Perceptions of Teachers and Students on Interactive Smartboards in Science Education: A Mixed-Methods Study from Sri Lanka

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Abstract

The integration of Interactive Smartboards (ISBs) has emerged as a pivotal component of technology-enhanced teaching and learning in secondary science education, particularly for subjects involving abstract and complex concepts. This study investigates the perceptions of teachers and students regarding the use of Interactive Smartboards in science education in selected national schools in the Matara District, Sri Lanka. The research aims to explore how ISBs influence teaching practices, student engagement, conceptual understanding, and overall learning experiences, while also identifying challenges related to technical infrastructure and professional development. A sequential explanatory mixed-methods design was employed. Quantitative data were collected through structured questionnaires administered to 125 science teachers and 372 Grade 10 and 11 students, while qualitative data were gathered through semi-structured interviews with five teachers and five students. Quantitative data were analyzed using descriptive and inferential statistics, and qualitative data were examined through thematic analysis. Findings reveal that both teachers and students hold generally positive perceptions of ISBs, particularly regarding increased student engagement, improved visualization of scientific concepts, and enhanced classroom interaction. Teachers reported that ISBs supported multimedia resources, simulations, and interactive activities, making science lessons more dynamic and learner-centered. However, technical malfunctions, inconsistent internet connectivity, limited access to technical support, and insufficient professional training were identified as significant challenges, more evident in resource-limited and rural settings. Regression analysis indicates that professional development is the strongest predictor of teacher perceptions ($\beta = 0.999$, $R^2 = 0.893$), while technical support ($\beta = 0.741$) and pedagogical practices ($\beta = 0.242$) are key predictors for students. The study concludes that while ISBs have significant potential to enhance science education, their effectiveness depends on appropriate pedagogical integration, reliable technical infrastructure, and continuous professional development.

Keywords: Interactive Smartboards, science education, teacher perceptions, student engagement, technical support, professional development

Introduction

The global expansion of educational technology has fundamentally transformed the landscape of teaching and learning, particularly in science education where abstract concepts, dynamic processes, and microscopic phenomena demand more than conventional chalk-and-board methods can offer. Organizations such as UNESCO and the OECD have consistently emphasized the integration of Information and Communication Technology (ICT) into education systems as a means of promoting equitable access to quality learning, enhancing pedagogical innovation, and preparing students for knowledge-based economies (Higgins, 2010). Among the most prominent technological tools to emerge in this drive toward technology-rich classrooms are Interactive Smartboards (ISBs) large touchscreen displays that merge multimedia content delivery with real-time interactive capabilities.

An ISB is fundamentally different from traditional whiteboards or projectors. While conventional projectors allow teachers to display visual content, they do not permit real-time interaction. ISBs, by contrast, merge display and interaction in one platform, facilitating smooth transitions between presenting information, demonstrating experiments, and directly involving students in content manipulation (Rossouw, 2020). In chemistry, ISB-based molecular modelling software allows teachers to rotate 3D molecular structures; in physics, interactive simulations model projectile behaviour under varying gravitational conditions; and in biology, layered diagrams progressively expose students to human anatomy or plant cells. These capabilities are particularly valuable at the secondary level, where abstract thinking and spatial reasoning skills are still developing (Tang, 2025).

Sri Lanka has recognized the potential of ISBs as part of its broader national ICT in Education policy, which prioritizes the construction of smart classrooms equipped with digital boards, internet access, and multimedia tools. The Ministry of Education, in collaboration with the Information and Communication Technology Agency (ICTA) has introduced ISBs to selected secondary schools through the flagship Smart Classroom Programmed (Smith, 2023). However, adoption remains unequal across provinces due to disparities in infrastructure, teacher preparation, and maintenance support. Science education in Sri Lanka, covering physics, chemistry, and biology at Ordinary Level (O/L) and Advanced Level (A/L), remains systemically constrained by large class sizes exceeding 40 students in many state schools, limited laboratory resources, and a widening digital divide between urban and rural schools.

Despite growing investment in ISB infrastructure, empirical understanding of how teachers and students perceive and experience these technologies in Sri Lankan science classrooms remains limited. Most existing local research focuses on general ICT integration rather than ISBs specifically, and typically examines only one stakeholder group. This study addresses this gap by investigating perceptions from both teachers and students through a mixed-methods approach aiming to provide a comprehensive and contextually grounded understanding of ISB integration in secondary science education.

The introduction of interactive technologies into science classrooms has been driven by the recognition that scientific concepts (molecular dynamics, electromagnetic fields, cellular mitosis) are difficult to adequately portray through static diagrams or verbal description alone. Interactive technological tools enable teachers to simulate these processes, provide immediate feedback, and allow learners to engage meaningfully with the learning process (Smith, 2023). Nations with well-developed digital infrastructures, such as the United Kingdom, Australia, and Singapore, have documented considerable gains in student engagement and conceptual understanding through ISB integration, though these benefits are consistently contingent upon teacher training quality and technical reliability.

In the Sri Lankan context, urban national schools have begun benefiting from ISBs, with teachers reporting increased student attention and greater flexibility in lesson delivery. However, anecdotal evidence and limited pilot studies also reveal persistent challenges: frequent technical problems, inadequate maintenance, insufficient teacher training in advanced ISB features, and uneven integration into lesson planning. These challenges are more pronounced in rural and semi-urban schools, where electricity supply, internet connectivity, and technical support are less reliable. This study situates its investigation within the Matara District (a representative setting encompassing both urban national schools and schools with more limited resources) to generate findings that are relevant across diverse Sri Lankan school contexts.

The core problem identified in this study is the lack of empirical understanding of how both teachers and students perceive and experience the use of ISBs in science education in Sri Lanka. Although investment in interactive smartboards is increasing, there remains insufficient knowledge about how teachers and students experience these devices, what factors determine successful integration, and how effective current professional training programs are. Previous studies have typically examined only one stakeholder group, leading to an incomplete understanding of classroom dynamics. In the absence of this knowledge, policymakers and classroom teachers risk failing to fully leverage ISBs' potential to promote learning and engagement in science, especially where funds are scarce and technology investment must yield clear educational dividends (Hennessy, 2021).

This study was guided by four objectives: (1) to explore the lived experiences of science teachers and students engaging with ISBs in diverse Sri Lankan secondary school settings; (2) to identify and analyze pedagogical practices that facilitate or hinder meaningful integration of smartboard features for teaching complex scientific concepts; (3) to examine technical and infrastructural challenges (including hardware malfunctions, software issues, and support constraints) and their impact on lesson continuity and teaching efficacy; and (4) to evaluate the efficacy of existing professional development programs in enhancing teachers' competencies, confidence, and instructional innovations with smartboards.

This research contributes to the relatively sparse empirical literature on ISB integration in resource-constrained educational environments in developing countries. By capturing the perspectives of both teachers and students, it provides a dual-stakeholder understanding of classroom realities that single-perspective studies cannot achieve (Patil, 2023). Practically, findings can assist teachers in developing more effective ISB-based lesson strategies and help school administrators justify targeted resource investments. At the policy level, results provide evidence-based guidance to the Ministry of Education and ICTA for optimizing professional development programs and improving the equity of technology distribution across Sri Lankan schools.

Literature Review

Theoretical Framework

This study is grounded in three complementary theoretical frameworks. Constructivist Learning Theory, derived from Piaget (1972) and Vygotsky (1978), posits that learners build understanding by connecting new information with prior knowledge through active problem- solving and social interaction. ISBs align closely with constructivist pedagogy by enabling interactive simulations, collaborative annotation, and hands-on exploration of scientific phenomena (Silva, 2022). Research by Hennessy, Ruthven, and Brindley (2005) demonstrated that interactive boards facilitate exploratory learning in science classrooms, allowing students to develop higher-order thinking skills through active engagement with content.

Cognitive Load Theory (CLT), introduced by Sweller (1988), highlights the limited capacity of working memory and its implications for instructional design. In science education, abstract phenomena and complex multi-variable processes can easily overwhelm students' working memory through poorly designed instruction. When properly implemented, ISBs provide visualizations, simulations, and interactive activities that minimize extraneous cognitive load while promoting germane load through meaningful problem-solving (Alejandro, 2024). Mayer and Moreno (2003) demonstrated that multimedia learning tools integrating visual and interactive elements improve student comprehension by reducing unnecessary cognitive processing a principle that directly supports ISB-based instruction.

The Technology Acceptance Model (TAM), introduced by Davis (1989), examines how individuals adopt and use technology based on two key factors: perceived usefulness (PU) and perceived ease of use (PEOU). In the context of ISBs, teachers are more likely to integrate these tools when they believe they will enhance lesson delivery and student comprehension, while students engage more readily when the technology feels intuitive and accessible (Alismaiel, 2022). Professional development programs play a critical role in shaping these perceptions: training workshops can improve PEOU by building familiarity with ISB functions, while demonstrations of effective classroom integration strengthen PU (Alejandro, 2024). The integration of these three theoretical lenses (constructivism, CLT, and TAM) provides a comprehensive framework for examining ISB adoption from both pedagogical and behavioral perspectives.

Empirical Research on ISBs in Science Education

International research consistently documents the pedagogical benefits of ISBs in science education. Studies in the United Kingdom demonstrate that ISBs enable students to manipulate content directly, annotate diagrams, and collaborate in small groups, promoting deeper conceptual understanding in physics and chemistry (Hennessy, Deaney, & Ruthven, 2007). In Australia, Higgins, Beauchamp, and Miller (2007) reported enhanced problem-solving skills and higher-order thinking in secondary science classrooms using ISBs, with physics and chemistry teachers using interactive simulations to allow students to visualize and manipulate variables. American research by Lowther et al. (2008) found that ISB-supported lessons encouraged active participation in laboratory discussions, increasing retention of scientific concepts.

However, international research also highlights persistent challenges. The novelty effect (whereby initial enthusiasm for ISBs diminishes if integration remains superficial) is a recurring concern (Rosen & Beck-Hill, 2012). Teachers who use ISBs primarily for presentation rather than interactive engagement fail to achieve long-term learning benefits (Patrick, 2024). Technical complications including software malfunctions, hardware failures, and network disconnection can delay lessons and reduce teacher confidence (Aldosemani, 2023). Professional development quality is consistently identified as a critical determinant of sustainable ISB adoption: schools in the UK and Australia that provided structured training and technical support observed more effective and sustained integration (Higgins et al., 2007).

In Asian contexts, Singapore, South Korea, and India offer instructive precedents. Singapore's ICT in Education Masterplan integrates ISBs with digital content repositories, enabling blended physical and virtual experiments, supported by comprehensive formal training and peer mentoring programs (Romero-Hall, 2023). South Korea's Smart Classroom initiative combines ISBs with e-textbooks and mobile devices to create fully interactive environments (Mehta, 2025). In India, ISB adoption is strong in urban private schools but faces significant barriers in rural settings including irregular electricity supply, limited internet coverage, and inadequate teacher training challenges closely analogous to those encountered in Sri Lanka (Patil, 2023).

Research in the Sri Lankan context, though limited, indicates that ISBs increase student motivation and engagement in science lessons through interactive simulations and dynamic diagrams (Wickramasinghe & Jayawardena, 2017). Perera and Senanayake (2018) found higher attention and participation levels during ISB-supported lessons in urban schools with better infrastructure. However, Fernando and Jayasuriya (2019) highlight that infrastructural limitations remain a key barrier to equitable implementation of Smart Classroom initiatives. Rural schools face erratic electricity supply, poor internet connectivity, and outdated hardware, while teacher professional development access is concentrated in urban areas, creating significant inequalities in teacher competence and confidence (Kumari & Rajapakse, 2020).

Conceptual Framework

The conceptual framework of this study identifies three independent variables (pedagogical practices, technical support and infrastructure, and professional development) as key determinants of the dependent variable: teacher and student perceptions of ISBs. Pedagogical practices encompass active learning, inquiry-based, and collaborative strategies; technical support refers to hardware, software, connectivity, and maintenance availability; and professional development includes workshops, peer mentoring, and blended learning modules. The framework draws upon constructivist theory (supporting active pedagogical strategies), CLT (highlighting the role of technical reliability in managing cognitive load), and TAM (emphasizing professional development's role in shaping perceived usefulness and ease of use). Three research hypotheses were formulated: H1 — pedagogical practices significantly relate to ISB integration; H2 — technical support significantly relates to ISB integration; H3 — professional development significantly relates to ISB integration.

Methodology

Research Design

A sequential explanatory mixed-methods research design was adopted, collecting and analyzing quantitative data first, followed by qualitative data to interpret and elaborate upon quantitative results (Creswell & Plano Clark, 2018). This design was selected because the research problem (attitudes, infrastructural constraints, and pedagogical processes) is complex and multifaceted, requiring both the breadth of quantitative generalization and the depth of qualitative contextualization. The sequential structure enables triangulation that enhances validity, while complementarity allows statistical trends to be enriched by qualitative insights, yielding practically applicable recommendations.

Population and Sample

The target population comprised science teachers and Grade 10–11 students in national schools in Matara District, Sri Lanka. According to the Annual School Census Summary Report (Ministry of Education, 2023), Matara District has 23 national schools with 184 science teachers and approximately 11,500 students in Grades 10 and 11. For the quantitative phase, stratified random sampling following the Krejcie and Morgan (1970) table yielded a sample of 125 science teachers and 372 students, stratified by school to ensure proportional representation across different school sizes and geographical locations. For the qualitative phase, purposive sampling was used to select five teachers and five students based on direct ISB experience, ability to articulate experiences, and diversity in school location (urban and rural), teaching experience, and academic performance levels.

Data Collection Instruments

The quantitative instrument was a structured questionnaire with Likert-scale items (1 = Strongly Disagree to 5 = Strongly Agree) organized into four sections: pedagogical practices, technical support and infrastructure, professional development and training, and perceptions of ISBs, preceded by demographic data. Content validity was established through review by three educational technology specialists and two experienced ISB users. Pilot testing with 15 teachers and 30 students from non-sample schools confirmed item clarity and adequate internal consistency (Cronbach's $\alpha > 0.70$ across all sections). Final Cronbach's α values ranged from 0.793 to 0.906 for teachers and 0.825 to 0.930 for students, confirming acceptable to excellent reliability.

The qualitative instrument was a semi-structured interview guide organized into four thematic areas: experiences using ISBs, effectiveness of teaching and learning, challenges faced, and suggestions for improvement. Interviews were conducted in quiet, private settings, audio-recorded with participants' consent, and transcribed verbatim. Personal identifiers were anonymized throughout to maintain confidentiality and comply with ethical requirements.

Data Analysis

Quantitative data were analyzed using SPSS, beginning with descriptive statistics (frequencies, percentages, means, and standard deviations) to summarize demographic characteristics and identify response trends. Inferential analysis included Pearson correlation to examine relationships between independent variables and ISB perceptions, and multiple regression to identify the strongest predictors. Statistical significance was set at $p < 0.05$. Normality assumptions were confirmed (skewness −1.612 to −1.057; kurtosis 0.245 to 1.950, within ±2 range). Exploratory factor analysis (KMO values 0.748–0.844; Bartlett's test $p = 0.000$) confirmed construct validity.

Qualitative data were analyzed through thematic analysis involving open, axial, and selective coding to identify preliminary codes, develop linkages between concepts, and synthesize broad themes with direct relevance to the research objectives. Findings from both methodological phases were integrated through triangulation in the discussion, with quantitative patterns providing the statistical foundation and qualitative themes offering contextual explanations.

Ethical Considerations

Ethical clearance was obtained from relevant educational authorities prior to data collection. Participation was strictly voluntary, and all participants provided informed written consent (parents or guardians provided consent for student participants). Confidentiality was maintained through anonymous coding; all data were stored in encrypted digital files with restricted access and will be destroyed following completion of the research. Participants were informed of their right to withdraw at any time without consequence.

Results

Objective 1: Lived Experiences with ISBs: Teachers versus students

The quantitative sample comprised 125 science teachers (44% male, 56% female), of whom 53.6% were aged 40–49 and 56% had 11–15 years of teaching experience, indicating a predominantly mid-career sample with substantial professional background. The student sample of 372 participants (57.3% male, 42.7% female) included nearly equal proportions from Grade 10 (51.1%) and Grade 11 (48.9%), with 55.6% aged 14–15 years.

Descriptive analysis of ISB perceptions revealed a mean score of 3.9020 (SD = 0.71271) for teachers and 3.7614 (SD = 0.78546) for students, both indicating generally positive attitudes toward ISB use. These scores reflect favorable perceptions across items related to usefulness, engagement enhancement, and relevance to science curriculum goals. The moderate standard deviations suggest meaningful variability in perceptions, reflecting differences in individual experience, school resources, and exposure frequency.

Table 1: *Descriptive Statistics — Perceptions of ISBs: Teachers vs. Students*

Group	N	Min	Max	Mean	SD	Variance
Teachers (PISBT)	125	1.50	4.75	3.9020	0.71271	0.508
Students (PSIBT)	372	1.50	4.75	3.7614	0.78546	0.617

Thematic analysis revealed two primary themes. Theme 1, Positive Learning Experiences, encompassed enhanced engagement and motivation, and improved conceptual understanding through visualization. Both teachers and students reported that ISBs created more engaging and motivating learning environments. Students found science lessons more enjoyable when visuals, colors, and sounds replaced traditional chalkboard methods, and teachers observed improved enthusiasm, particularly among previously passive students. Animations and 3D graphics were identified as particularly effective for bridging the gap between theory and practice in topics such as photosynthesis and Newton's Laws.

Theme 2, Unequal Access and Usage Frequency, surfaced as a significant concern. Many schools had only one functioning ISB shared among multiple teachers, necessitating scheduling systems that severely limited individual teachers' access frequency. Furthermore, teachers frequently maintained control over board operation due to concerns about equipment damage, restricting student hands-on interaction. This teacher-dominated pattern reduced collaborative learning opportunities and constrained ISBs' interactive potential, despite teachers acknowledging the learning benefits of student participation.

Objective 2: Pedagogical Practices in relation to ISBs: Teachers vs. students

Teachers reported high levels of pedagogical engagement with ISBs (mean = 3.9960, SD = 0.64444), while students perceived their teachers as effectively using ISBs to support learning (mean = 3.7876, SD = 0.76430). Pearson correlation analysis revealed significant positive relationships between pedagogical practices and ISB perceptions for both teachers ($r = 0.535$, $p < 0.01$) and students ($r = 0.514$, $p < 0.01$). These moderate correlations confirm that effective teaching methods substantially influence favorable attitudes toward ISB technology.

Table 2: *Correlation Between Pedagogical Practices and ISB Perceptions*

Stakeholder Group	r	p-value
Teachers (PPT ↔ PISBT)	0.535**	< 0.01
Students (PPT ↔ PSIBTT)	0.514**	< 0.01

*** Correlation is significant at the 0.01 level (2-tailed).*

Qualitative findings identified two further themes. Theme 3, Interactive and Visual Teaching Approaches, captured the widespread use of multimedia; videos, animations, and 3D simulations to make science lessons more dynamic. Teachers reported that multimedia captured attention, promoted curiosity, and supported diverse learning styles. Student participation through ISB-based quizzes and labeling tasks increased feelings of ownership and engagement, though most participation remained teacher-directed rather than student-initiated.

Theme 4, Pedagogical Adaptation Challenges, revealed that many teachers struggled with ISB integration due to limited training, leading to reliance on basic features rather than advanced interactive capabilities. Teachers expressed difficulty balancing traditional teaching responsibilities with the time-intensive demands of preparing digital lessons, often reverting to whiteboard-based instruction when digital lesson preparation proved insufficient. This finding resonates with Ertmer's (2012) identification of time constraints as a persistent barrier to technology integration.

Objective 3: Technical and Infrastructural Challenges in engaging with ISBs

Mean scores for technical support perceptions were 3.8860 (SD = 0.70318) for teachers and 3.8199 (SD = 0.71149) for students, suggesting general satisfaction. However, the strongest correlations in the study emerged between technical support and ISB perceptions: $r = 0.901$ ($p < 0.01$) for teachers and $r = 0.605$ ($p < 0.01$) for students. The exceptionally strong teacher correlation underscores that reliable infrastructure is the most critical environmental determinant of positive ISB attitudes.

Table 3: *Correlation Between Technical Support and ISB Perceptions*

Stakeholder Group	r	p-value
Teachers (TSIT ↔ PISBT)	0.901**	< 0.01
Students (TSIT ↔ PSIBTT)	0.605**	< 0.01

*** Correlation is significant at the 0.01 level (2-tailed).*

Qualitative findings revealed the severity of technical challenges that quantitative averages partially obscure. Theme 5, Technical Barriers, encompassed frequent equipment malfunctions (unresponsive touch screens, software freezing, projector failures) that routinely disrupted lesson flow and discouraged ISB-based planning. Critically, delayed technical support emerged as a persistent systemic failure; in most schools, no dedicated IT staff were available, forcing teachers to wait days or weeks for technicians from zonal offices. This extended downtime rendered equipment unusable for extended periods, resulting in lost instructional time and reduced confidence in technology-based teaching.

Theme 6, Infrastructure Limitations, highlighted poor internet connectivity as a critical barrier particularly in rural schools. Video buffering and disconnections during planned lessons forced teachers to abandon digital activities and revert to traditional methods. Inadequate equipment distribution (often a single ISB shared across multiple classes) combined with unstable electricity supply, severely restricted access frequency and discouraged ISB-dependent lesson planning. These findings closely align with international research documenting infrastructure as a more significant barrier in developing educational contexts than in technologically advanced nations (Hennessy et al., 2010).

Objective 4: Professional Development Efficacy and perceptions of ISBs: Teachers vs. students

Professional development perceptions were positive for both teachers (mean = 3.9880, SD = 0.67937) and students (mean = 3.8212, SD = 0.71041). Correlation analysis revealed the strongest relationship in the study between professional development and teacher perceptions of ISBs ($r = 0.945$, $p < 0.01$), while the student correlation was moderate ($r = 0.501$, $p < 0.01$). Multiple regression analysis for teachers confirmed professional development as the overwhelmingly dominant predictor ($\beta = 0.999$, $p < 0.001$), with the full model explaining 89.3% of variance in teacher ISB perceptions ($R^2 = 0.893$, $F = 338.361$, $p < 0.001$). For students, the regression model explained 64.6% of variance ($R^2 = 0.646$, $F = 120.993$, $p < 0.001$), with technical support ($\beta = 0.741$) and pedagogical practices ($\beta = 0.242$) as positive predictors, and professional development showing a negative coefficient ($\beta = -0.516$), indicating that training alone does not enhance student experiences without accompanying pedagogical and technical improvements.

Table 4: *Regression Coefficients — Predictors of ISB Perceptions*

Predictor Variable	β Teachers	p	β Students	p
Pedagogical Practices (PPT)	-0.029	.001	0.242	.000
Technical Support (TSIT)	-0.039	.000	0.741	.001
Professional Development (PDTT)	0.999	.000	-0.516	.001
R^2	0.893		0.646	

Qualitative findings starkly contrast with positive quantitative means, revealing critical inadequacies in existing professional development. Theme 7, Professional Development Gaps, identified that most teachers had received only brief, one-time introductory workshops covering basic technical operations with minimal pedagogical guidance. Teachers reported learning primarily through trial and error, lacking confidence in ISB operation, and feeling unprepared to design interactive digital lessons. Students' observations that teachers sometimes sought student assistance for board operation confirmed the inadequacy of current training programs.

Theme 8, Perceived Value of ISBs in Science Education, captured strong agreement among both teachers and students that ISBs significantly increase motivation and curiosity, particularly transforming previously passive students into active participants. Teachers viewed ISBs as transformative tools essential for 21st-century science classrooms, valued for their ability to make abstract scientific ideas visible and combine visuals, sound, and interactivity. However, participants consistently emphasized that realizing this potential required comprehensive support systems not just initial training, but dedicated lesson planning time, ongoing mentoring, and reliable technical infrastructure.

Discussion

The findings of this study paint a nuanced picture of ISB integration in Sri Lankan secondary science education: one of genuine potential constrained by systemic deficiencies in infrastructure, professional development, and resource equity. The generally positive perceptions held by both teachers ($M = 3.9020$) and students ($M = 3.7614$) align with international research documenting ISBs' capacity to enhance engagement, visualization, and conceptual understanding (Glover et al., 2007; Hennessy & London, 2013). However, the integrated analysis reveals critical gaps between perception and practice that mirror challenges documented in developing educational contexts internationally.

The most striking finding is the exceptionally strong relationship between technical support and teacher ISB perceptions ($r = 0.901$), the strongest correlation in the study. This underscores the foundational role of reliable infrastructure, confirming that ISBs' pedagogical potential cannot be realized when equipment malfunctions are frequent, maintenance response is delayed, and internet connectivity is unreliable. This finding is consistent with Higgins et al. (2012) and Tondeur et al. (2016), who identify infrastructure reliability as a prerequisite for sustained technology integration. The qualitative evidence that teachers routinely abandoned ISB-based lesson plans due to technical failures, and sometimes faced weeks without functional equipment, reveals infrastructure inadequacies that quantitative means partially obscure. The disparity between schools with adequate technical support and those without (strongly correlated with urban-rural location) creates inequitable learning experiences that contradict the stated equity objectives of Sri Lanka's Smart Classroom Programmed.

Professional development emerges as the most powerful lever for changing teacher perceptions and practices, explaining 89.3% of variance in teacher ISB perceptions through regression analysis ($\beta = 0.999$). This extraordinary predictive power strongly supports the extensive literature identifying professional development as the cornerstone of effective technology integration (Guskey, 2002; Desimone, 2009). However, the qualitative evidence reveals that current programs fall dramatically short of this potential: most teachers received only brief, one-time workshops focused on technical operations rather than pedagogical integration. This finding aligns with Ertmer's (2012) distinction between surface-level technology training and the meaningful, pedagogically-focused professional development that produces sustained behavioral change. The negative coefficient for professional development in the student regression model ($\beta = -0.516$) provides a particularly important insight: teacher training alone does not enhance student learning experiences unless it translates into effective pedagogical practices supported by reliable infrastructure. This finding suggests that professional development must be embedded within comprehensive support systems (not isolated training events) to produce student-visible outcomes.

The moderate correlations between pedagogical practices and ISB perceptions ($r = 0.535$ for teachers, $r = 0.514$ for students) reveal that teaching approach significantly influences attitudes toward ISB technology, but that considerable variability exists in implementation quality. The paradox of high mean pedagogical practice scores (3.9960 for teachers) alongside qualitative evidence of reliance on basic multimedia features rather than fully interactive strategies reflects the tension between what teachers aspire to and what they can achieve given training limitations and time constraints. This pattern is consistent with Mishra and Koehler's (2006) TPACK framework, which emphasizes that effective technology integration requires the simultaneous development of technological, pedagogical, and content knowledge a complex competency that cannot be built through brief introductory training.

The teacher-controlled usage patterns documented qualitatively (where students rarely interact directly with ISBs due to equipment damage concerns) represent a critical missed opportunity. When teachers use ISBs primarily for presentation rather than student interaction, the technology functions essentially as an expensive projector, failing to capitalize on the collaborative and exploratory capabilities that distinguish ISBs from passive display technologies. This finding resonates with Wood and Ashfield's (2008) concerns about technology adoption that remains teacher-centered rather than genuinely interactive, and with constructivist research demonstrating that active, student-directed engagement produces superior learning outcomes compared to passive observation.

The rural-urban disparities evident across all objectives raise important equity concerns for Sri Lankan education policy. Rural schools face disproportionate challenges across infrastructure reliability, professional development access, equipment availability, and maintenance response times. These compounding disadvantages mean that students in rural schools receive substantially less exposure to quality ISB-enhanced science education, potentially widening existing academic achievement gaps. Addressing these disparities requires not just technology provision but comprehensive ecosystem support dedicated technical staff, reliable connectivity infrastructure, mobile professional development programs, and policy frameworks ensuring equitable resource distribution.

Conclusion

This study provides comprehensive mixed-methods evidence that Interactive Smartboards have significant potential to transform secondary science education in Sri Lanka, but that current implementation falls substantially short of this potential due to systemic deficiencies in infrastructure, professional development, and resource equity. Both teachers and students recognize ISBs' value for enhancing engagement, visualization, and conceptual understanding of complex scientific phenomena a consensus that provides a strong foundation for future investment.

The four key conclusions are: First, while perceptions of ISBs are generally positive, access barriers and teacher-controlled usage patterns prevent realization of ISBs' full interactive potential, requiring deliberate policy interventions to increase equipment availability and enable student-centered engagement. Second, pedagogical practices significantly influence ISB perceptions, but effective integration remains inconsistent due to training gaps and time constraints, necessitating comprehensive support for lesson design and pedagogical innovation. Third, technical and infrastructural support is the most critical determinant of ISB effectiveness for teachers, with the very strong correlation ($r = 0.901$) confirming that no pedagogical innovation can succeed without reliable equipment, timely maintenance, and stable connectivity. Fourth, professional development is the most powerful lever for transforming ISB integration, but current one-time workshop programs fail to realize this potential; sustained, pedagogically-focused professional learning communities represent the most critical intervention point.

These findings yield clear practical implications. The Ministry of Education and ICTA should prioritize dedicated IT support staff for all ISB-equipped schools, establish preventive maintenance protocols and rapid-response systems, and invest in reliable internet infrastructure, particularly for rural schools. Professional development programs must be redesigned from brief technical introductions into multi-year, practice-based learning programs combining technical skill-building with pedagogical integration strategies, peer mentoring, and follow-up coaching. Teacher education institutions should embed ISB pedagogy into pre- service science teacher preparation, ensuring graduates enter classrooms with the TPACK competencies required for effective ISB integration. Policy frameworks must explicitly address rural-urban equity disparities through targeted resource allocation, mobile professional development programs, and minimum technology-to-student ratio standards.

This study has several limitations that contextualize its findings. The research was conducted exclusively in Matara District national schools, limiting geographic generalizability. The cross-sectional design captures perceptions at a single time point, preventing assessment of how integration evolves longitudinally. Self-reported data may be subject to social desirability bias, and the small qualitative sample (5 teachers, 5 students) may not fully capture the diversity of district experiences. Future research should expand to multi-regional comparative studies, incorporate objective infrastructure metrics alongside perceptual measures, and design longitudinal studies tracking how ISB integration develops over time. Studies examining the direct impact of ISBs on student academic achievement, conceptual understanding, and scientific inquiry skills would provide valuable outcome evidence to complement this perception-focused investigation. Research comparing different professional development models in terms of their sustained impact on pedagogical transformation would directly address the critical gap identified in this study.

In conclusion, Interactive Smartboards represent a genuinely valuable educational investment for Sri Lankan secondary science education, but their transformative potential will only be achieved when adequate infrastructure, continuous professional development, and equitable resource distribution are treated as inseparable components of technology integration policy rather than optional supplements. The convergent findings of this mixed-methods study provide both a diagnostic assessment of current implementation challenges and an evidence- based roadmap for realizing the full educational promise of interactive smartboard technology.

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