaluations of specific digital use which go beyond simple functional skills to also cover adaptive, ethical and collaborative dimensions [4,31]. Third, the literature points to an important trade-off between universalist policy responses and context-specific approaches rooted in local needs, especially within socio-economically diverse populations [2,6,32]. These lacunae highlight a necessity for empirical work that combines the 'quantitative proficiencies' with 'qualitative understandings of stylized facts of students' life experiences, motivational orientations and sociocultural situatedness [33]. Stress-related pressures may be similar to those in traditional academic environments where students experience ongoing stress prior, during and after exams [34-36]. These findings support the need to position mental health within digital inclusion strategies. [37,38] Ongoing and adaptive institutional training is key as piecemeal or one-off approaches tend not to create sustained change [39].

Another layer of complexity is the contribution potential of new technologies to adult trajectories in digital learning. Mobile learning, gamification and peer-led digital mentorship initiatives have demonstrated potential to improve engagement and retention; however, the evidence is mixed and context specific [15,40]. Chetty et al. [7] note that, in G20 settings, innovations using such technologies as springboards for skill development initiatives might fast-track digital inclusion so long as they are grounded within coherent institutional structures and culturally appropriate pedagogies. Similarly, Mwansa et al. [35] show that rural and disenfranchised communities need hybrid interventions with low-tech access solutions accompanied by high-touch pedagogical support, revealing the intertwining of technological, cognitive and social aspects of inclusion.

Drawing these strands together, the literature paints a picture that suggests digital divide in adult education is a complex problem to be tackled from an inter-disciplinary perspective of structuration, cognitive theories, socio-cultural and policy perspectives [41]. Digital exclusion is not simply a matter of lack, but an integrated problem characterized by variations in access, skills, motivation and institutional support. There is a strong theoretical base and empirical evidence from the literature [9,42], yet much remains to be understood of how inclusive ICT skill development can be practically operationalised in different adult learning settings, especially taking into account transitional economies such as Romania. The current research fills this gap by using a mixed-method design combining quantitative digital competence measurements with the qualitative analysis of the psychological, cultural and experiential profile of learners towards an integrated theoretical framework for interpreting (and hopefully preventing) technology related exclusion [45].

Crucially, the review emphasizes the novelty and theoretical significance of this study. Although previous work has discussed digital divides within distinct academia, the present paper theorises inclusive development of ICT skills at the crossroads of adult learning pedagogy, digital sociology and equity policy analysis. Through the notion of neurodiversity in learning profiles, cognitive diversity and culturally responsive instructional design at its explicit forefront, from a focus on functional skills, we move towards considering ethical, social and adaptive dimensions of digital literacy. Such a multi-dimensional view is essential for guiding national educational policy and institutional practice, providing empirically informed strategies that are scalable and contextually adjustable, yet congruent with the wider imperatives of lifelong learning and socio-educational justice [21,46,47].

In sum, the literature review identifies agreement around the extent to which digital inclusion of adults depends on an interplay between provisioning, pedagogical sophistication, psychological support and socio-cultural responsiveness. Continued gaps and controversies underscore the need for comprehensive empirical studies that take into account the lived experiences, motivational dispositions and institutional contexts of digitally disenfranchised adults [48-50]. This is the agenda which the

current study supports by proposing a theoretically grounded and methodologically sound approach to investigating ICT skills development for all as one of the key mechanisms in closing divides, fostering lifelong learning and advancing social educational equity in Romania, but beyond it as well.

2 METHODOLOGY

We will use a strong mixed-methods research design, to judiciously employ quantitative as well as qualitative methods of investigation into the complex issue of digital exclusion in adult learners and about promising practices that promote inclusive ICT skill development. The motivation for a convergent design construction is the recognition that objective data about digital competence, access and participation rates can be provided through quantitative assessments, qualitative research can in turn highlight the nuanced socio-cultural, psychological and experiential aspects of technology exclusion [1–3]. Through triangulation of these sources, the study has sought to build an inclusive contextual picture of the elements that drive digital inclusion in the Romanian AE sector.

Study Setting and Participants

The empirical research was developed in the context of adult education programs, conducted at Bucharest University of Economic Studies, where a demographically and socio-economically diverse sample of participants aged between 25 - 64 were enrolled. Participants were selected using purposive sampling to be able to represent variation along several axes of potential vulnerability including education, socio-economic status, regional origin and previous digital experience. The study was conducted in two phases: 312 participants (quantitative phase) and a subset of 48 maximum variational samples (based on digital skill and socio-cultural background) which took part in semi-structured interviews and focus groups. Ethical principles such as informed consent, confidentiality and voluntary participation were strictly adhered to based on institutional protocols and international ethical standards [4,5].

Quantitative Component

The quantitative arm used a highly structured, multi-faceted instrument, one on digital competence and access. We measured digital skills with a validated questionnaire based on the European Digital Competence Framework for Adults (DigComp) and covering cognitive, operational, and evaluative competencies in the domain of ICT [6–8]. Measures of access were based on objective (device availability, Internet connection speed and how often children use technology) and subjective criteria (perceived ease of access and usability). Attendance rates at online learning modules and the number of ICT-specific courses accessed were also monitored longitudinally via 12 months. Descriptive statistics, correlations and multiple regression analyses were used to examine which predictors (socio-demographic variables as well as prior educational achievements versus motivational indicators) of digital competence contributed significantly. Hierarchical linear modelling (HLM) was used to adjust for nesting and investigate the impact that institutional and community variables had on learning outcomes at an individual level [9,10].

Qualitative Component

The quantitative approach employed a high-structured, multifaceted tool on digital competence and access. We assessed digital skills through a validated self-report questionnaire, which was grounded on the European Framework for the Digital Competence of Adult Learners in five key areas, including cognitive, operational and evaluative competences in managing ICT (DigComp) [6–8]. Access measures were derived from both objective (device availability and internet connection speed, frequency of children using technology) as well as subjective characteristics (perceived ease of access and usability). attendance in the online learning modules and number of ICT-specific courses accessed over 12 months were also longitudinally tracked. To identify relevant predictors (descriptive statistics and bivariate correlational analyses, as well as multiple regression analyses) of digital competence, the question was posed which aspects (socio-demographic factors vs. prior educational achievements vs. motivating cues) would make a significant contribution. To account for nesting and relatedness of the participants, hierarchical linear modelling (HLM) was performed to estimate the effect that institutional- and community-level variables had on individual learning outcomes at the sampling units [9,10].

Integration of Quantitative and Qualitative Data

The integrated mixed-methods approach was achieved through the use of a joint display matrix to compare and contrast patterns emerging from digital competency metrics, access indices, and socio-demographic variables with the major themes arising from the qualitative data. This enabled us to identify patterns of convergence, divergence and complementarity, thereby offering multiple viewpoints on the drivers of technological inclusion and exclusion [19,51]. For instance, the quantitative analyses showed a strong correlation between socio-economic status and ICT skills ($\beta =$

0.42, $p < 0.01$), but qualitative data explained why such disparities existed by providing insight into psychological reasons for disparities in computer access (e.g., perceived self-efficacy) and motivational variables against practical values of technology as well as prior education experiences with marginalization in other areas substantiated these differences.

Psychological, Cultural, and Organizational Factors

Consistent with the theoretical perspective guiding the study, substantive attention was paid to investigating psychological, cultural and organizational precursors of digital skill acquisition. In order to spark engagement, some learners suggested enabling volume control within the sound of their web pages as well as an option to bookmark favorite pages. 2.4 Instruments The quantitative tools incorporated psychometric scales measuring self-efficacy, digital anxiety, and motivational orientation while qualitative interviews explored the impact of cultural norms, intergenerational dynamics, and organisational support systems on learners' ICT uptake. This double focus permitted a nuanced comprehension of how macro-level inequities intersected with micro-level psychological processes, producing participation, persistence and skill acquisition in the context of adult education [20–22].

Validity, Reliability, and Ethical Considerations

Several methods were used to maintain methodological rigor and credibility. Internal consistency reliability was calculated for continuous variables by estimating Cronbach's alpha coefficients, which for all instruments exceeded the acceptable criterion of 0.80. Confirmatory factor analysis and correlations with established digital literacy measures demonstrated construct validity. Qualitative rigor was enhanced with member checking, peer debriefing and iterative code refinement. An institution review board ethic statement confirms this study was conducted in accordance with the highest ethical standards of protection and security for human participants and integrity in scientific research [23–25].

3 RESULTS

The empirical analysis offers a multi-dimensional picture of digital exclusion and the effectiveness of inclusive ICT skills-building programs for adult learners. Quantitative analyses of 312 participants are complemented by qualitative depth found in the text of 48 semi-structured interviews and focus groups. Findings are structured into three interconnected areas: digital competence and differences in access, predictors of ICT skill development, and thematic understandings of the socio-cultural and organisational determinants of inclusion.

The descriptive data show great variation in digital skills among the respondents. The average DCA score showed moderate digital expertise ($M = 52.8$, $SD = 13.4$, range: 18–89), with pronounced differences by SES, educational level and age. Namely, those with tertiary education scored on average significantly higher ($M = 63.2$, $SD = 9.7$) than those with secondary or lower education ($M = 46.7$, $SD = 11.8$), $t(310) = 9.81$, $p < 0.001$, Cohen's $d = 1.22$ Sex contribution effects as a function of cognitive ability The sex difference discussed earlier also raises the question if it could be explained by potential female over-representation at lower levels of cognitive ability compared to males [Why are there more male villains than female?]. Geographical inequalities were also noticeable and rural inhabitants showed much lower digital skills ($M = 48.6$, $SD = 12.5$) than urban participants ($M = 55.7$, $SD = 13.1$), $F(1, 308) = 12.54$ $p < 0.001$ $\eta^2 = .04$ - emphasising continued existing spatial discrepancies in terms of ICT access and literacy!

These inequities were also reflected in objective access measures. Access to high-speed Internet was only reported by 63% of respondents and 27 % had only intermittent or mobile access. Device access was also unequal, with 18% of respondents using shared or old devices which limited their ability to fully participate in digital learning opportunities. Self-reported usability perceptions also were differentiated out by socio-economic status, with lower-status respondents reporting much stronger feelings of digital anxiety ($M = 4.12$, $SD = 1.03$) than their higher-status counterparts ($M = 2.87$, $SD=0.92$), $t(310) = 10.34$, $p < 0.001$].

Hierarchical multiple regression models were used to assess predictors of digital competence. Socio-demographic characteristics were included in the first level (age, sex, education, socio-economic status according to the Casmin system, and geographical origin), while motivational and psychological variables (self-efficacy, digital anxiety as deficits motivation from technology acceptance model 3 and intrinsic motivation) were added on the second level. Model 62% of the variance in digital competence was explained by this model ($R^2 = 0.62$, $F(8, 303) = 63.48$, $p < 0.001$). The most important predictors are education level ($B = 0.34$, $p < .001$), digital self-efficacy ($B = 0.41$, $p < .001$), age-inverted sufficient competence is not the effect because they reversed the coding of ICT skills and age of participants ($B = -0.21$, $p < .001$) which emphasizes the mixed existence of structural and psychological factors behind ICT skill mastering process.

To correct for data nesting - participants nested within learning centers - a hierarchical linear model (HLM) was used. Level-1 predictors were composed of individual socio-demographic characteristics and motivational indices, and Level-2 predictors accounted for institutional support (availability of digital mentors, did the hands-on workshops more than once or very often, access to community learning resources). The HLM showed a strong between-center variation ($\tau_{00} = 0.18$, $SE = 0.06$, $p < 0.01$), suggesting that cross-institutional context was an important factor of variations in the individual skill outcomes. Specifically, respondents enrolled in centres which offered a form of peer mentorship curriculum had 27% higher odds of achieving advanced digital proficiency compared to their counterparts (random-intercept models estimate: $\gamma = 0.24$, $SE = 0.07$, $p < .01$).

A multivariate analysis of covariance (MANCOVA) was conducted to investigate the combined influences of SES, age and prior education on three dependent measures: digital competence, frequency of technology use; and engagement with online learning modules. The Pillai's profile also revealed a significant multivariate effect for SES ($V = 0.21$, $F(6, 602) = 13.57$ $p < 0.001$) and educational level ($V = 0.18$, $F(6, 602) = 11.03$ $p < .001$), indicating that structural inequities synergize to compound digital exclusion. Post hoc analyses identified the poorest subgroup, older adults with low education and living in rural communities, as having both weaker access to and lower engagement with digital learning modules; effect sizes ranged from $\eta^2 = 0.12$ to 0.18 for these comparisons.

Qualitative Themes: Psychological, Cultural, and Organizational Determinants

Thematic analysis of interviews and focus groups revealed three primary categories mediating ICT skill acquisition:

1. **Psychological Factors:** Participants consistently reported that self-efficacy, motivation, and digital anxiety significantly shaped engagement with technology. One respondent emphasized, "I often feel left behind because I cannot quickly grasp new applications, which makes me hesitant to participate in online courses" [36]. Digital anxiety was particularly pronounced among older learners and those with limited prior exposure, highlighting the need for scaffolding and confidence-building strategies.
2. **Cultural and Socio-Cognitive Norms:** Cultural perceptions regarding technology shaped participation. Learners from communities with limited technological penetration often viewed ICT skills as optional rather than essential, reinforcing structural exclusion. Conversely, exposure to peer role models and intergenerational learning networks fostered positive attitudes toward digital skill acquisition.
3. **Organizational and Institutional Support:** Availability of mentoring, supportive instructors, and structured curricula emerged as critical enablers. Centers that incorporated blended learning approaches - combining hands-on workshops, gamified online modules, and peer-led digital mentorship - achieved higher engagement and competence outcomes. One participant noted, "Having someone to guide me step-by-step changed my perception; I realized I could actually keep up with technology if I had support" [37].

The merging of quantitative and qualitative evidence highlights the multidimensional structure in which structural, psychological, and organizational conditions affect digital competence in adult learning. Regression and HLM analysis are used to determine the extent of socio-demographic and institutional factors, while qualitative data is used to explain through lived experience what mediates these relationships. For example, although age and education emerged as important predictors of digital literacy in large representative studies with multivariate analyses, qualitative findings showed that customised mentoring and culturally responsive pedagogies could alleviate these structural inequalities greatly. Such convergence provides further evidence that successful ICT open access strategies should be tackling access disparities, enabling psychological empowerment and engaging with institutional supportive systems at once [38,39,40].

4 DISCUSSION

The present study yields an in-depth, evidence-based understanding of the multi-faceted determinants that underpin digital exclusion and ICT learning faced by adult learners. The combination of hierarchical linear modeling, multivariate analyses and thematic qualitative coding offers a fine-grained understanding of underlying structural as well as psychosocial determinants, which yields significant implications for theory, policy and practice.

Quantitative results reveal that SES, education, age and region are strong predictors of digital literacy in the population - a finding which compares well to previous research underscoring structural factors [1,9] shaping technological inclusion. The HLM results demonstrate that individual learning outcomes are significantly influenced by between-center variability ($\tau_{00} = 0.18$, $SE = 0.06$, $p < .01$), indicating the

institutional context is a statistically significant moderator for ICT skill acquisition. These findings are in-line with Ragnedda and Ruiu [26] who frame digital inequality as the product of both micro-level individual attributes, but also meso-level institutional factors. The absolute values of the regression coefficients ($\beta = 0.34$ for education, $\beta = -0.21$ for age, and $\beta = 0.41$ for digital self-efficacy) emphasize the quantitative impact of these factors; structural constraints and psychological capacities interacted as a joint function in determining competence outcomes.

The multivariate intersectional analyses also showed that elderly with low levels of education in rural areas are an especially vulnerable group ($\eta^2 = 0.12-0.18$). These results echo the social stratification view suggested by Selwyn et al. [1] and Warschauer [4], suggesting that equitable ICT access calls for a policy response that acknowledges layered, context-specific disadvantages; rather than an adult learner population of uniform needs.

Digital self-efficacy and anxiety were found to be significant psychological mediators which accounted for 41% variance of ICT competence in the hierarchical regression model. The qualitative thematic coding of this section serves to explicate those dynamics, showing that the affective experience of learners - emotions of anxiety and intimidation (when dealing with unfamiliar technologies) in particular - can be barriers as well as a possible leverage points for interventions. These results are consistent with those of Fang et al. [8], highlighting the importance of psychological capital in negotiating online settings. The statistical mediation of competence by self-efficacy ($\gamma = 0.24$, $SE = 0.07$, $p < 0.01$ in HLM models) quantitatively validates the qualitative observation that mentorship and scaffolding interventions markedly boost confidence and involvement among the learners.

In addition, the combination of intrinsic motivation and structural supports is underscored by MANCOVA (Pillai's trace: $V = 0.21$, $F(6,602) = 13.57$, $p < 0.001$), which highlights the importance of integrating cognitive and affective as well as contextual levers when establishing an inclusive curriculum for ICT learning. It is also evident that motivation does not exist in vacuum, it is shaped by perceived access, pedagogical fit and cultural affirmation of digital literacy thereby validating multi-level attribution theories postulated by Parsons and Hick [5] Chetty et al. [7].

Supportive resources at the institutional level - such as peer mentoring, organized workshops and culturally responsive curricula - consistently buffered against the impact of structural inequities. Results of HLM analyses reveal that learners situated in high mentorship-based centers are nearly 27 percent more likely to develop advanced digital competency, indicating a statistically and practically meaningful intervention effect. These conclusions affirm with Adam and Dzang Alhassan [9] that the ICT usage is influenced by factors of organizational ecology of adults learning centers such as fund management, instructional scaffolding and culturally responsive pedagogy.

Cross-cultural concerns are especially relevant in this regard. It indicates that cultural values surrounding technology influence the legitimacy and utility of ICT engagement, in line with the research of Lopez-Aguado et al. [3] and Akinlar et al. [15]. Within technology-informed societies, learners showed more intrinsic motivation to troubleshoot digital challenges and push technological boundaries, with communities restrained in their usage of ICT often mirroring intergenerational circuits of estrangement. Such statistical modulation evidence suggests that culture-specific factors may interact with age and education to generate distant outcomes to be taken into consideration for policy making and curriculum development.

From a policy standpoint, the mixing of quantitative with qualitative evidence supports that interventions should be multi-level in working towards inclusiveness. First, while structural investments in broadband infrastructure and hardware provisioning are still necessary condition for (enhancing) digital competence level, they are not the sole answer; as revealed by the HLM and regression models, access on its own accounts for only part of variance in digital competence levels (R^2 for Level-1 variables =0.62). Second, policy designs should integrate pedagogical innovations such as blended learning, gamified instruction and peer-led digital mentorship that the statistical analysis finds to be high-leverage factors for increasing competence among heterogeneous populations. Third, the provision of targeted interventions to intersectionally disadvantaged subgroups - older adults, rural residents and low-education learners - should be given priority as these relatively marginalised groups exhibit greatest effect sizes on indicators of exclusion.

Further, the engagement and attrition in adult learning programs can survive from cross-sector cooperation among government, education sectors, and civil agencies. The HLM results show that the variance contribution from institutional context is substantive, implying that policy interventions not paying attention to these meso-level structures could be ineffective in transforming macro level investments into gains at individual level. The findings are in line with studies that underlines the importance of a shared socioeducational ecosystem to overcome digital divide [2, 52].

Theoretically, the study combines structural, psychological and organizational determinants in a statistically verified multilevel model of adult digital competence acquisition. By operationalizing digital

self-efficacy, access measures, and institutional support in an integrated HLM and multivariate approach, this study extends earlier conceptualizations of the digital divide [7,53] to include micro-level affective processes and meso-level pedagogical infrastructures. Furthermore, the inclusion of themed qualitative coding improves the interpretive quality of the results by exposing to view through some socio-cultural situation that qualifies correlational predictors.

The convergence of qualitative and quantitative findings in this respect emphasises the importance of understanding digital inclusion as a systemic, multilevel phenomenon rather than a one-dimensional relationship defined by access. This is in-line with Memon and Memon [2] as well as Choudhary and Bansal [17] who suggest that digital inclusion is a combination of socio-cognitive, infrastructural, and pedagogical variables that are simultaneously at work.

But, the strengths of using strong mixed-methods designs and sophisticated statistics should not detract us from limitations. First of all, the sample, although it is representative for adult learners in Bucharest, might not reflect national or international heterogeneity; it is especially applicable to culturally different groups or groups highly marginalized. Second, although HLM and multivariate analysis control for clustering and intersectionality, causal inference is limited by cross-sectional design. Longitudinal studies using HLM or structural equation modelling could also explore temporal patterns and possible sustainability of intervention effects. Third, although thematic coding emphasizes culturally relevant barriers, the psychometric validation of culture-specific constructs could help to better measure their impact.

All in all, the results provide valuable insights regarding the complex interrelations of social/demographic characteristics, psychological factors, institutional support and cultural context to adult digital competence. Multi-level statistical analyses - regression, HLM, MANCOVA - show that the effective intervention is one that deals with structural access in a simultaneous manner to cognitive empowerment and pedagogical adaptation. Policy frameworks that address these dimensions are likely to result in statistically and practically significant enhancements of digital literacy to support social equity, economic mobility, and lifelong learning goals. This research contributes sound theoretical and actional evidence-based lessons, helping to close digital divide by way of context-sensitive culturally-relevant adult learning strategies.

5. CONCLUSIONS

This study provides an in-depth, empirically supported examination of digital exclusion and ICT learning amongst adult learners that centres on the multi-faceted factors that both contribute towards or challenge the existence of a digital divide. The combination of Hierarchical Linear Model, Multivariate analyses, and thematic qualitative coding has enabled the goals to be met – synergistic effects of structural/psychological/institutional factors have been elucidated, which forms a statistically robust and conceptually strong platform for policy/practice.

From the quantitative results, it appears that SES and education level, as well as age and geographical context are statistically significant predictors of digital competence with regard to both regression coefficients ($\beta = 0.34$ for education; $\beta = -0.21$ for age) and variance components in HLM analyses ($\tau_{00} = 0.18$, $SE = 0.06$, $p < 0.01$) providing evidence on an interaction between individual background characteristics and institutional factors shaping a person's ability to engage online with more personalized policy contents. These findings emphasize the importance for multilevel interventions that target access and cognitive empowerment as per the frameworks proposed by Ragnedda and Ruiu [26] and Selwyn et al. [1].

Psychological processes, the most influential of which are digital self-efficacy and technology-specific anxiety, were found to explain a great deal of acquisition in ICT skill (around 41% of variance) among older adults. Rigorous qualitative findings support these outcomes, indicating that scaffolding, mentorship, and culturally relevant pedagogy can substantially mitigate affective barriers in the line of Fang et al. [8] and Parsons and Hick [5]. This evidence underlines the need to combine psychological support with structural and pedagogical measures in order to achieve inclusive adult learning outcomes.

Institutional support was a key mediator, exposure to structured mentorship and flexible curricula increased the likelihood to achieve advanced digital competence by 27%. The HLM results are a further confirmation that the context of the organization has influence on individuals' results, indicating a need to base the policy design on meso-level educational structures, as suggested by Adam and Dzang Alhassan [9]. Cross-cultural investigation also suggests that culturally-mediated perspectives towards technology shape motivation and retention to a sizable extent, requiring context relevant curricular intervention [3,23].

From the policy standpoint, there are useful lessons in the study. There are also several long-term considerations for scaling-up investments in technological infrastructure. First, investment in technical

infrastructure should be coupled with capacity development efforts focused on at-risk subpopulations such as older adults, rural dwellers, and low education learners. Secondly, the blend of blended learning with gamification and peer-led digital mentorship is statistically proven high yield when enhancing ICT literacy. Third, the collaboration amongst government departments themselves along with academic institutions and civil society is necessary for maintaining participation, for mitigating dropout and for translating macro-level investments into micro-outcomes.

In theory, the present study adds to digital inclusion literature by amalgamating structural, psychological and systemic predictors into a statistically validated multilevel model. By linking quantitative and qualitative approaches, it contributes to emerging understandings of adult digital literacy as a dynamic, situated-in-practice, and socio-culturally mediated phenomenon. Furthermore, the research integrates previously developed models of the digital divide [1,2,4,7,37] to take into account affective motivations and institutional moderators in order to gain a more nuanced insight on how mechanisms underpin digital exclusion. Despite the merits, this study has limitations that must be considered such as its cross-sectional design, type of regional sample only and that culture-specific constructs should undergo longitudinal validation. Future studies could adopt the repeated-measures HLM or SEM design to better capture temporal dynamics and investigate psychometric instruments for more accurate measurement of culturally specific digital competences.

Conclusions reveal that addressing the digital divide in adult education demands a nuanced, statistically-grounded, culture of assessment approach that addresses access, motivation, pedagogy and institutional support. By drawing attention to the number of dimensions as impacting ICT competences, this study contributes to a strong evidence base for policies and programs that focus on creating opportunities for inclusive, lifelong learning in the digital age. In the end, this study also highlights the potential of technology-mediated adult education as a policy lever to move social, equity and economic inclusion and equitable participation in knowledge societies and empirically-grounded strategies to promoting digital equity inside Romania and beyond on an international basis.

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