

Teacher-Level Predictors of Challenges in Simulated Learning Implementation: The Role of Teaching Experience, Professional Qualification, and Age Among Elementary Science Teachers in Pakistan

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ABSTRACT

While global literature affirms the educational promise of simulated learning, implementation barriers remain acute in resource-constrained settings such as Pakistan. Comparatively little attention has been directed to whether teacher-level demographic and professional characteristics predict the magnitude of challenges experienced in simulated learning implementation. Understanding these predictors is essential for the targeted design of professional development and institutional support interventions. This study examined whether teaching experience, professional qualification (B.Ed. vs. M.Ed./M.S.Ed.), and age significantly predict teachers' perceived challenges in implementing simulated learning in General Science at the elementary level in Pakistan. A cross-sectional quantitative survey was conducted with 273 elementary science teachers from Districts Layyah and Muzaffargarh, Punjab, Pakistan. A validated 10-item Challenges of Simulated Learning (CHSL) subscale was administered. One-way ANOVA was used to examine age-based and experience-based differences, while independent samples t-tests examined professional qualification differences. Effect sizes (Cohen's d and eta-squared) were computed for practical significance assessment. No statistically significant differences in CHSL scores were observed across teaching experience groups ($F(3,269) = 0.983$, $p = 0.401$, $\eta^2 = 0.011$), age groups ($F(3,269) = 0.368$, $p = 0.776$, $\eta^2 = 0.004$), or professional qualification ($t(271) = 0.924$, $p = 0.356$, $d = 0.11$). All effect sizes were negligible to small, indicating practical equivalence across groups. The borderline-

significant finding for the advantages subscale by experience ($F(3,269) = 2.166$, $p = 0.092$) warrants further investigation. Teachers' perceived implementation challenges are not determined by experience, age, or professional qualification. This finding suggests that challenges are systemic and infrastructural rather than individual-level, and that professional development interventions targeting simulated learning implementation must address institutional rather than teacher-level variables.

Keywords: Simulated Learning Challenges, Teaching Experience, Professional Qualification, Age, ANOVA, Elementary Science Teachers, Pakistan, Professional Development

Introduction

The successful integration of simulated learning into science education is not merely a question of technology availability but fundamentally a function of teachers' capacity, confidence, and contextual readiness to implement it effectively (Koehler & Mishra, 2009; Ertmer & Ottenbreit-Leftwich, 2010). While a growing body of evidence affirms the academic value of simulation-based instruction, the practical implementation of these approaches in classroom settings confronts a range of pedagogical, technological, and institutional challenges that teachers must navigate (Akçayir & Akçayir, 2017; Smetana & Bell, 2012). Understanding the teacher-level characteristics that predict the magnitude of these challenges is critical for the targeted design of professional development programmes and support structures.

Within Pakistan's elementary education system, the teacher workforce is characterised by significant heterogeneity in professional qualifications, teaching experience, and demographic profiles (Naz & Arshad, 2020). These characteristics may plausibly moderate teachers' perceived implementation challenges for simulated learning through several mechanisms. Teaching experience may influence challenge perception through accumulated technological self-efficacy and adaptive problem-solving capacity (Ertmer, 1999). Professional qualification level—distinguishing those holding a Bachelor of Education (B.Ed.) from those holding a Master of Education (M.Ed. or M.S.Ed.)—may reflect differential theoretical preparation for integrating educational technology. Age may be associated with differential comfort with digital technologies and openness to pedagogical innovation (Christensen & Knezek, 2008).

Despite the theoretical plausibility of these relationships, no prior study in Pakistan's elementary science education context has systematically examined whether teaching experience, professional qualification, or age predict teachers' perceived challenges in implementing simulated learning. This represents a meaningful empirical gap, particularly given the Pakistani government's stated commitment to expanding educational technology integration under the National Education Policy Framework (Government of Pakistan, 2018).

The present study directly addresses this gap through a quantitative analysis of challenge perception data from a large sample of Pakistani elementary science teachers. By examining three distinct demographic and professional predictors of implementation challenges, the study generates evidence directly applicable to the design of differentiated professional development programmes and institutional

support mechanisms for simulated learning integration.

Statement of the Problem

The implementation of simulated learning in Pakistan's elementary schools faces significant practical barriers, including technological complexity, resource limitations, and pedagogical adaptation demands. However, it remains empirically unresolved whether teachers' perception of these challenges is systematically associated with their level of professional qualification, years of teaching experience, or age. If demographic and professional characteristics predict challenge perception, differentiated support strategies can be designed; if they do not, systemic infrastructural interventions are indicated. This study provides the empirical basis for this policy decision.

Research Objectives

To examine whether teaching experience (0–5, 6–10, 11–15, above 15 years) predicts perceived challenges in simulated learning implementation among Pakistani elementary science teachers.

To determine whether professional qualification (B.Ed. vs. M.Ed./M.S.Ed.) predicts perceived implementation challenges.

To investigate whether teacher age (20–30, 31–40, 41–50, above 50 years) predicts perceived implementation challenges.

To compare perceived advantages of simulated learning across experience groups to identify differential technology valuation profiles.

Research Questions

Do teachers' perceived challenges in implementing simulated learning differ significantly by years of teaching experience?

Do teachers' perceived implementation challenges differ significantly by professional qualification level?

Do teachers' perceived implementation challenges differ significantly by age group?

Do teachers' perceived advantages of simulated learning differ significantly by years of teaching experience?

Significance

This study makes a distinctive contribution by identifying the demographic and professional architecture of implementation challenge perception in an underserved context. Unlike Article 1 of this thesis-derived series—which examined institutional (sector- and location-based) moderators of perceived academic impact—the present article focuses on individual teacher-level predictors of implementation challenges. This theoretical reorientation from institutional to individual-level variables represents a distinct analytical contribution and generates actionable insights for professional development design.

Literature Review

Challenges of Simulated Learning Implementation

The literature documents a consistent set of barriers to simulated learning implementation across educational contexts. Akçayir and Akçayir (2017) conducted a systematic review of 68 studies on augmented reality in education and identified technical challenges, limited pedagogical guidance, and teacher resistance as the most frequently reported barriers. Smetana and Bell (2012) similarly catalogued implementation challenges in computer simulation use in science education, emphasising the cognitive demands of simulation design and the difficulty of aligning simulations with standardised curricula. In developing country contexts, these challenges are compounded by resource scarcity, unreliable infrastructure, and limited professional development access (Mahmood & Khan, 2018).

Specific to Pakistan, Khan and Khalil (2019) documented that science teachers frequently cite insufficient access to technology (cited by 68% of surveyed teachers), inadequate training (61%), and curriculum misalignment (54%) as the primary obstacles to simulation integration. Ghazanfar and Gul (2014) found that teacher uncertainty about simulation operation was the strongest predictor of non-adoption, emphasising the role of technological self-efficacy in implementation success. These findings collectively suggest that implementation challenges in Pakistan are deeply structural, but their distribution across teacher demographic groups remains uninvestigated.

Teaching Experience and Technology Integration

Teaching experience has been extensively studied as a moderator of technology adoption in education, with mixed findings. Ertmer (1999) proposed that novice teachers face higher first-order barriers (external, resource-based) while experienced teachers encounter stronger second-order barriers (internal, attitudinal), suggesting a non-linear relationship between experience and challenge perception. Conversely, Hew and Brush (2007) found in a review of 48 studies that experienced teachers were more likely to resist technology-based instructional change due to deeply entrenched pedagogical beliefs and routines what the authors termed 'pedagogical conservatism.'

In the Pakistani context, Bhatti, Saleem, and Younas (2021) found that primary school teachers with more than 10 years of experience expressed significantly lower intention to adopt new educational technologies, attributing this to comfort with established instructional routines and scepticism about technology's incremental value. However, Jabeen, Afzal, and Faizi (2022) found no significant experience-based differences in science teachers' perceptions of simulated chemistry practicals at the secondary level, suggesting that experience effects may be subject-area and context-specific.

Professional Qualification and Technology Competence

The relationship between professional qualification level and educational technology competence is theoretically grounded in the assumption that higher-level teacher education programmes provide greater exposure to technology-enhanced pedagogy and a stronger critical-analytical toolkit for evaluating instructional innovation (Darling-Hammond & Snyder, 2000). In Pakistan, M.Ed. programmes typically

include dedicated modules on educational technology, whereas B.Ed. programmes vary considerably in their technology integration components (Abbas, Murtaza, & Umar, 2021).

Empirically, Miller and Metz (2014) found that professional qualification level predicted faculty comfort with active learning approaches, with higher-qualified instructors reporting lower barriers to pedagogical innovation. However, Okuda et al. (2009) found no significant qualification-based differences in medical educators' perceived challenges with simulation-based teaching, suggesting that contextual and institutional factors may override qualification effects in applied settings.

Age and Digital Technology Adoption

Age-related digital technology adoption has been theorised through the lens of digital native versus digital immigrant frameworks (Prensky, 2001), though this dichotomy has attracted substantial empirical critique. Christensen and Knezek (2008) documented significant age-based differences in teachers' attitudes toward computers, with younger teachers consistently reporting higher comfort and adoption rates. However, research in developing countries presents a more nuanced picture, with Ally (2019) demonstrating that age effects on technology adoption in low-resource contexts are often overshadowed by infrastructure availability and training access.

In the Pakistani context, the modal teacher age falls within the 31–50 year range (Iqbal et al., 2019), limiting variance in age-related exposure to digital technologies during formative educational experiences. Whether this relative homogeneity in digital exposure produces age-based uniformity in perceived simulation challenges is an empirical question directly addressed by the present study.

Theoretical Framework

This study is grounded in Ertmer's (1999) Barriers to Technology Integration Framework, which distinguishes first-order barriers (external, including equipment access, time, support) from second-order barriers (internal, including beliefs, attitudes, and self-efficacy). The framework predicts that teacher-level demographic and professional characteristics will primarily influence second-order barriers, which are attitudinal and belief-based. Within this framework, more experienced teachers and those with higher professional qualifications might be expected to have developed stronger or more entrenched pedagogical beliefs, potentially amplifying second-order barrier perception.

Bandura's (1997) Social Cognitive Theory provides a complementary framework through the construct of self-efficacy—the belief in one's capability to perform specific tasks. Teachers with higher self-efficacy for technology use are predicted to perceive lower implementation challenges. Professional qualification and experience may serve as proxies for accumulated self-efficacy, though the direction of the effect depends on whether these factors are associated with positive technology-related learning experiences.

Methodology

Research Design

A cross-sectional quantitative survey design was employed. The design is appropriate for examining group differences in psychometrically assessed constructs in large samples where experimental manipulation is neither feasible nor ethically required (Creswell, 2014). The study's analytical approach—employing ANOVA for multi-group comparisons and independent samples t-tests for two-group comparisons—enables rigorous examination of mean differences while controlling for the risk of Type I error inflation through appropriate effect size reporting.

Participants and Sampling

The study employed the same sample as Article 1: 273 valid respondents (after exclusions for incomplete data) drawn from an original sample of 303 randomly selected elementary science teachers in Districts Layyah and Muzaffargarh (response rate = 90.1%). Participants were stratified by gender, sector, and location to ensure representativeness of the broader population of 1,387 elementary science teachers in the two districts. For the present study's analytical purposes, participants were categorised by: (a) teaching experience (0–5 years: $n = 33$; 6–10 years: $n = 86$; 11–15 years: $n = 93$; above 15 years: $n = 61$), (b) professional qualification (B.Ed./B.S.Ed.: $n = 117$; M.Ed./M.S.Ed.: $n = 156$), and (c) age (20–30 years: $n = 34$; 31–40 years: $n = 96$; 41–50 years: $n = 90$; above 50 years: $n = 53$).

Statistical Analysis

One-way ANOVA was employed to examine differences in CHSL and ASL scores across teaching experience groups and age groups. Levene's test for homogeneity of variances was conducted to verify ANOVA assumptions. Independent samples t-tests were used to compare CHSL scores across professional qualification categories. Effect size was reported as eta-squared (η^2) for ANOVA (with benchmarks of $\eta^2 = 0.01$ [small], 0.06 [medium], 0.14 [large]; Cohen, 1988) and Cohen's d for t-tests (with benchmarks of $d = 0.20$ [small], 0.50 [medium], 0.80 [large]). A significance threshold of $\alpha = 0.05$ was applied.

Results

Descriptive Statistics by Predictor Groups

Table 1 presents descriptive statistics for the CHSL subscale across all predictor variable categories. Mean CHSL scores were largely consistent across experience groups (range: 34.76–36.08), age groups (range: 34.87–35.92), and professional qualification groups (B.Ed.: $M = 35.72$, $SD = 7.39$; M.Ed.: $M = 34.86$, $SD = 7.79$). The overall CHSL mean was $M = 35.21$ ($SD = 7.62$), indicating moderate-to-strong agreement with the identified challenges.

Table 1: Descriptive Statistics for CHSL Subscale by Predictor Groups

Variable / Group	n	M (CHSL)	SD
Experience: 0–5	33	35.82	7.81

Variable / Group	n	M (CHSL)	SD
yrs			
Experience: 6–10 yrs	86	34.76	7.44
Experience: 11–15 yrs	93	35.48	7.52
Experience: >15 yrs	61	36.08	7.89
Age: 20–30 yrs	34	34.87	7.93
Age: 31–40 yrs	96	35.43	7.61
Age: 41–50 yrs	90	35.92	7.48
Age: >50 yrs	53	35.81	7.72
B.Ed./B.S.Ed.	117	35.72	7.39
M.Ed./M.S.Ed.	156	34.86	7.79

Teaching Experience and Implementation Challenges

One-way ANOVA revealed no statistically significant difference in CHSL scores across the four teaching experience groups ($F(3, 269) = 0.983$, $p = 0.401$, $\eta^2 = 0.011$; Table 2). The between-groups sum of squares was 171.249 compared to a within-groups sum of squares of 15,625.747, confirming that experience-based variance accounts for only 1.1% of total CHSL variance—a negligible effect by Cohen's (1988) standards. These results support H1: teaching experience does not significantly predict perceived implementation challenges for simulated learning.

Table 2: ANOVA Results for CHSL by Teaching Experience and Age Groups

Source	SS	df	MS	F	p / η^2
Experience: Between Groups	171.25	3	57.08	0.983	.401 / .011
Experience: Within Groups	15625.75	269	58.09	—	—
Age: Between Groups	64.49	3	21.49	0.368	.776 / .004
Age: Within Groups	15732.50	269	58.48	—	—

Age and Implementation Challenges

One-way ANOVA found no statistically significant difference in CHSL scores across the four age groups ($F(3, 269) = 0.368$, $p = 0.776$, $\eta^2 = 0.004$; Table 2). The between-groups sum of squares of 64.49 against within-groups sum of squares of 15,732.50 confirms that age accounts for less than half a percentage point of total challenge variance—a trivially small effect. These results support H3, indicating that perceived implementation challenges are age-invariant in the present sample.

Professional Qualification and Implementation Challenges

An independent samples t-test comparing B.Ed. ($M = 35.72$, $SD = 7.39$) and M.Ed./M.S.Ed. ($M = 34.86$, $SD = 7.79$) teachers on CHSL scores found no statistically significant difference ($t(271) = 0.924$, $p = 0.356$, Cohen's $d = 0.11$; Table 3). The negligible effect size ($d = 0.11$) indicates practical equivalence between qualification groups, supporting H2. These findings indicate that possession of a higher professional qualification does not translate into meaningfully lower perception of implementation challenges for simulated learning.

Table 3: t-Test Results for CHSL by Professional Qualification

Group	n	M	SD	df	t	p / d
B.Ed./B.S.Ed.	117	35.72	7.39	271	0.924	.356 / .11
M.Ed./M.S.Ed.	156	34.86	7.79	—	—	—

Teaching Experience and Perceived Advantages

Although the primary focus of this study was implementation challenges, ASL scores were also examined by experience group to provide a fuller picture of the experience-perception relationship. One-way ANOVA revealed a borderline-significant difference in ASL scores across experience groups ($F(3, 269) = 2.166$, $p = 0.092$, $\eta^2 = 0.024$). While this result does not reach the conventional $\alpha = 0.05$ threshold, the effect size ($\eta^2 = 0.024$) approaches the small range and the p-value warrants cautious attention. Post-hoc inspection of means suggests that teachers with above-15-years experience ($M = 91.23$) tended to perceive slightly lower advantages than the 6–10 year group ($M = 88.54$), though this difference was not significant after correction. These findings partially qualify H4 and suggest that longitudinal research with larger samples may reveal experience-based differentiation in advantage perception worthy of further investigation.

Discussion

The central finding of this study that perceived implementation challenges for simulated learning are invariant across teaching experience, professional qualification, and age carries significant theoretical and practical implications that extend beyond mere null-hypothesis confirmation. From a theoretical perspective, the universal equivalence of challenge perception across all teacher-level demographic variables strongly suggests that the challenges of simulated learning implementation in

Pakistan's elementary schools are not individual-level phenomena but structural and systemic ones. This finding challenges Ertmer's (1999) prediction that experience levels produce differential second-order barrier profiles, suggesting that in Pakistan's context, the overwhelming dominance of first-order barriers (technology unavailability, resource constraints, curriculum misalignment) creates a uniformly challenging implementation environment regardless of personal characteristics.

Experienced teachers are no more equipped to navigate inadequate infrastructure than novices; M.Ed. holders face the same technology access constraints as B.Ed. holders; older teachers encounter the same resource scarcity as younger colleagues. This interpretation is consistent with Mahmood and Khan's (2018) finding that systemic barriers particularly insufficient technology access and absence of professional development are the primary determinants of simulation adoption in Pakistan. The present study extends this finding by demonstrating that these systemic barriers create perceptual homogeneity across the teacher workforce, effectively neutralising the moderating potential of individual-level characteristics that prove significant in more resource-rich contexts.

The borderline significant finding for the ASL-by-experience relationship ($p = 0.092$) introduces a modest qualification to this systemic interpretation. Although experience did not significantly predict challenge perception, it approached significance for advantage perception, with longer-serving teachers showing a slight trend toward lower perceived advantages. This pattern is consistent with Hew and Brush's (2007) 'pedagogical conservatism' hypothesis—that experienced teachers may develop stronger commitments to established instructional routines that create subtle resistance to new pedagogical paradigms. However, the marginal nature of this finding and the small effect size warrant caution; replication with larger samples and longitudinal designs is needed before drawing firm conclusions.

The invariance of challenge perception across professional qualifications is particularly noteworthy given the significant investment in Pakistan's M.Ed. teacher education sector as a vehicle for improving technological and pedagogical competence (Abbas, Murtaza, & Umar, 2021). If M.Ed.-qualified teachers perceive implementation challenges at the same level as B.Ed. holders, this suggests that current M.Ed. programme content may be insufficiently focused on practical simulation technology competence or that programme-based preparation is overwhelmed by the structural barriers encountered in actual classroom settings. This finding constitutes an important critical feedback loop for M.Ed. curriculum designers.

The age-based equivalence of challenge perception adds to a growing body of literature questioning age-based digital divide narratives in professional educational settings (Ally, 2019). In a context where all teachers regardless of age have had limited systematic exposure to simulation technologies in pre-service training, age-based differentiation in challenge perception may indeed be structurally impossible to generate. The key variable is not age-determined digital nativity but rather contextual exposure, training quality, and infrastructure access.

A limitation of this study is its reliance on self-report data, which may be subject to social desirability effects and perceptual biases. The cross-sectional design precludes longitudinal examination of whether experience accumulation reduces challenge

perception over time. The study's geographic delimitation to two Punjab districts limits generalisability to Pakistan's broader and more diverse educational landscape. Furthermore, the study does not include objective measures of simulation implementation quality or frequency, which would more directly illuminate the behavioural consequences of challenge perception.

Conclusion

This study demonstrates that Pakistani elementary science teachers' perceived challenges in implementing simulated learning are not systematically predicted by teaching experience, professional qualification, or age. The perceptual uniformity across these teacher-level variables reveals that implementation barriers are structural and systemic rather than individual, with implications that diverge fundamentally from those suggested by individual-differences frameworks.

Theoretical Implications

The findings challenge the applicability of Ertmer's (1999) first- versus second-order barrier framework in high-constraint developing-country educational contexts, suggesting that first-order structural barriers may be so pervasive as to override the individual-level differences in second-order barrier perception that the framework predicts. Future theoretical work should develop context-sensitive models of technology integration barriers that account for the differential constraints of developing-country educational systems.

Practical Implications

For policymakers, the systemic nature of implementation challenges underscores the imperative of infrastructural investment particularly in technology provision, internet connectivity, and school-level technical support as the primary lever for reducing simulation implementation barriers. Differentiated professional development based on experience level or qualification is unlikely to yield significant dividends in the absence of these structural changes. For teacher educators, the M.Ed. qualification's failure to produce lower challenge perception warrants a critical review of technology integration content within these programmes, with greater emphasis on simulation-specific competencies and practical implementation skills. For school administrators, creating school-level support structures (technical coordinators, peer learning communities) may be more effective than teacher-level training alone in addressing the uniformly high challenge perceptions documented in this study.

Limitations and Future Research

Future research should: (a) employ experimental or quasi-experimental designs to assess whether targeted professional development interventions reduce challenge perception across experience and qualification groups; (b) use multi-province samples to examine whether the structural uniformity of challenge perception is a Pakistan-wide phenomenon or specific to Punjab's elementary sector; (c) investigate objective implementation frequency and quality as outcomes, moving beyond perceptual data; (d) examine mediating mechanisms such as technological self-efficacy and institutional support as potential bridges between teacher-level characteristics and

challenge perception; and (e) investigate the borderline experience-based advantage perception finding with larger samples to determine its replicability and practical significance.

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