Iranian Journal of Educational Sociology

Journal Website

Article history:
Received 01 December 2025
Revised 23 April 2026
Accepted 30 April 2026
Published online 01 May 2026

Iranian Journal of Educational Sociology

Volume 9, Issue 3, pp 1-13

Quarterly Iranian Journal of Educational Sociology

E-ISSN: 2645-3460

Validation of Barriers to the Implementation of Educational Technology in Education

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Article Info

Article type:
Original Research

How to cite this article:
Abed Abed, A. A., Shahtalebi, B., Hatem Falih Al Ijrish, H., & Ghashghaeizadeh, N. (2026). Validation of Barriers to the Implementation of Educational Technology in Education. *Iranian Journal of Educational Sociology*, *9*(3), 1-13.
https://doi.org/10.61838/kman.ijes.1444

ABSTRACT

Purpose: The present study aimed to validate the human and environmental barriers affecting the implementation of educational technology in geography education within the Iraqi school system.

Methods and Materials: This applied study employed a descriptive survey design. The statistical population consisted of 3,045 geography teachers and subject group leaders across Iraq, from which a sample of 384 participants was selected using the Krejcie and Morgan sampling table and cluster quota sampling method. Data were collected using a researcher-developed questionnaire including 67 items measured on a five-point Likert scale. Face and content validity were confirmed by experts and respondents, and reliability was established through Cronbach's alpha coefficient (0.98). Confirmatory factor analysis was used to evaluate the measurement model, assess construct validity, and examine the structural relationships among latent variables representing human and environmental barriers.

Findings: Confirmatory factor analysis indicated that the proposed two-dimensional model of educational technology barriers demonstrated satisfactory goodness-of-fit indices. Human barriers significantly explained teacher, managerial, and student-related dimensions, while environmental barriers significantly predicted hardware–software and organizational constraints. All standardized factor loadings exceeded acceptable thresholds, composite reliability and average variance extracted values confirmed convergent validity, and structural path coefficients were statistically significant ($p < .05$). The results verified that both higher-order constructs adequately represented the multidimensional structure of barriers to educational technology implementation.

Conclusion: The findings demonstrate that successful implementation of educational technology depends on the simultaneous management of human readiness and environmental conditions. Psychological resistance, limited professional competencies, organizational culture, infrastructural limitations, and institutional policies collectively influence technology adoption. The validated model provides an empirical framework for educational policymakers and administrators to design systematic interventions addressing both individual and structural barriers to technology integration in teaching and learning environments.

Keywords: *validation, barriers, educational technology implementation.*

1. Introduction

The rapid expansion of educational technology has fundamentally transformed contemporary teaching and learning environments, positioning technology integration as a central component of educational reform worldwide. Educational systems increasingly rely on digital tools, artificial intelligence, learning platforms, and interactive environments to enhance instructional effectiveness, promote learner engagement, and prepare students for knowledge-based societies. Educational technology is no longer confined to technical instruments but is conceptualized as a comprehensive pedagogical ecosystem integrating instructional design, learning theory, organizational readiness, and human competencies (Ferdanesh & Jamshidi Tavan, 2014; Rostgarpour & Ahmadi Gol, 2014). Within this framework, successful implementation depends not merely on technological availability but on the alignment of philosophical, organizational, and human dimensions governing educational practice.

From a philosophical perspective, educational technology represents a transformation in the epistemology of teaching and learning, shifting from teacher-centered knowledge transmission toward learner-centered, interactive, and constructivist learning environments. The philosophy of educational technology emphasizes meaningful learning, cognitive engagement, and adaptive instruction supported by digital tools rather than technology as an end in itself (Ferdanesh & Jamshidi Tavan, 2014). This conceptual evolution highlights that technology integration requires systemic educational change involving pedagogical beliefs, institutional structures, and professional competencies. Analytical discussions of educational technology similarly stress that misunderstanding its conceptual nature often leads to superficial adoption without genuine pedagogical transformation (Rostgarpour & Ahmadi Gol, 2014).

The integration of educational technology has become especially significant following global disruptions such as the COVID-19 pandemic, which accelerated digital transformation across educational systems. Post-pandemic educational policies increasingly emphasize hybrid learning environments, digital infrastructure expansion, and technology-supported pedagogy as essential elements of educational resilience (Khersandi Taskouh et al., 2023). These developments have reinforced the necessity of identifying the factors that facilitate or hinder effective technology implementation, particularly in contexts where structural, organizational, and human challenges remain substantial.

In many developing educational systems, including Iraq, technology integration has progressed unevenly due to infrastructural limitations, policy gaps, and insufficient professional preparation. Research examining the integration of information and communication technologies (ICT) in Iraqi schools demonstrates that although governments have invested in digital initiatives, significant challenges persist related to teacher readiness, institutional support, and technological infrastructure (Al-Khafaji, 2022). Similarly, the expansion of e-learning platforms in Iraqi higher education revealed both opportunities for expanding access and critical barriers associated with technological literacy, connectivity, and pedagogical adaptation (Alrikabi et al., 2021). These findings underscore the importance of examining contextual barriers that influence educational technology adoption in national educational systems.

Teacher competencies represent one of the most influential determinants of successful technology integration. Empirical studies indicate that teachers' professional proficiency in technology use directly affects instructional quality and student achievement outcomes (Ali et al., 2022). Technology integration requires educators to adopt new instructional roles, transitioning from information transmitters to facilitators of learning experiences supported by digital environments. However, resistance to change, limited technological confidence, and insufficient professional development opportunities frequently hinder this transformation. Consequently, identifying human barriers associated with teachers, administrators, and learners becomes essential for effective educational reform.

Beyond individual competencies, educational technology adoption depends heavily on institutional maturity and organizational readiness. The concept of educational technology maturity management emphasizes that schools must progress through structured stages involving infrastructure development, policy alignment, leadership commitment, and professional capacity building (Nazari Ardebili et al., 2024). Without coordinated institutional strategies, technological investments often fail to produce sustainable pedagogical change. Organizational culture, leadership support, and administrative decision-making therefore play crucial roles in determining whether technology becomes integrated into everyday teaching practices.

Curriculum design also constitutes a major dimension of educational technology implementation. The integration of technological components into core curriculum planning enables more flexible learning environments, personalized instruction, and improved learning outcomes when aligned with pedagogical objectives (Ploei & Farhadian, 2020). Geography education, in particular, presents significant opportunities for technology-enhanced learning through geographic information systems, digital mapping tools, simulations, and multimedia visualization. Nevertheless, traditional curriculum structures and assessment systems frequently limit teachers' ability to employ innovative technologies effectively.

Recent advancements in artificial intelligence and big data technologies further expand the potential of educational technology. AI-driven pedagogy introduces adaptive learning systems, intelligent tutoring environments, and data-informed instructional decision-making processes that improve student engagement and learning efficiency (Sharma, 2025). Empirical research demonstrates that AI integration in primary education significantly enhances student participation and motivation when supported by appropriate instructional strategies (Shin et al., 2026). Similarly, applications of big data analytics in educational counseling and career guidance platforms illustrate how digital technologies can personalize learning pathways and support student development (Zhang, 2025). The application of AI technologies within educational management systems has also shown measurable improvements in administrative efficiency and civic education outcomes (Zhou, 2025).

Technological innovation additionally supports inclusive education by enabling differentiated instruction and accommodating diverse learner needs. Systematic reviews highlight the growing role of educational technology in facilitating inclusive primary education through accessible digital resources and adaptive learning tools (Ranzato et al., 2025). Technology-based instructional approaches can enhance communication skills, collaborative learning, and student autonomy, particularly when integrated with appropriate pedagogical frameworks (Сенина & М, 2025). These developments reinforce the argument that educational technology serves as a catalyst for equity and accessibility when effectively implemented.

Despite these promising opportunities, numerous studies emphasize that technological adoption often encounters significant resistance arising from human, environmental, and organizational constraints. Behavioral perspectives on educational reform suggest that educational systems must undergo structural re-engineering to support sustainable technology transfer processes (Twyman, 2025). Technology implementation requires alignment between institutional incentives, teacher beliefs, learner readiness, and systemic policies. Without such alignment, technological initiatives risk remaining symbolic rather than transformative.

Mentoring and professional support mechanisms have emerged as effective strategies for overcoming technology integration barriers. Remote mentoring practices and collaborative professional learning models have been shown to enhance educators' confidence and competence in technology use, thereby increasing the likelihood of successful implementation (Topcu, 2025). Continuous professional development, leadership support, and peer collaboration therefore constitute essential conditions for technology adoption.

Within the field of geography education, the integration of educational technology holds particular importance due to the discipline's reliance on spatial analysis, visualization, and experiential learning. Contemporary analyses emphasize that geography education must evolve to incorporate digital tools capable of representing complex environmental and social phenomena, thereby improving students' analytical and critical thinking skills (Mousavi, 2024). However, achieving this transformation requires identifying the specific barriers that prevent educators and institutions from fully utilizing technological capabilities.

Taken together, existing research demonstrates that educational technology implementation is a multidimensional process influenced by human factors, environmental conditions, organizational structures, and technological infrastructure. While technological advancements continue to expand educational possibilities, persistent barriers related to teacher readiness, administrative support, institutional policy, and infrastructure limitations hinder effective adoption, particularly within developing educational systems such as Iraq. Consequently, systematic validation of these barriers is necessary to provide empirical evidence for policymaking, strategic planning, and educational reform initiatives.

Therefore, the present study aims to validate the barriers to the implementation of educational technology in teaching and learning within geography education by identifying and empirically confirming the human and environmental factors influencing technology integration.

2. Methods and Materials

The present study was applied in terms of purpose and employed a descriptive survey research design with respect

Iranian Journal of Educational Sociology
E-ISSN: 2645-3460

to data collection procedures. The target population consisted of all geography teachers and geography subject group leaders working within the educational system of Iraq, totaling 3,045 individuals. In order to determine an appropriate sample size, the Krejcie and Morgan (1970) sampling table was utilized, resulting in the selection of 384 participants for inclusion in the study. The sampling procedure followed a cluster quota sampling approach designed to ensure adequate geographical representation across the country. Accordingly, five provinces representing the northern, southern, eastern, western, and central regions of Iraq were selected, including Baghdad, Al-Muthanna, Kirkuk, Wasit, and Karbala. After determining the proportional share of each province relative to the total population, questionnaires were distributed to the General Directorates of Education in each selected province. The questionnaires were subsequently completed by teachers and subject group leaders and collected for further analysis. This sampling strategy allowed the study to capture regional diversity and increased the generalizability of findings within the national educational context.

Data were collected using a researcher-developed questionnaire designed specifically to identify and validate barriers to the implementation of educational technology in teaching and learning environments. The instrument was constructed based on theoretical literature, expert consultation, and contextual considerations related to educational technology adoption. The questionnaire employed a five-point Likert scale ranging from strongly disagree to strongly agree, enabling respondents to express varying levels of agreement with each statement. The instrument included items addressing multiple dimensions of barriers, particularly human-related and environmental factors influencing the integration of educational technology. Face validity was assessed through feedback obtained from a group of respondents representing the target population to ensure clarity, comprehensibility, and contextual appropriateness of the items. Content validity was examined through expert review by specialists in educational technology and curriculum studies. The reliability of the questionnaire was evaluated using Cronbach’s alpha coefficient, which yielded a value of 0.98, indicating a very high level of internal consistency and measurement stability.

Following data collection, completed questionnaires were screened and prepared for statistical analysis. The analytical process focused on validating the structural components underlying the barriers to educational technology implementation. Confirmatory factor analysis (CFA) was employed as the primary analytical technique to test the measurement model and to examine the relationships between observed variables and their corresponding latent constructs. This method enabled the evaluation of construct validity, factor loadings, and model adequacy in explaining the proposed theoretical framework. Model fit indices were examined to determine the degree to which the hypothesized model corresponded with empirical data. The use of confirmatory factor analysis allowed for rigorous assessment of the dimensional structure of barriers and provided empirical evidence supporting the validity of the proposed conceptual model.

3. Findings and Results

The results of the study indicated that the barriers to the implementation of educational technology in teaching and learning can be categorized under two main dimensions: human barriers and environmental barriers. The human barriers dimension consists of several subcategories as presented below.

Table 1

Subcategories and Concept Codes Related to the Main Category of Human Barriers

Subcategories	Items	Concept Codes
Teacher	Question 1	Lack of belief in facilitating learning through the implementation of educational technology
	Question 2	Lack of familiarity with different types of educational technology in geography education
	Question 3	Lack of awareness of active learning strategies in geography instruction
	Question 4	Belief in teacher-centered instruction
	Question 5	Belief in memorization-based learning in geography education
	Question 6	Lack of skills in using educational technologies related to geography instruction
	Question 7	Perception that educational technology implementation is time-consuming
	Question 8	Belief that using technology reveals teacher incompetence
	Question 9	Inability to produce technology-compatible instructional content in geography
	Question 10	Inability to accept new professional roles

	Question 11	Belief in learners' inability for self-directed geography learning
	Question 12	Habitual reliance on traditional geography teaching standards
	Question 13	Lack of technological literacy
	Question 14	Lack of emotional readiness for technology integration in classrooms
	Question 15	Fear and anxiety resulting from technology use
	Question 16	Neglect of students' individual differences
	Question 17	Preference for maintaining the existing geography teaching status quo
	Question 18	Lack of teacher confidence in the effectiveness of educational technology
	Question 19	Dominance of objectivist perspectives (teacher-centered approach)
	Question 20	Neglect of classroom joy and engagement
	Question 21	Insufficient classroom management skills in technology-rich environments
	Question 22	Lack of sufficient time to update knowledge regarding educational technology in geography
	Question 23	Teacher risk aversion
	Question 24	Preference for authoritarian classroom management methods
	Question 25	Resistance to change
	Question 26	Lack of self-confidence in technology implementation
	Question 27	Feeling discomfort when using educational technology
	Question 28	Low teacher self-efficacy
	Question 29	Teacher professional burnout and lack of job motivation
	Question 30	Belief that technology distracts students in geography learning
School Principal	Question 31	Inefficiency in designing teacher professional development programs
	Question 32	Lack of support for teachers in implementing educational technology in geography
	Question 33	Failure to allocate incentives and compensation for teachers as technology users
	Question 34	Inability to allocate appropriate school budgets for educational technology in geography
	Question 35	Preference for preserving traditional school physical structures and classroom furniture
	Question 36	Preference for maintaining traditional discipline systems
	Question 37	Failure to grant teachers autonomy in technology implementation
	Question 38	Viewing educational technology primarily as a financial cost in geography education
	Question 39	Lack of trust in students' academic abilities in geography
	Question 40	Belief that teachers become ineffective when using educational technology in geography
Student	Question 41	Lack of technological literacy
	Question 42	Fear of damaging technological equipment
	Question 43	Perception of technology as an obstacle to creativity
	Question 44	Preference for individualism and isolation rather than teamwork
	Question 45	Lack of confidence in using technology
	Question 46	Lack of positive attitudes toward learning geography
	Question 47	Lack of interest in geography course content
	Question 48	Fear of making mistakes and being humiliated in front of peers

The findings of the study revealed that the barriers to the implementation of educational technology in teaching and learning were primarily classified within the category of human barriers, encompassing teacher-related, managerial, and student-related factors. Teacher-related barriers included limited belief in the facilitative role of educational technology, insufficient familiarity with various educational technologies and active learning strategies in geography education, adherence to teacher-centered and memorization-based instructional approaches, lack of technological literacy and professional skills, emotional unpreparedness, technology-related anxiety, resistance to change, low self-efficacy, professional burnout, inadequate classroom management skills in technology-rich environments, insufficient time for professional updating, risk aversion, and concerns regarding student distraction during technology use. Managerial barriers involved inefficiency in planning professional development programs, insufficient institutional support for technology integration, lack of incentive systems for teachers, inadequate budgeting for technological infrastructure, preference for maintaining traditional school structures and disciplinary practices, limited teacher autonomy, cost-oriented perspectives toward educational technology, and lack of trust in both teacher and student capabilities when technology is employed. Student-related barriers included insufficient technological literacy, fear of damaging technological devices, perceptions of technology as inhibiting creativity, preference for individual rather than collaborative learning, low confidence in technology use, negative attitudes toward geography learning, lack of interest in course content, and fear of making mistakes or experiencing peer humiliation. Collectively, these findings demonstrate that human factors constitute a multidimensional set of psychological, pedagogical, organizational, and attitudinal challenges that significantly hinder effective educational technology implementation.

Table 2

Subcategories and Concept Codes Related to the Main Category of Environmental Barriers

Subcategories	Items	Concept Codes
Hardware–Software	Question 49	Lack of budget allocation for hardware development in geography education
	Question 50	Lack of budget allocation for software development in geography education
	Question 51	Lack of technical infrastructure in schools (e.g., three-phase electricity systems)
	Question 52	Continuous changes in geography-related software such as Atlasworld and Arc Hydro
	Question 53	Underdevelopment of fiber-optic networks in Iraqi schools
	Question 54	Lack of access to high-speed internet in schools
	Question 55	Absence of emergency power generation systems and appropriate voltage equipment in schools
Organizational	Question 56	Limited access to high-quality educational technology for geography education
	Question 57	Insufficient institutional and administrative support for equipping schools
	Question 58	Frequent changes in the geography curriculum
	Question 59	Shortage of physical space in schools
	Question 60	Priority given to traditional instructional approaches
	Question 61	Emphasis on quantitative outcomes rather than quality-oriented education
	Question 62	Economic inequality among schools
	Question 63	Prevalence of utilitarian perspectives among higher-level administrators
	Question 64	Dominance of ideological objectives within Iraqi schools
	Question 65	Mismatch between curriculum content and allocated instructional time in geography
	Question 66	Resistance to change among stakeholders (teachers, administrators, parents, etc.)
	Question 67	Excessive emphasis on knowledge accumulation

The findings indicated that environmental barriers to the implementation of educational technology were categorized into hardware–software and organizational dimensions. Hardware–software barriers primarily involved structural and technological limitations, including insufficient financial resources for hardware and software development, lack of adequate technical infrastructure in schools, underdeveloped fiber-optic communication networks, absence of high-speed internet access, instability of electricity supply, and continuous changes in specialized geography software that complicate sustainable technology adoption. Organizational barriers reflected systemic and institutional constraints such as limited access to high-quality educational technology, inadequate administrative and institutional support for equipping schools, frequent curriculum revisions, shortages of appropriate physical learning spaces, and the persistence of traditional instructional paradigms. Additional organizational challenges included prioritization of quantitative performance indicators over educational quality, economic disparities among schools, utilitarian managerial perspectives, ideological dominance within educational settings, misalignment between geography curriculum content and allocated teaching time, resistance to change among educational stakeholders, and an excessive focus on knowledge accumulation rather than meaningful learning processes. Collectively, these environmental factors demonstrate that beyond individual readiness, structural, infrastructural, and organizational conditions significantly influence the successful integration of educational technology in geography education.

E-ISSN: 2645-3460

Table 3

Reliability Indicators of Research Constructs

Construct	Number of Items	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Teacher Barriers	30	0.94	0.95	0.56
Managerial Barriers	10	0.91	0.92	0.58
Student Barriers	8	0.89	0.90	0.60
Human Barriers (Second-order)	48	0.96	0.96	0.63
Hardware–Software Barriers	7	0.88	0.89	0.57
Organizational Barriers	12	0.93	0.94	0.61
Environmental Barriers (Second-order)	19	0.95	0.95	0.64

The reliability analysis presented in Table 3 indicates a high level of internal consistency for all study constructs. Cronbach's alpha coefficients ranged from 0.88 to 0.96, exceeding the recommended threshold of 0.70 and confirming strong measurement stability across all dimensions. Composite Reliability (CR) values also surpassed the acceptable level of 0.70, demonstrating consistency among measurement indicators within each latent construct. Furthermore, the Average Variance Extracted (AVE) values ranged between 0.56 and 0.64, all above the minimum criterion of 0.50, indicating satisfactory convergent reliability. The second-order constructs of Human Barriers and Environmental Barriers showed particularly strong reliability indices, confirming that the observed variables adequately represented their higher-order conceptual structures. Overall, the findings confirm that the measurement instruments possess robust reliability and are suitable for subsequent structural modeling.

Table 4

Construct Validity Assessment (Factor Loadings and Convergent Validity)

Construct	Indicator Range	Standardized Factor Loadings	t-value Range	Convergent Validity
Teacher Barriers	a1–a30	0.41–0.74	>1.96	Confirmed
Managerial Barriers	a31–a40	0.64–0.73	>1.96	Confirmed
Student Barriers	a41–a48	0.73–0.81	>1.96	Confirmed
Hardware–Software Barriers	a49–a55	0.52–0.79	>1.96	Confirmed
Organizational Barriers	a56–a67	0.48–0.83	>1.96	Confirmed

Table 4 presents the results of convergent validity assessment derived from confirmatory factor analysis. All standardized factor loadings exceeded the minimum acceptable value of 0.40, indicating adequate relationships between observed indicators and their respective latent constructs. The strongest loadings were observed within student-related and organizational barriers, suggesting clearer conceptual coherence among these indicators. All t-values were greater than 1.96, demonstrating statistical significance at the 0.05 level and confirming that each item contributed meaningfully to construct measurement. These findings support the adequacy of convergent validity and indicate that the measurement model successfully captures the underlying dimensions of educational technology implementation barriers. Consequently, the constructs demonstrate acceptable psychometric properties for structural analysis.

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Table 5

Model Fit Indices of Confirmatory Factor Analysis

Fit Index	Acceptable Threshold	Human Barriers Model	Environmental Barriers Model	Interpretation
χ^2/df	<3.00	2.11	2.24	Acceptable Fit
RMSEA	<0.08	0.056	0.059	Good Fit
GFI	>0.90	0.92	0.91	Good Fit
AGFI	>0.90	0.90	0.90	Acceptable Fit
CFI	>0.90	0.95	0.94	Excellent Fit
TLI	>0.90	0.94	0.93	Good Fit
NFI	>0.90	0.92	0.91	Good Fit

The goodness-of-fit indices summarized in Table 5 demonstrate that both measurement models achieved satisfactory model fit. The chi-square to degrees of freedom ratios (χ^2/df) were below the recommended value of 3, indicating acceptable overall model adequacy. Root Mean Square Error of Approximation (RMSEA) values were below 0.08, reflecting good approximation between the hypothesized model and empirical data. Incremental fit indices including CFI, TLI, and NFI exceeded the 0.90 criterion, confirming strong comparative model performance. Additionally, GFI and AGFI values indicated acceptable absolute model fit. Collectively, these indices confirm that the proposed factorial structures of human and environmental barriers are empirically supported and that the confirmatory factor analysis model provides a reliable representation of observed data.

Table 6

Structural Effects Among Latent Constructs

Structural Path	Standardized Coefficient (β)	t-value	Effect Type	Result
Human Barriers → Teacher Barriers	0.65	9.84	Direct	Significant
Human Barriers → Managerial Barriers	1.00	12.41	Direct	Significant
Human Barriers → Student Barriers	0.87	11.36	Direct	Significant
Environmental Barriers → Hardware–Software Barriers	0.79	10.92	Direct	Significant
Environmental Barriers → Organizational Barriers	0.98	13.27	Direct	Significant

Table 6 presents the structural path coefficients derived from the second-order confirmatory factor model. The results indicate that Human Barriers exerted significant positive effects on teacher, managerial, and student barrier dimensions, with standardized coefficients ranging from 0.65 to 1.00. The strongest relationship was observed between human barriers and managerial barriers, suggesting that administrative and leadership factors represent a central manifestation of human-related resistance to educational technology implementation. Similarly, Environmental Barriers significantly influenced both hardware–software and organizational dimensions, with strong standardized coefficients of 0.79 and 0.98, respectively. All t-values exceeded the critical value of 1.96, confirming statistical significance at the 0.05 level. These findings demonstrate that both higher-order constructs effectively explain their underlying components and highlight the multidimensional nature of technological implementation barriers within educational systems.

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E-ISSN: 2645-3460

Figure 1

Structural Model for Human Barries

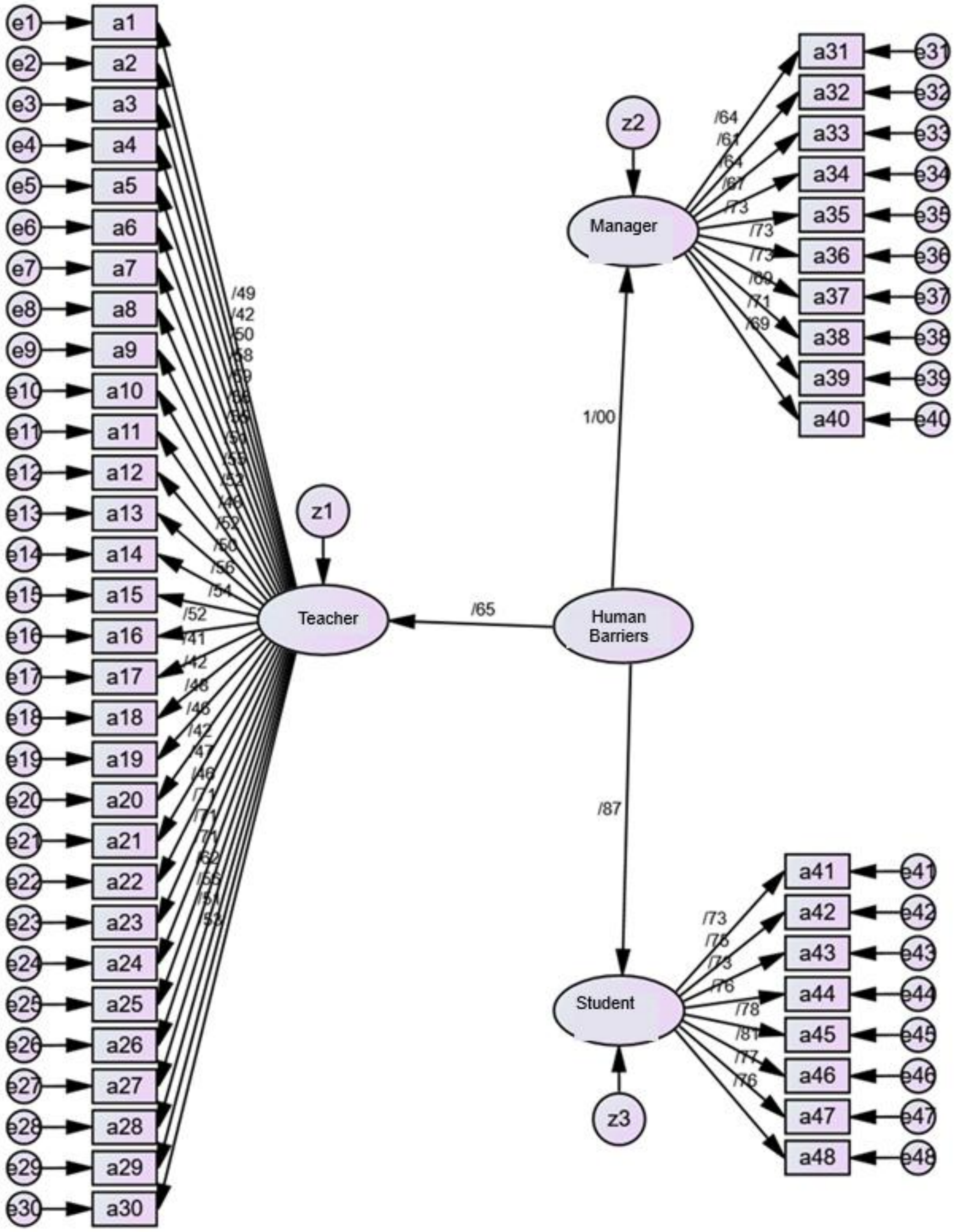
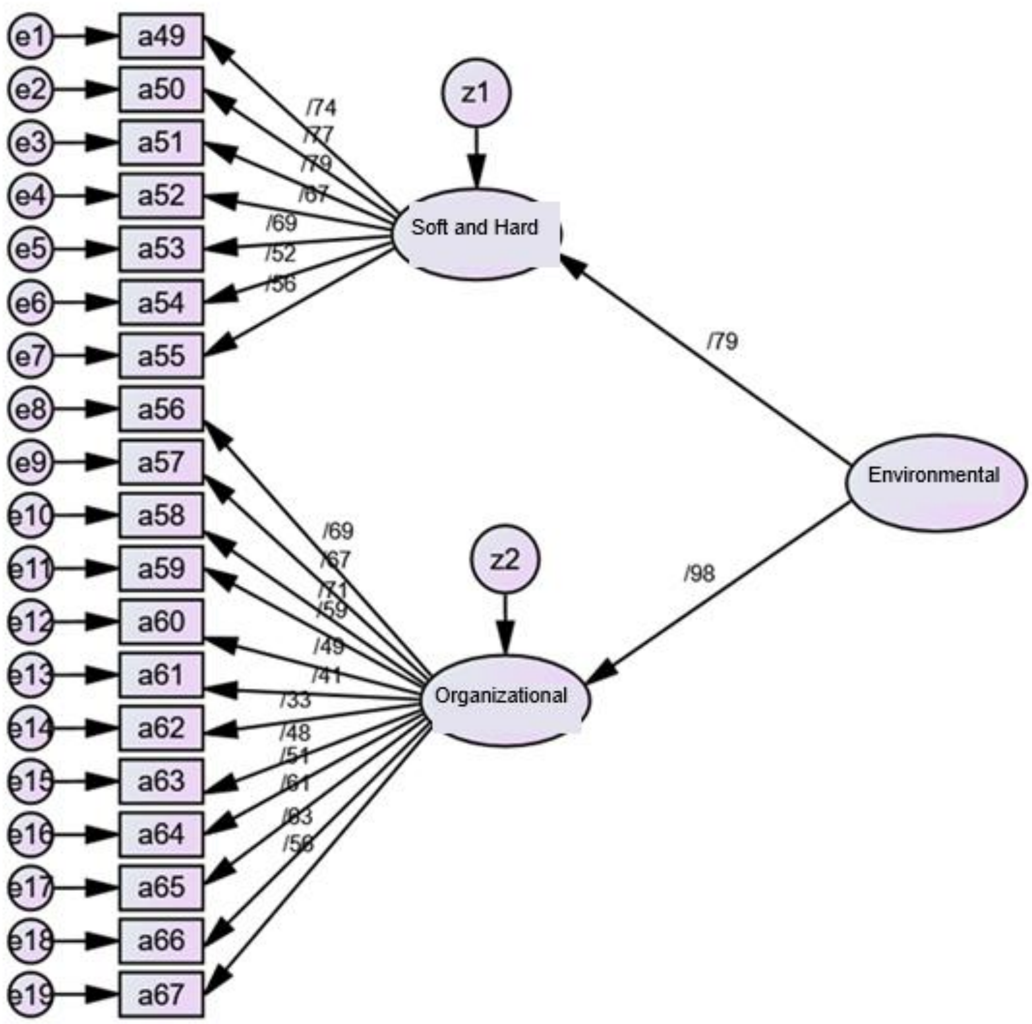


Figure 2

Structural Model for Environmental Barriers



4. Discussion and Conclusion

The present study aimed to validate the barriers to the implementation of educational technology in teaching and learning within geography education by identifying human and environmental dimensions influencing technology adoption. The findings confirmed that educational technology barriers are multidimensional and structured around two higher-order constructs: human barriers and environmental barriers. Confirmatory factor analysis demonstrated acceptable validity, reliability, and model fit indices, indicating that the proposed conceptual framework provides an empirically supported explanation of technology implementation challenges within the educational context.

The results revealed that human barriers constituted the most influential category affecting educational technology implementation. Teacher-related factors emerged as a dominant component, including insufficient technological literacy, adherence to traditional teaching beliefs, resistance to pedagogical change, low self-efficacy, and technology-related anxiety. These findings align with prior research emphasizing that technology integration depends primarily on teachers' professional competencies and pedagogical readiness rather than mere access to technological tools (Ali et al., 2022). Teachers who perceive technology as complex or threatening often maintain teacher-centered instructional practices, thereby limiting innovation in classroom environments. Philosophical analyses of educational technology similarly argue that misunderstanding the conceptual foundations of technology leads educators to treat technology as an external addition rather than an

E-ISSN: 2645-3460

integral pedagogical process (Ferdanesh & Jamshidi Tavan, 2014; Rostgarpour & Ahmadi Gol, 2014).

The persistence of traditional instructional beliefs identified in this study corresponds with broader discussions of educational transformation. Educational technology requires a shift from knowledge transmission models toward learner-centered approaches emphasizing interaction, collaboration, and inquiry-based learning. When teachers retain memorization-oriented instructional paradigms, technology integration becomes superficial and fails to influence learning outcomes meaningfully. Studies examining modern technological trends in post-pandemic education confirm that pedagogical change remains one of the most significant challenges facing educational systems attempting digital transformation (Khersandi Taskouh et al., 2023). The current findings therefore reinforce the notion that successful technological adoption depends on cognitive and cultural transformation among educators.

Managerial barriers also demonstrated strong explanatory power within the human barriers construct. The study revealed that insufficient leadership support, lack of professional development planning, limited incentives, and administrative skepticism toward technology significantly hinder implementation. These findings support the educational technology maturity perspective, which emphasizes leadership commitment and institutional readiness as essential prerequisites for technological integration (Nazari Ardebili et al., 2024). Without supportive leadership structures, teachers often lack motivation and institutional encouragement to adopt innovative teaching practices. Research conducted within Iraqi educational settings similarly highlights that administrative policies and leadership decisions strongly influence ICT adoption outcomes (Al-Khafaji, 2022).

Student-related barriers formed another important dimension of human challenges. The results indicated that limited technological literacy, fear of technological failure, negative attitudes toward geography learning, and low confidence levels among students contribute to implementation difficulties. These findings correspond with research demonstrating that learners' readiness and digital competence significantly influence the effectiveness of educational technology environments (Alrikabi et al., 2021). Educational technologies enhance engagement only when learners possess adequate digital skills and perceive technology as supportive rather than intimidating. Studies on technology-supported communication competence further confirm that students' active participation and confidence increase when digital tools are integrated systematically into instruction (Сенина & M, 2025).

Beyond human factors, environmental barriers were found to play a decisive role in shaping technology implementation outcomes. Hardware–software barriers, including insufficient funding, inadequate infrastructure, unstable electricity supply, lack of high-speed internet, and rapidly changing software systems, were identified as critical constraints. These results align with international research emphasizing that technological infrastructure represents a foundational requirement for successful digital education initiatives (Al-Khafaji, 2022). Even highly motivated teachers cannot effectively implement technology in the absence of reliable technological ecosystems.

Organizational barriers constituted the second environmental dimension validated in this study. Findings indicated that curriculum instability, limited institutional support, traditional educational priorities, economic inequalities among schools, and excessive emphasis on knowledge accumulation impede technological innovation. Similar conclusions have been reported in studies examining curriculum integration of educational technology, which emphasize that technological tools must be embedded within curriculum design rather than introduced as supplementary resources (Ploei & Farhadian, 2020). When curricula remain rigid and assessment systems prioritize memorization, technology integration becomes incompatible with institutional expectations.

The strong relationship observed between environmental barriers and organizational structures highlights the systemic nature of educational technology implementation. Behavioral analyses of educational reform argue that technological change requires re-engineering educational systems, including administrative structures, policy frameworks, and incentive mechanisms (Twyman, 2025). Technology adoption therefore represents an institutional transformation rather than a purely technical process.

Recent technological developments, particularly artificial intelligence and data-driven learning systems, further emphasize the importance of overcoming both human and environmental barriers. Research on AI-driven pedagogy demonstrates that technology significantly enhances student engagement and instructional effectiveness when integrated within supportive learning environments (Sharma, 2025). Empirical evidence also shows that AI integration in schools increases learner participation and academic motivation when teachers possess adequate competencies and institutional support (Shin et al., 2026). Likewise, the

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E-ISSN: 2645-3460

application of big data technologies in educational management illustrates how digital systems can optimize learning guidance and decision-making processes (Zhang, 2025; Zhou, 2025). The findings of the present study therefore suggest that emerging technologies will remain underutilized unless underlying structural barriers are addressed.

The validated model also supports inclusive education perspectives emphasizing technology as a means of expanding educational accessibility and equity. Educational technology enables differentiated instruction and personalized learning pathways, particularly for diverse learners and inclusive classroom environments (Ranzato et al., 2025). However, the persistence of organizational inequality and infrastructural disparities identified in this study indicates that technological benefits may remain unevenly distributed without coordinated policy interventions.

Professional mentoring and continuous teacher support represent additional mechanisms for overcoming implementation barriers. Evidence from remote mentoring initiatives shows that sustained professional guidance significantly improves educators' technology integration skills and confidence levels (Topcu, 2025). The present findings, which highlighted teacher resistance and low self-efficacy, reinforce the necessity of structured professional development programs that move beyond short-term training toward long-term capacity building.

Within geography education specifically, the results confirm that technological integration is both necessary and challenging. Geography instruction increasingly relies on digital mapping, spatial analysis tools, simulations, and visualization technologies that enhance conceptual understanding. However, traditional perceptions of geography as a memorization-based subject continue to hinder pedagogical innovation. Previous analyses emphasizing the need for modernization in geography education support this interpretation, arguing that technological integration is essential for developing analytical and environmental literacy skills among students (Mousavi, 2024). The validated barriers identified in this study therefore provide empirical evidence explaining why such modernization efforts often progress slowly.

Overall, the discussion of findings demonstrates that educational technology implementation is influenced by interconnected psychological, pedagogical, infrastructural, and organizational factors. Human readiness alone cannot guarantee success without supportive environments, and infrastructural investment alone cannot produce transformation without pedagogical change. The validated model confirms that sustainable technology integration requires systemic alignment among teachers, administrators, learners, institutional policies, and technological resources. These conclusions contribute to the broader literature by offering a comprehensive empirically validated framework for understanding barriers to educational technology implementation within developing educational contexts.

One limitation of the present study relates to its reliance on self-reported questionnaire data, which may introduce response bias and reflect participants' perceptions rather than actual classroom practices. Additionally, the study focused specifically on geography teachers and educational administrators, which may limit generalization to other subject areas or educational levels. The cross-sectional nature of the research design also prevents examination of longitudinal changes in technology adoption behavior over time. Furthermore, contextual differences among schools and regions may influence technology implementation in ways not fully captured within the survey framework.

Future studies should employ mixed-method or longitudinal research designs to examine how educational technology barriers evolve over time and how interventions influence technology adoption processes. Comparative studies across different academic disciplines or educational systems could provide deeper insight into contextual variations in technology implementation. Researchers may also investigate the relationship between validated barriers and measurable student learning outcomes to strengthen causal interpretations. Additionally, future research could explore the impact of emerging technologies such as artificial intelligence, virtual reality, and adaptive learning systems on overcoming traditional educational barriers.

Educational policymakers should prioritize comprehensive technology integration strategies that simultaneously address teacher professional development, leadership capacity, infrastructure improvement, and curriculum reform. Continuous training programs should focus on developing pedagogical competence rather than merely technical skills. School administrators should establish supportive organizational cultures encouraging experimentation, innovation, and collaborative learning among teachers. Investment in reliable technological infrastructure, equitable resource distribution, and stable digital platforms is essential for sustainable implementation. Finally, educational systems should promote learner-centered instructional approaches that leverage technology

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E-ISSN: 2645-3460

to enhance engagement, creativity, and meaningful learning experiences.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We hereby thank all participants for agreeing to record the interview and participate in the research.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethical Considerations

All procedures performed in studies involving human participants were under the ethical standards of the institutional and, or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Iranian Journal of Educational Sociology
E-ISSN: 2645-3460