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ROLE OF TECHNOLOGY IN ENHANCING TEACHING AND LEARNING OUTCOMES: A STUDY OF SECONDARY SCHOOLS IN CUTTACK, ODISHA

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Abstract:

The rapid diffusion of digital tools in classrooms has generated widespread interest in how technology reshapes teaching and learning. This study examines the role of technology in enhancing teaching and learning outcomes in secondary schools in Cuttack, Odisha. A qualitative research design was employed, drawing on structured survey questionnaires and semi-structured interviews administered to 20 secondary school teachers and 60 students from government and private institutions. Data were analysed thematically to identify patterns relating to technology use, student engagement, perceived academic performance, access and equity, and barriers to integration. Findings indicate that multimedia and interactive digital tools substantially enhance student engagement and support differentiated, self-paced learning, particularly in science and mathematics. However, infrastructural constraints, unequal access to devices and connectivity, limited teacher training, and student distraction emerged as persistent barriers, with government-school students disproportionately affected. The study concludes that technology functions best as a complement to, rather than a replacement for, conventional pedagogy, and that its benefits are contingent on adequate infrastructure, sustained teacher professional development, and equity-oriented policy support. Implications for educators, curriculum developers, and policymakers are discussed, along with directions for future research.

Index Terms **-** educational technology; teaching-learning outcomes; digital divide; secondary education; technology integration

The integration of technology into education has fundamentally altered traditional teaching and learning practices, offering new pathways to enhance instructional delivery, student engagement, and collaborative learning. From smart classrooms and virtual learning environments to adaptive platforms and artificial-intelligence-driven tools, technology has reshaped how educators teach and how students learn (Kirkwood & Price, 2014). Perhaps the most consequential shift has been the move from teacher-centred to student-centred learning: interactive digital tools such as educational apps, online platforms, and multimedia

resources allow learners to progress at their own pace, revisit difficult concepts, and engage with content until mastery is achieved (Jonassen, 1999). Gamified and simulation-based environments further render complex subjects more accessible and enjoyable, deepening understanding and retention (Johnson et al., 2016). Technology has also strengthened communication and collaboration in education. Discussion forums, video-conferencing platforms, and shared-document tools enable real-time interaction even in remote settings, fostering peer-to-peer learning and continuous feedback (Means et al., 2013). Adaptive learning systems personalise instruction by analysing individual performance and tailoring content accordingly (Schrum & Levin, 2015), while assistive technologies such as screen readers and speech-to-text tools extend access to learners with disabilities (Hennessy, Ruthven, & Brindley, 2005). At the same time, technology integration is not without difficulty: limited digital infrastructure, especially in rural and under-resourced settings, insufficient teacher training, and concerns over data privacy and content quality continue to constrain its effective use (Kirkwood & Price, 2014).

These tensions are particularly salient in the Indian context, where urban and rural, and government and private, institutions differ markedly in the resources available to support digital learning. Understanding how technology is actually experienced by teachers and students in a specific local setting is therefore essential for designing interventions that are both effective and equitable. This study addresses that need by examining the perceptions, practices, and challenges associated with technology use in secondary schools in Cuttack, Odisha.

Significance of the Study

This study contributes to the growing body of research on educational technology by offering context-specific evidence from a mid-sized Indian city with a mixed government-private schooling ecosystem. For educators, it clarifies how digital tools can make teaching more engaging and personalised while identifying the practical barriers that limit their use. For students, it highlights how technology can support individualised learning and where access gaps most acutely undermine that potential. For policymakers, it offers evidence-based grounds for investment in infrastructure, teacher training, and equity-focused digital initiatives (Selwyn, 2011), while also drawing attention to the role of parental involvement in sustaining a healthy balance between screen-based and offline learning (Livingstone & Stoilova, 2021).

Objectives of the Study

The study was guided by three objectives:

- To examine the impact of technology on student engagement, participation, and academic performance.
- To identify key challenges in integrating technology into educational practice across different school settings.
- To propose measures for addressing barriers to equitable and effective technology use in education.

Theoretical Framework

This study draws on several established frameworks for understanding technology integration in education. The Technological Pedagogical Content Knowledge (TPACK) model (Mishra & Koehler, 2006) extends Shulman's (1986) concept of pedagogical content knowledge by adding a technological dimension, arguing that effective teaching requires the intersection of content, pedagogical, and technological knowledge. The Substitution-Augmentation-Modification-Redefinition (SAMR) model (Puentedura, 2010) describes a continuum along which technology can substitute for, augment, modify, or fundamentally redefine learning tasks. Vygotsky's (1978) Social Constructivism situates learning within the Zone of Proximal

Development, a space that collaborative technologies such as shared documents and video conferencing can extend beyond the physical classroom. Bloom's Digital Taxonomy (Churches, 2008) maps technology-based tasks onto six cognitive levels from remembering to creating, while Rogers' (1962) Diffusion of Innovation Theory explains variation in the pace at which teachers and institutions adopt new tools. Siemens' (2005) Connectivism further frames learning as a process of navigating and synthesising information across digital networks. Together, these frameworks provide a structured lens for interpreting how technology shapes pedagogy, engagement, and cognitive development, while also drawing attention to the institutional and individual factors that mediate adoption.

Empirical Studies

A substantial body of empirical work supports the view that technology, when appropriately integrated, enhances student engagement and 21st-century skill development. Kalyani (2024) found that virtual simulations and multimedia content improved engagement and problem-solving skills, provided teachers received adequate training, while unequal access in rural areas remained a limiting factor. Similarly, Juliana (2022) reported that language-learning apps and multimedia lessons enhanced comprehension and communication skills, though technological access and teacher preparedness again emerged as constraints. Parveen and Ramzan (2024) and Yasin, Amin, and Yasin (2024) both found that Learning Management Systems and virtual labs improved accessibility, flexibility, and academic performance, while identifying infrastructure gaps and digital-literacy deficits as recurring barriers.

Several studies situate these findings in the specific context of developing regions. Shohel and Kirkwood (2012), studying technology integration in Bangladesh, found that limited device access, unreliable connectivity, and inadequate teacher training constrained otherwise positive engagement effects, a pattern echoed by Satish et al. (2022) in their analysis of India's National Education Policy (NEP) 2020, and by Itighise and Wordu (2024) and Duterte (2024) in their respective studies of technology as a catalyst for quality teaching. Kouser and Majid (2021) similarly found that smart boards and educational apps improved engagement and retention but required sustained professional development to be used effectively. In specialised contexts, Alselaiti (2023) demonstrated that virtual simulations and collaborative tools improved knowledge retention and clinical skills among medical students, while Haleem et al. (2022), in a broader sustainability-focused review, highlighted the environmental and pedagogical benefits of cloud-based platforms alongside persistent concerns about digital-literacy gaps and data privacy.

Collectively, this literature converges on two consistent themes: technology, particularly multimedia, adaptive, and collaborative tools, has a demonstrable positive effect on engagement, personalisation, and skill development; and this potential is consistently constrained by unequal access, inadequate teacher training, and infrastructural limitations, especially in under-resourced and rural settings. The present study extends this literature by examining how these dynamics play out concretely among teachers and students in Cuttack, Odisha, across both government and private school settings.

Methodology

Research Design

The study employed a qualitative research design to capture the lived experiences, perceptions, and challenges of educators and students regarding technology integration. This approach was chosen for its capacity to generate an in-depth understanding of how technology influences teaching practices, student engagement, and academic performance across varied educational settings.

Study Area and Population

The study was conducted in Cuttack, Odisha, a city with a diverse educational ecosystem spanning government and private institutions at varying stages of technology adoption. The target population comprised secondary school teachers and students with direct experience of technology-enhanced learning, drawn from both government and private schools to ensure comparability across institutional contexts.

Sampling and Data Collection

A stratified random sampling technique was used, with strata defined by institution type (government versus private) and subject area, to ensure a representative cross-section of educational contexts. The final sample comprised 20 secondary school teachers (8 from government schools and 12 from private schools) and 60 students across Grades 8 to 10. Data were collected using structured questionnaires administered separately to teachers and students, supplemented by semi-structured interviews with a purposively selected subgroup of 10 teachers and 10 students. The questionnaires captured technology usage patterns, perceived benefits and challenges, and suggestions for improvement, while the interviews probed these themes in greater depth.

Data Analysis

Questionnaire responses were compiled and analysed using Microsoft Excel, with quantitative response patterns summarised as frequencies and percentages. Interview transcripts and open-ended responses were subjected to thematic analysis, in which data were coded and grouped into recurring themes relating to perceived benefits, challenges, and recommendations for improving technology-enhanced learning environments.

Ethical Considerations

All participants were informed of the study's purpose and provided written consent prior to data collection. Participation was voluntary, with the right to withdraw at any stage, and confidentiality was maintained by anonymising participant identities and securely storing all data.

Results

The teacher sample (N = 20) comprised 40% government-school and 60% private-school educators, spanning Social Studies, Science, Mathematics, Languages, and other subjects, with 40% having 11 or more years of teaching experience. The student sample (N = 60) comprised 42% from government schools and 58% from private schools, drawn from Grades 8 (28.3%), 9 (38.3%), and 10 (33.3%). Table 1 summarises the demographic composition of both samples.

Table 1. Demographic Profile of Teacher and Student Respondents

Category	Government	Private	Total
Teachers (N = 20)	8 (40%)	12 (60%)	20 (100%)
Students (N = 60)	25 (42%)	35 (58%)	60 (100%)

As shown in Table 2, technology use among teachers was dominated by video-based content: 80% used YouTube videos in instruction, 60% used educational apps, and 50% used Learning Management Systems (LMS) such as Google Classroom or Moodle, while smartboard use remained comparatively low at 30%. Half of the teachers reported using digital presentations regularly as their primary mode of technology integration, while a smaller proportion incorporated simulations, digital labs, or LMS platforms into instruction. Among students, 90% reported access to a smartphone and 80% to an internet connection, but only 40% had access to a computer or laptop, indicating a marked disparity between mobile and more versatile computing access.

Table 2. Technology Access and Use Among Teachers and Students

Indicator	Percentage
Teachers using YouTube videos in instruction	80%
Teachers using educational apps	60%
Teachers using LMS platforms	50%
Teachers using smartboards	30%
Students with smartphone access	90%
Students with internet access	80%
Students with access to educational apps	70%
Students with computer/laptop access	40%

Engagement and Academic Performance

Half of the teachers surveyed believed technology increases participation and keeps students more engaged, while the remaining half felt it made lessons visually appealing without necessarily improving participation; notably, no teacher reported a negative or negligible effect on engagement. On academic performance, half of the teachers observed that students performed better with technology-based reinforcement such as apps, quizzes, and videos, while the other half reported mixed results depending on subject area and student access. Among students, 33.3% reported that videos, animations, and presentations were the most common form of technology use in lessons, and a similar proportion (33.3%) identified video or animation as the tool that most helped them understand a difficult concept, followed by online quizzes or apps (26.7%) and collaborative digital activities (25%).

Barriers and Challenges

Infrastructure and connectivity emerged as the most consistently cited barrier. Half of the teachers identified poor internet connectivity or inadequate infrastructure as their biggest challenge, matched by an equal proportion who cited student distraction and misuse of devices during lessons. Among students, poor or no internet connection was the most frequently reported problem (30%), followed by shared or absent personal devices (26.7%), and, in equal measure, difficulty focusing due to distractions and unfamiliarity with digital tools (21.7% each). Regarding equity, teachers were evenly split between observing that most students had adequate access both at home and school, and observing that many students shared devices or had limited access; a comparable pattern emerged among students, of whom 33.3% noted that some classmates lacked access to technology at home even where in-class access was more equitable.

Support Needs and Recommendations from Participants

When asked what would improve technology use, teachers were evenly divided between prioritising reliable access to devices and internet (50%) and requesting more curriculum-aligned digital resources (50%); similarly, requests for training were split evenly between basic device and platform training and advanced training on integrating technology into lesson planning (50% each). At the policy level, teachers strongly favoured government funding for devices, software, and internet access (80%), mandatory professional development in educational technology (70%), and clearer guidelines for classroom technology use (60%). Students most frequently called for better internet and device access (30%), more interactive learning materials such as games and simulations (28.3%), and clearer guidance on using educational apps (25%).

Interview Insights

Semi-structured interviews with 10 teachers and 10 students reinforced and deepened the survey findings across five recurring themes. First, participants described a clear pedagogical transformation, with teachers noting that tools such as LMS platforms and smartboards enabled more interactive, multimedia-rich instruction, and students reporting that video- and app-based learning made difficult concepts more intuitive. Second, both groups converged on a preference for accessible, user-friendly platforms, teachers favouring Google Classroom and multimedia presentations, and students favouring mobile apps and gamified tools, with science learners particularly valuing video tutorials and virtual labs. Third, participants identified persistent barriers including poor connectivity, limited device access (especially in government schools), software instability, and inadequate professional development, alongside student difficulty navigating platforms without orientation. Fourth, most interviewees perceived technology as enhancing attentiveness and motivation when used judiciously, while cautioning against distraction and screen fatigue. Finally, participants recommended regular teacher training, expanded school-wide internet access and device availability, more interactive and locally relevant content, and stronger technical support as priorities for improving technology integration.

Discussion

The findings of this study align closely with the broader literature reviewed above, while offering context-specific nuance for Cuttack, Odisha. Consistent with Kalyani (2024) and Juliana (2022), multimedia and interactive digital tools were found to meaningfully enhance student engagement, particularly through video and animation content that clarified difficult concepts in subjects such as science and mathematics. Teacher and student interview responses corroborated this pattern: one teacher observed that animations "keep even weak students interested" and prompt them to ask questions, while a student described how a video finally clarified a difficult concept in electricity. This supports the view, consistent with the SAMR and TPACK frameworks, that technology functions most effectively when it augments or redefines instruction rather than merely substituting for existing methods. At the same time, the study's findings on infrastructural and access barriers echo Shohel and Kirkwood (2012) and Satish et al. (2022), both of whom identified device access and connectivity as central obstacles to effective technology integration in resource-constrained settings. The near-even split among Cuttack teachers between those observing adequate student access and those observing shared or limited access suggests a partial, rather than absolute, digital divide, one that nonetheless disproportionately affects government-school students and mirrors patterns documented elsewhere in India (Selwyn, 2011; Livingstone & Stoilova, 2021). This partial divide has important implications: policies aimed at bridging access gaps cannot assume uniform need across all students, but must instead account for variation both between and within institutions.

Student distraction and misuse of devices, cited by half of teachers as a leading challenge, is a theme less prominent in some of the literature reviewed but consistent with concerns raised by Twenge (2019) regarding screen time and student well-being. This suggests that technology integration strategies in Cuttack schools may need to pair access-expansion efforts with structured digital-citizenship and classroom-management guidance, rather than treating access and appropriate use as separate concerns. Similarly, the finding that teachers were evenly split between wanting basic device training and advanced pedagogical-integration training reflects the dual capacity-building need identified by Ertmer and Ottenbreit-Leftwich (2010): technology adoption requires not only technical competence but also pedagogical reasoning about when and how to deploy digital tools meaningfully.

A further point of divergence from some earlier studies concerns content relevance. Teachers in this study specifically noted that many digital tools are available primarily in English, limiting their usability for students who prefer instruction in Odia, particularly in Social Studies and Language subjects. This localisation gap, less emphasised in international literature but consistent with UNESCO's (2019) call for culturally and linguistically adapted open educational resources, represents an important and under-addressed barrier to equitable technology use in linguistically diverse regions such as Odisha.

Implications

These findings carry implications for several stakeholder groups. For educators, the study underscores the need for professional development that extends beyond basic technical orientation to include subject-specific pedagogical integration, supported by in-school mentoring and access to shared digital-resource libraries. For students, the evidence points to the importance of expanding access to versatile computing devices, not merely smartphones, alongside structured digital-literacy instruction that helps students navigate platforms confidently and use them for sustained, rather than merely supplementary, learning. For curriculum developers, the strong preference among both teachers and students for interactive, multimedia content suggests that subject-specific digital pedagogies, such as virtual science labs, gamified mathematics practice, and localised language-learning tools, should be embedded directly into curriculum frameworks rather than treated as optional supplements.

For policymakers, the findings support continued investment in digital infrastructure, particularly in government schools, alongside mandatory and sustained professional development programmes, clear guidelines for classroom technology use, and monitoring systems to track integration outcomes over time. Finally, given the concerns raised around distraction, screen time, and data privacy, policy frameworks should also address digital well-being and cybersecurity as integral components of technology integration strategy, rather than as peripheral concerns.

Recommendations

- Strengthen teacher professional development through regular, subject-specific training that combines technical skills with pedagogical integration strategies.
- Prioritise equitable access to devices and reliable internet connectivity, with particular attention to government schools and economically disadvantaged students.
- Embed technology-driven pedagogies, such as virtual labs, gamified practice tools, and localised multimedia content, directly into curriculum design.
- Establish dedicated technical support systems within schools to minimise disruption from infrastructure or software issues.
- Develop clear, school-level guidelines on responsible technology use to address distraction, screen time, and digital well-being.

- Invest in the development of Odia-language and regionally contextualised digital learning resources to improve content relevance.
- Introduce continuous monitoring and evaluation mechanisms to track the outcomes of technology integration and inform iterative improvement.

Conclusion

This study examined the role of technology in enhancing teaching and learning outcomes among secondary school teachers and students in Cuttack, Odisha, drawing on structured surveys and semi-structured interviews with 20 teachers and 60 students across government and private institutions. The findings confirm that technology, when thoughtfully integrated, meaningfully enhances student engagement, supports differentiated and self-paced learning, and enriches instructional delivery, particularly through multimedia and interactive content. At the same time, the study surfaced persistent barriers, including unequal access to devices and connectivity, limited teacher training, student distraction, and a shortage of linguistically and culturally relevant digital content, that continue to constrain technology's full potential, with government-school students bearing a disproportionate share of these constraints.

Taken together, these findings suggest that technology is best understood not as a replacement for conventional pedagogy but as an enabler that complements and extends it, provided it is supported by adequate infrastructure, sustained teacher development, and equity-conscious policy design. Future research should extend this qualitative, cross-sectional account through longitudinal designs that track the long-term impact of technology integration on academic performance and teacher effectiveness, examine the emerging role of artificial intelligence and adaptive learning platforms in personalising instruction, and investigate technology integration in rural and underserved areas with particular attention to access, inclusivity, and student well-being.

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