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Smart Classroom Technologies and Its Status in Tertiary Education in Bangladesh: A Case of Cumilla District

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Abstract

This study explores the availability, accessibility, and utilization of smart classroom technologies in three National University-affiliated colleges in Cumilla—Comilla Victoria Government College, Comilla Government Women's College, and Chandina Redwan Ahmed College—under the College Education Development Project (CEDP). Using a mixed-methods approach, data were collected from 180 respondents through surveys, interviews, focus group discussions, and classroom observations. Although all institutions received technological resources such as smart boards, projectors, and internet facilities, their integration into teaching practices was limited. Only 30% of teachers used laptops in classrooms, and smart boards were seldom utilized due to inadequate training and technical barriers. While 85% of students reported increased engagement, challenges like poor internet, lack of maintenance, and absence of technical staff hindered full implementation. The study recommends continuous teacher training, institutional commitment, maintenance funding, and partnerships for sustainable integration of smart technologies in tertiary education.

Keywords:Smart classroom, tertiary education, Cumilla, technology integration, teacher training, digital infrastructure, CEDP, sustainability, Bangladesh.

1.1 Introduction

In the 21st century, the use of Information and Communication Technology (ICT) in education has significantly changed teaching-learning dynamics across the globe. A smart classroom is a technology-enhanced space that integrates digital tools such as interactive whiteboards, multimedia projectors, laptops, sound systems, and internet connectivity to improve instruction and promote student engagement (Christian Andres, 2017; Ramesh et al., 2016). These classrooms aim to make learning more enjoyable and interactive while supporting personalized and student-centered approaches (Hwang, 2014). Developed countries have

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successfully integrated smart classroom technologies to enhance learning outcomes, but in developing countries like Bangladesh, such efforts are relatively new and face implementation challenges (Islam & Grönlund, 2016). Recognizing the role of technology in transforming education and aligning with **Sustainable Development Goal (SDG) 4**, the Government of Bangladesh launched the **College Education Development Project (CEDP)** in 2016 with World Bank support (UNESCO, 2016; Rahman, 2010). The project seeks to enhance quality tertiary education in 122 government and non-government colleges affiliated with the National University through digital infrastructure and capacity-building initiatives (CEDP, 2024). However, despite these investments, the practical integration of smart classroom technologies into teaching remains inconsistent. This study investigates the current status, utilization, and challenges of smart classroom technologies in three selected colleges in Cumilla district to assess their effectiveness and sustainability in tertiary education.

1.2 Statement of the Problem

Although smart classroom technologies offer transformative potential, their effective use in tertiary education in Bangladesh remains limited. While colleges have received digital resources and training under CEDP, the integration of these tools into regular teaching practices is often hindered by infrastructure limitations, lack of continuous training, poor internet connectivity, and absence of technical support (Mukesh, 2021; Nenad et al., 2012). Moreover, teachers often lack practical guidance on how to incorporate smart tools like interactive boards and digital content effectively into pedagogy (Bano & Ganaie, 2016). Furthermore, most existing literature in Bangladesh has emphasized general ICT integration or focused on primary and secondary education (Islam & Grönlund, 2016). There is a noticeable gap in research specifically addressing how smart classroom technologies function at the tertiary level—how they are used, what challenges are faced, and how they impact teaching and learning outcomes. Given the government's long-term vision for quality education and employability through strategic plans like the Strategic Plan for Higher Education 2017–2031, understanding the ground realities of smart classroom implementation is essential (Government of Bangladesh, 2017). This study thus addresses an urgent need to evaluate current practices, perceptions, and institutional readiness to ensure technology-driven learning is effective and sustainable in Bangladesh's higher education sector.

1.3 Rationale of the Study

The integration of smart classroom technologies is reshaping education globally by promoting interactive, personalized, and student-centered learning. In Bangladesh, particularly in tertiary education, such technologies are essential for modernizing the teaching-learning environment and achieving Sustainable Development Goal 4 (SDG-4). Smart classrooms not only enhance student engagement and accommodate diverse learning needs but also support the country's broader goals for inclusive and quality education. As Bangladesh continues to invest in digital infrastructure under initiatives like the College Education Development Project (CEDP), understanding how these technologies are adopted and utilized at the college level becomes increasingly important. Despite these developments, empirical studies focusing

on smart classroom implementation in tertiary institutions remain scarce. Most research has centered on ICT integration at primary and secondary levels, overlooking the distinct needs and technological capacities of colleges under the National University. This study aims to fill that gap by exploring the current status, challenges, and potential of smart classroom technologies in selected colleges in Cumilla. It seeks to provide evidence-based insights from both teachers and students to inform educational policy, strengthen institutional strategies, and guide the sustainable integration of technology in tertiary education.

1.4 Research Question and Objectives

1.4.1 Research Questions

1. What is the current status of smart classroom technologies in terms of available facilities, accessibility, and utilization by teachers and students in selected tertiary colleges of Bangladesh?
2. What are the benefits and challenges of implementing and using smart classroom technologies in enhancing educational experiences and outcomes in selected tertiary colleges of Bangladesh?

1.4.2 Objectives of the Study

The general objective of the study is to assess the current implication status of smart classroom technologies along with the challenges in the selected tertiary colleges of Bangladesh.

The specific objectives of the study are:

i. To identify the existing technological facilities of smart classrooms in the selected tertiary colleges;

ii. To assess the current accessibility and utilization of smart classroom technologies by both teachers and students in tertiary colleges; and

iii. To explore the challenges associated with the implementation and use of smart classroom technologies in tertiary colleges.

1.5 Scope of the Study

In recent years, the integration of smart classroom technologies has emerged as a promising strategy for enhancing teaching and learning experiences across educational institutions worldwide. In the context of Bangladesh, this study focuses on examining the current state and effectiveness of smart classroom technologies in selected tertiary-level colleges. The scope includes evaluating the availability, accessibility, and utilization of smart classroom infrastructure, as well as identifying the challenges faced in its implementation and use by both teachers and students.

The following scope matrix outlines the key objectives of the study, along with the associated indicators, variables, and methods of data collection:

Table-1: Scope Matrix of the Study

Objectives	Indicators	Variables	Methods of Data Collection
i.To identify the existing technological facilities of smart classrooms in the selected tertiary colleges;	-Infrastructure Availability, - Accessibility -Technical Support and Maintenance	-variety of smart technologies - Interactive Whiteboards, Projectors and Displays, internet connections, Multimedia Equipment, Computing Devices, power backup systems, maintenance services, devices and resources -availability of technical support service	Questionnaire and checklist, KII, Interview and FGD, document analysis
ii.To assess the current accessibility and utilization of smart classroom technologies by both teachers and students in tertiary colleges;	Frequency of Use Technology Utilization User Competency Perceived Effectiveness	- Number of classes per week utilizing smart technologies, Level of training received by teachers, technology access across different departments, course content delivered using smart classroom technologies, Number of assignments or assessments conducted using digital tools, Satisfaction levels with the technology	Questionnaire and checklist, KII, Interview and FGD, document analysis
iii.To explore the challenges associated with the implementation and use of smart classroom technologies in tertiary colleges.	Infrastructure and Resource Limitations Training and Skill Gaps Resistance to Change Funding Constraints	-Availability and quality of necessary devices and equipment -Confidence levels in using technology effectively. - attitudes of teachers and students - budget allocation for technology acquisition and maintenance.	Questionnaire and checklist, KII, FGD, Situation analysis.

2. Literature Review

This chapter explores the evolving landscape of higher education in the digital era, focusing on the integration of smart classroom technologies. It provides an overview of global trends, national initiatives, and theoretical foundations that drive the adoption of Information and Communication Technology (ICT) tools in tertiary education. Drawing on both international and local literature, the chapter highlights the significance of ICT-enhanced learning environments for improving pedagogy and educational outcomes. It also discusses specific initiatives in Bangladesh, such as the College Education Development Project (CEDP), aimed at upgrading teaching and learning in National University-affiliated colleges. These insights provide a conceptual framework for analyzing the current status and impact of smart classroom technologies in tertiary institutions in the Cumilla district.

2.1 The Role of Higher Education and ICT in Development

Higher education plays a pivotal role in a nation's social and economic development, contributing to global competitiveness in the 21st century (Sultana, 2018). Modernization of teaching and learning systems is imperative, and smart classrooms incorporating ICT are critical to this transformation. Research has shown that effective use of ICT devices promotes student-centered active learning, encourages collaborative group work, enhances social skills, cognitive development, creativity, and problem-solving abilities (Ellis et al., 2008; Dodge, Colker, & Heroman, 2003; Khan, Hasan, & Clement, 2012).

2.2 National Initiatives for ICT-Enhanced Learning in Bangladesh

Bangladesh has initiated several projects to integrate ICT in education, including the Secondary and Higher Secondary ICT-based Education project, which established 20,000 multimedia classrooms (MMCs) across schools, madrassas, and colleges with internet access, laptops, and multimedia devices (Sultana, 2018). Teachers share digital content via the centralized Teacher's Portal (https://www.teachers.gov.bd/), supporting e-learning and professional development. Globally and locally, educational research emphasizes the shift toward knowledge societies and 21st-century skills, necessitating creative pedagogical practices beyond traditional methods (Ottestad, 2010).

2.3 Global Demand and Policy Emphasis on ICT in Higher Education

The worldwide demand for higher education continues to grow, compelling governments and universities to enhance access and quality. Many countries prioritize ICT integration in universities as a means to improve learning outcomes and prepare students for the information economy (Rahman, 2010; UNESCO, 2016). Developed nations have transformed their university teaching and administrative systems through ICT, and Bangladesh has followed suit by introducing smart classroom technologies in higher education to elevate quality and competitiveness (Islam & Grönlund, 2016).

2.4 Technological Impact on Pedagogy and Learning Outcomes

Teaching methodologies have evolved alongside technological advances, although not all technology positively impacts learning. Careful assessment is necessary to determine each technology's effect on pedagogy. For example, digital presentations have been shown to improve classroom teaching effectiveness (Glover et al., 2005). Studies highlight the importance of aligning technology use with sound pedagogical strategies to enhance learning outcomes.

2.5 Empirical Studies on Smart Tools in Education

Surveys and empirical research have documented varying acceptance and usage levels of digital whiteboards and Classroom Response Systems (CRSs). Higgins et al. (2007) found initial acceptance of digital whiteboards, while Martin et al. (2014) reported that teachers use them about half of the time. Fies and Marshall (2006) examined the limitations of CRSs, and Kay and LeSage (2009) analyzed Audience Response Systems, noting their role in increasing student interaction via mobile devices.

2.6 Rise of Mobile Learning and Digital Platforms

Mobile learning ("M-learning") is expanding rapidly with the proliferation of tablets, smartphones, and portable computers (Georgiev et al., 2004). Studies indicate that multimedia technology usage in business schools enhances both student and instructor performance (Parker & Burnie, 2009). Interactive smart classroom technologies positively affect student performance and engagement (Zhou, 2016; Pishva et al., 2008).

2.7 Emerging Teaching Models in Smart Classrooms

Smart classrooms have catalyzed new pedagogical models such as flipped classrooms, blended learning, and e-learning, allowing students to access materials at their own pace (Zhang et al., 2017). According to Kwet and Prinsloo (2020), smart classrooms also leverage IoT and sensor data to monitor student participation and engagement, offering novel insights into classroom behavior.

2.8 Smart Classrooms as Interactive Learning Spaces

Smart classrooms have transformed teacher-student interactions, making learning more interactive and collaborative. ICT applications facilitate dynamic teaching, moving beyond the traditional lecture format. Technology-enabled language learning is one area that has shown considerable success compared to conventional methods (Abowd, 1999; Katz et al., 2021).

2.9 Tools and Platforms for Smart Learning

Digital platforms such as Zoom, MS Teams, Google Meet, and Webex support large-scale online education and collaboration (Katz et al., 2021; Zou et al., 2020). These tools enable content sharing via cloud storage and enhance teamwork among students and educators (Chou et al., 2015).

2.10 Innovations in Classroom Interaction and Technology

Innovations like multimodal interaction systems integrating touch, gesture, and motion sensors improve human-computer interaction in classrooms (León et al., 2016; Tawafak et al., 2019). Smartphones and handheld devices have also been incorporated to monitor presentations and improve classroom experiences (Al-Hunaiyyan et al., 2017; Weidong et al., 2011).

2.11 Implementation and Utilization in Bangladesh's Higher Education

Smart classroom technologies encompass both hardware and software to support instruction through smart content, engagement, assessment, and physical environment enhancements. In Bangladesh, despite initiatives like CEDP introducing smart classrooms in National University-affiliated colleges, challenges remain in effective technology integration, teacher training, and infrastructure maintenance, limiting their full potential (CEDP, 2017; Siddiqui & Ahmed, 2018).

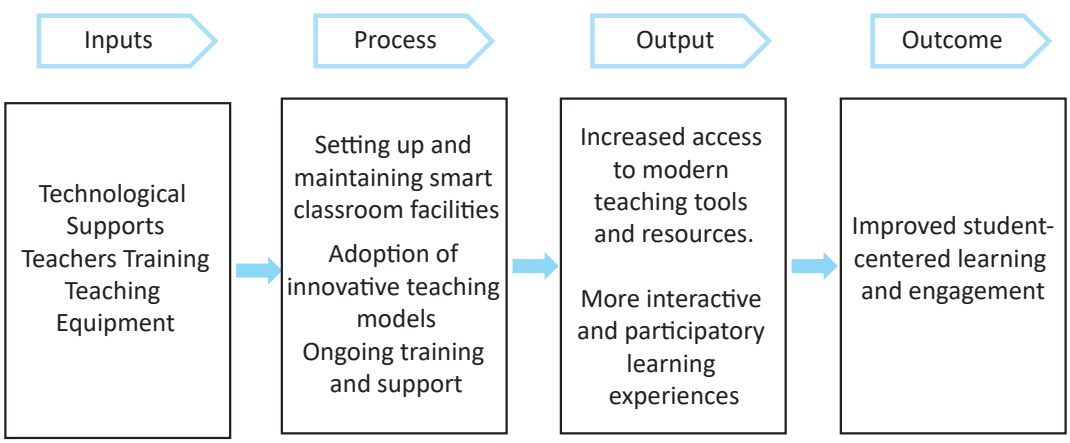
2.12 Purpose of the Study

This study investigates the current implementation, utilization, and perceived effectiveness of smart classroom technologies in tertiary institutions in Cumilla district, Bangladesh. It aims to fill research gaps by exploring how these technologies shape teaching and learning environments, identifying challenges, and suggesting pathways for sustainable advancement in higher education.

2.13 Conceptual Framework Incorporating Theory of Change

In Bangladesh, higher education comprises three main sub-sectors, including government and non-government colleges affiliated with the National University (NU), which enroll about two-thirds of the country's three million higher education students. These colleges produce the majority of graduates but face challenges such as weak governance, poor teaching quality, limited resources, and restricted access. To address these issues, the Government of Bangladesh, with World Bank support, launched the College Education Development Project (CEDP) in 2016. The project aims to strengthen strategic planning and improve teaching-learning environments in 122 participating NU-affiliated colleges by providing technological resources (e.g., laptops, smart boards, projectors) and capacity-building for teachers and staff. Building on this, the study's conceptual framework examines how the adoption of smart classroom technologies influences pedagogical innovation, educational effectiveness, and institutional dynamics, guiding the research on their impact within Bangladesh's tertiary education system.

Figure-01: Conceptual Framework Incorporating Theory of Change



3. Methodology of the Study

3.1 Methodology of the Study

This study adopted a mixed-methods approach, combining both quantitative and qualitative techniques to assess the status, usage, and challenges of smart classroom technologies in tertiary

education within Cumilla district. Data were collected through structured questionnaires, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and classroom observations.

3.2 Study Area and Sample

The study employed a purposive and convenience sampling approach to ensure balanced representation from key stakeholders involved in the use of smart classroom technologies. Data were collected from three CEDP-intervened tertiary colleges in Cumilla district, focusing on the Science, Humanities, and Business Studies disciplines. A total of 45 teachers and 135 students were selected, ensuring discipline-wise representation and diversity of perspectives. Participants were chosen based on their availability and willingness, ensuring a voluntary process. In addition, key personnel involved in CEDP implementation at the institutional level were included to provide contextual insights. Classroom observations were also conducted to complement the survey findings and assess the real-time use of smart classroom facilities. This multi-layered sampling strategy ensured depth and relevance in addressing the study objectives.

Table-2: Sampling at a Glance

No.	District	Name of the Selected Colleges	Academic Discipline Including Subjects	Number of Respondents	Total Number of Respondents
1	Cumilla	Comilla Victoria Government College	Science, Humanities, Business Studies	5x3 (Teacher)=15 15x3 (Student)=45	Teachers= 45 Students=135
2		Comilla Government Women College	Science, Humanities, Business Studies	5x3 (Teacher)=15 15x3 (Student)=45	
3		Chandina Redwan Ahmed College	Science, Humanities, Business Studies	5x3 (Teacher)=15 15x3 (Student)=45	

3.3 Data Sources and Tools

This study utilized both primary and secondary data sources to gain a comprehensive understanding of smart classroom technology adoption in tertiary colleges. Primary data were collected through structured questionnaires, focus group discussions (FGDs), key informant interviews (KIIs), and participatory field observations, with researchers personally visiting the institutions to gather in-depth insights from teachers, students, and classroom practices. Emphasis was placed on participatory approaches to capture real-time teaching-learning dynamics. Secondary data were sourced from relevant books, research articles, institutional reports, and project documents, which provided contextual background and supported the analysis of CEDP interventions.

3.4 Analytical tools

To analyze quantitative data from survey, analysis were based on descriptive statistics i.e. mean/average, ranks, percentage, graphs were done. To organize qualitative data emanated

from FGD, Case Study and KII, data were analyzed using thematic arrangements and thus research's subjective judgments were used.

4. Result and Discussion

4.1 Existing Technological Facilities of Smart Classrooms in Selected Tertiary Colleges

Integrating smart classroom technologies in tertiary colleges has modernized teaching by making learning more interactive and accessible. This section outlines the available digital tools, their usage, and their impact on academic activities.

4.1.1 Availability of Smart Classroom Technologies in Different Departments

Smart classroom technologies' availability across different departments is crucial in enhancing the overall learning experience. All the selected colleges had dedicated classrooms equipped with smart technologies provided under the CEDP project featuring a multimedia projector or interactive flat panel, maintaining a teacher-student ratio of 1:40. Additionally, UPS, sound systems, and internet connectivity were available in these smart classrooms. The table below shows the availability of smart classroom technologies in departments of the selected colleges.

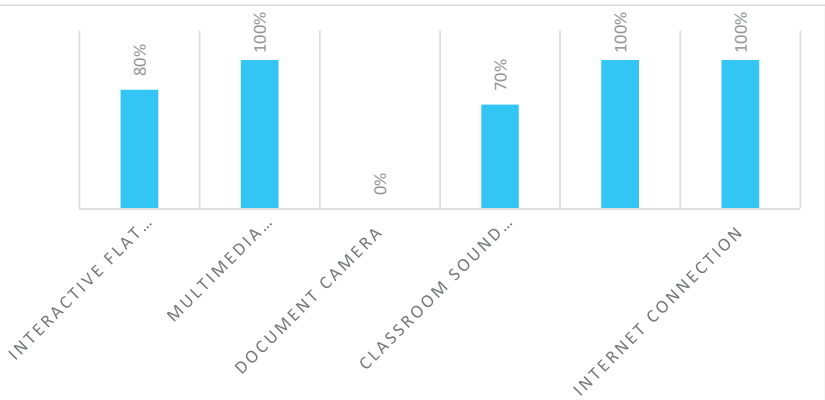


Figure 1. Availability of Smart Classroom Technologies

Source: Field Survey 2024

The integration of smart classroom technologies in tertiary colleges of Cumilla has brought noticeable improvements in teaching methods, making them more interactive and accessible. All selected colleges had desktop computers (65–130 units), laptops (10–25), and interactive flat panels (4–10), primarily used by faculty for administrative and instructional purposes, while "some of the teachers claimed that they used their personal computer in the office and for taking sessions in the smart classroom." Despite internet availability and sound systems in 70% of classrooms, students reported having "no computers available in the classroom for their use, nor did they have access to classroom laptops." Smart classrooms provided under the CEDP project were well-equipped but remained teacher-centric. Some proactive steps were

noted—one teacher shared, "After completing the freelancing course, three female students have successfully started their small-scale businesses and are now earning independently." Similarly, a principal remarked, "To ensure the proper utilization of the computer lab, we have made ICT classes mandatory for all honors students per week." These initiatives reflect efforts to enhance digital literacy, yet overall integration into regular pedagogy remains limited. As Madhur et al. (2024) also observed, smart technologies are often "used as standalone tools rather than integrating them across subjects," highlighting the need for systemic support and ongoing professional development.

4.1.2 Integration of Smart Classroom Materials in the Class Lessons

The use of interactive displays, digital whiteboards, and multimedia content transforms traditional lecture methods into interactive sessions that capture students' attention and invite participation. Lall et al. (2020) explored the possibilities of smart classes as an innovation in the field of education that transforms teaching and learning methods in modern times. On the other hand, they also discussed on 'smart classes' many benefits which include: more learner responses, improved memory and easier access to all learning materials. The integration of smart classroom materials such as digital whiteboards, multimedia projectors, and laptops has the potential to transform traditional lectures into interactive, student-centered learning experiences.

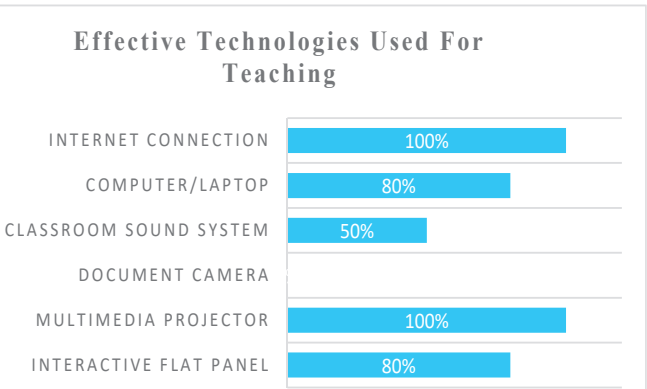


Figure 2. Most Effective Technologies Used for Teaching
Source: Field Survey 2024

While 70% of teachers reported having laptops in classrooms, direct observation revealed actual usage in only 30% of lessons, with many classes still relying on traditional whiteboards due to "the prevalence of theatrical topics" and teacher shortages. Although all colleges were equipped with electricity, internet, UPS systems, and smart classrooms with a 40-seat capacity, disruptions from slow internet and lack of technical support were common. One teacher noted that "introducing smart classroom interventions had rendered one departmental classroom unusable," underscoring infrastructure limitations amid growing student numbers. Moreover, overcrowded honors departments and limited staff made it difficult to fully utilize smart classrooms for all cohorts. These findings align with Lall et al. (2020), who highlighted the benefits of smart classes—such as increased learner responses and easier access to learning materials—while also echoing Boakye and Banini's (2008) reminder that "the role of the teacher... should not be overlooked or underestimated" in successful ICT integration.

In the studied government colleges, teachers commonly used computers for document,preparationand browsing the internet, with a significant number showing readiness to incorporate ICT into their teaching practices. Although 60% of teachers reported using multimedia presentations, only 30% of classrooms demonstrated this practice, highlighting a disparity caused by infrastructural and skill constraints. Student disengagement posed additional challenges to effective ICT usage, with one teacher stating, “When I conduct a session using PowerPoint, my questions often remain unansweredsome students even face difficulty in reading English fluently.” Another teacher observed, “Inconsistent student attendance makes it hard to teach effectively with smart technologies.”

4.2 Current Accessibility, Utilization and Culture of Smart Classroom after Introducing Technologies

Smart classroom technologies enhance teaching and learning in tertiary education, but their effective use depends on accessibility, infrastructure, and user competence. Despite offering interactive opportunities, challenges like inadequate training, limited resources, and digital literacy gaps hinder their full implementation. Assessing their current use is vital to understanding their impact and improving educational outcomes.

4.2.1 Utilizing Smart Technologies in Daily Classes

Utilizing smart technologies in daily classes transforms traditional teaching methods into interactive, student-centered learning experiences. Integrating smart technologies into daily classes has revolutionized traditional teaching methods, creating interactive, student-centered learning environments. The research revealed that PowerPoint was used in 100% of lectures, information sharing occurred in 80% of sessions, educational videos were displayed in 50%, digital whiteboards were employed in 70%, and photos were showcased in 30% of classes. But during class lesson observation the researchers found that only 40% of the observed sessions made use of the interactive smart board, suggesting limited engagement with one of the core components of smart classroom infrastructure. PowerPoint presentations were employed in 50% of the sessions, often serving as the dominant mode of content delivery, which reflects a more traditional approach to digital instruction. Educational videos—intended to enhance conceptual clarity and student interest—were used in just 25% of the classes. This suggests that while the technological infrastructure exists, its full pedagogical potential remains underutilized in a significant number of classroom interactions.

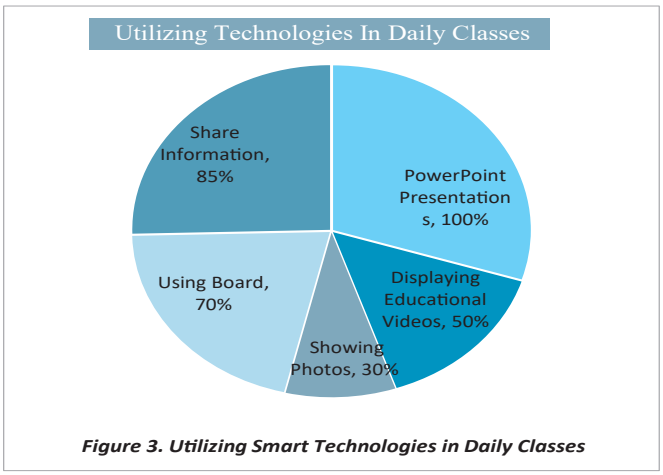


Figure 3. Utilizing Smart Technologies in Daily Classes

4.2.2 Frequency and Percentage of Using Smart Classroom Technologies in a Week

This section examines the weekly frequency and percentage of smart classroom technology usage, providing a detailed snapshot of how digital tools are integrated into routine teaching practices.

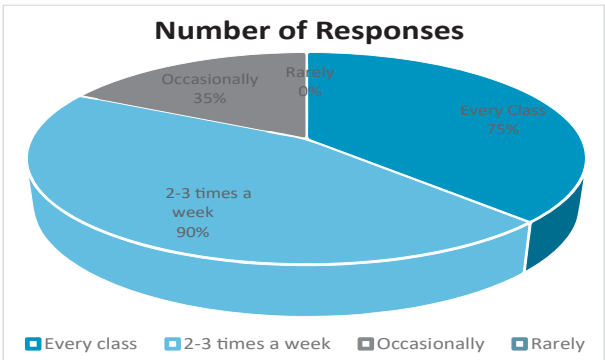


Figure 1. Frequency Of Using Smart Classroom Technologies
Source: Field Survey 2024

This section highlights the frequency of smart classroom technology use, showing that 90% of teachers use digital tools two to three times per week, and 75% report using them in every class, though 35% admit to occasional use. No teacher reported using them rarely. While there is strong enthusiasm for integrating technologies like multimedia presentations and interactive tools, practical challenges—such as connectivity issues and limited setup time—affect consistent use. One teacher explained, "I try to incorporate digital presentations in nearly every lesson... but connectivity issues sometimes force me to revert to traditional methods," while another remarked, "Two or three times a week seems more realistic... we also aim to encourage student attendance by incorporating technology into our lessons." These insights reflect both the motivation and constraints in daily classroom practices.

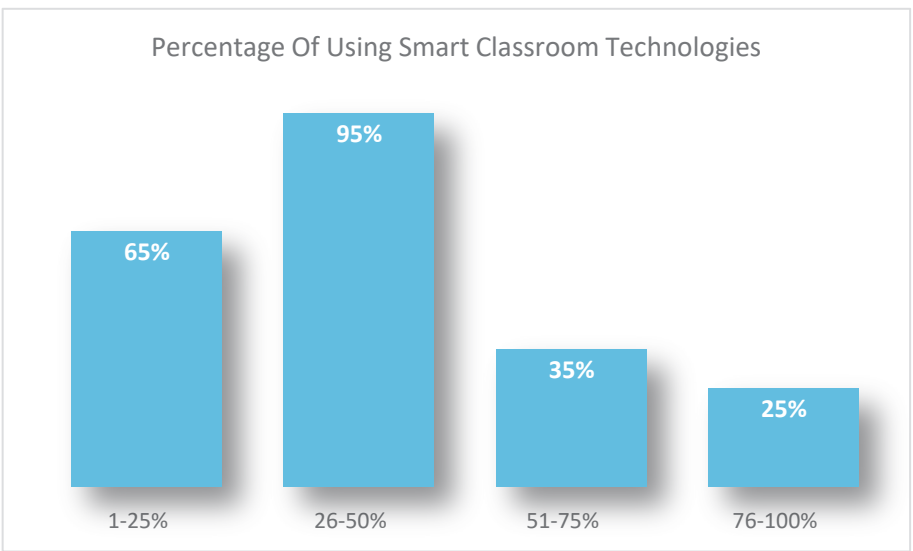


Figure 7. Percentage Of Using Smart Classroom Technologies
Source: Field Survey 2024

The bar chart reveals that most teachers use smart classroom technologies in only 26–50% of their lessons, with 65% using them in up to 25% of classes, and just 25% applying them consistently across 76–100% of sessions. While teachers value the role of digital tools

in engaging students, practical challenges like time constraints and lesson planning limit their use. As one teacher shared, "I try to integrate digital presentations in about half my lessons… not so frequent that it feels forced," while another noted, "Time constraints and scheduling make it hard to use technology in every class." This reflects a balanced approach between smart tools and traditional teaching methods.

4.3 Level of Student Participation in Smart Classroom-Based Learning

To evaluate student participation levels in smart classroom settings across the three selected colleges, both quantitative and qualitative data were analyzed. The assessment focused on attendance, interaction frequency, technological engagement, and perceived learning effectiveness.

4.3.1 Percentage of Students Who Actively Participate In Smart Classroom Sessions

To assess the effectiveness of smart classroom implementation, it is essential to understand the extent of student engagement during these sessions. Active participation serves as a key indicator of how well students are adapting to and benefiting from digital learning environments. This section presents a comparative analysis of the percentage of students who actively engage in smart classroom activities across the three selected colleges. The data reflects student involvement through various means such as responding to interactive content, participating in discussions, and utilizing digital tools during lessons.

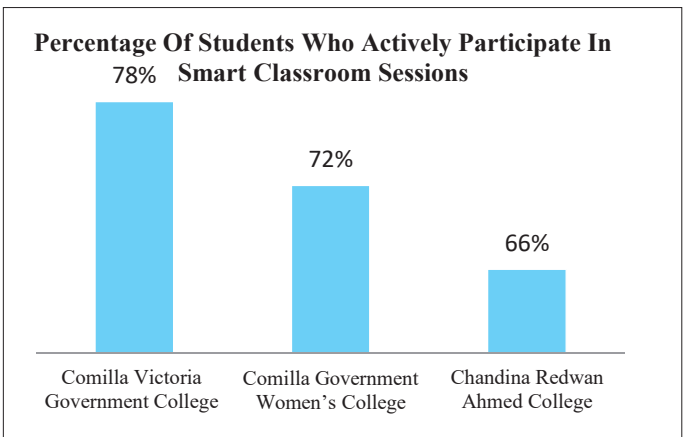


Figure 8 Percentage Of Students Who Actively Participate In Smart Classroom

Source: Field Survey 2024

The comparative data highlights notable variation in student engagement levels across the three selected colleges. Student engagement levels vary notably across the three colleges, with Comilla Victoria Government College showing the highest at 78%, followed by Comilla Government Women's College (72%) and Chandina Redwan Ahmed College (66%). A student from Comilla Victoria remarked, *"The use of multimedia presentations and interactive content helps us to understand lessons better, and we feel more interested to participate."* At the Women's College, one student shared, *"We enjoy the classes when teachers use smart boards*

and videos, but sometimes technical problems interrupt the flow." In contrast, a student from Chandina Redwan Ahmed College commented, "Smart classes make learning more engaging, and we would benefit even more if they were held more regularly." These quotes underscore that while smart classroom technologies enhance learning and participation, their effectiveness depends on consistent use, reliable infrastructure, and teacher training.

4.3.2 Forms of Participation

Understanding the various ways students engage in smart classroom environments is essential to evaluating the overall effectiveness of technology-integrated learning. "Forms of Participation" refers not only to verbal responses or attendance but also includes a range of interactive behaviors such as responding to questions, engaging with multimedia content, collaborating in group activities, using digital tools, and contributing to discussions through smart devices. These diverse forms of involvement reflect the evolving dynamics of classroom interaction in a digital context. Identifying and analyzing these participation modes offers valuable insight into how students adapt to and benefit from smart classroom settings.

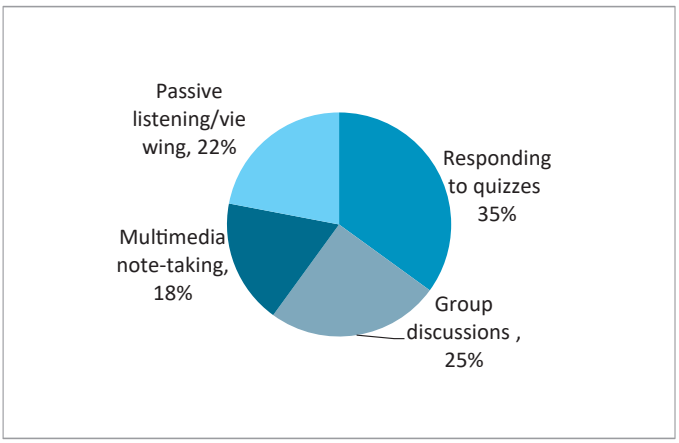


Figure 9 **Forms of Participation of the Students**
Source: Field Survey 2024

The pie chart shows that quizzes are the most frequent form of student participation in smart classrooms (35%), followed by group discussions using digital boards (25%), while passive listening during videos accounts for 22%. Multimedia note-taking is less common (18%). Classroom observations reveal that despite the availability of smart tools, interactive use remains limited in about 60% of sessions, indicating significant room to better harness digital technologies for active, student-centered learning.

4.3.3 Most Helpful Smart Technologies for Students' Learning

Students' feedback and classroom observations revealed that certain smart technologies play a significant role in enhancing the learning process. While all digital tools have potential, students identified specific technologies that directly contributed to their understanding, engagement, and overall classroom experience. The following section highlights the smart tools students found most beneficial.

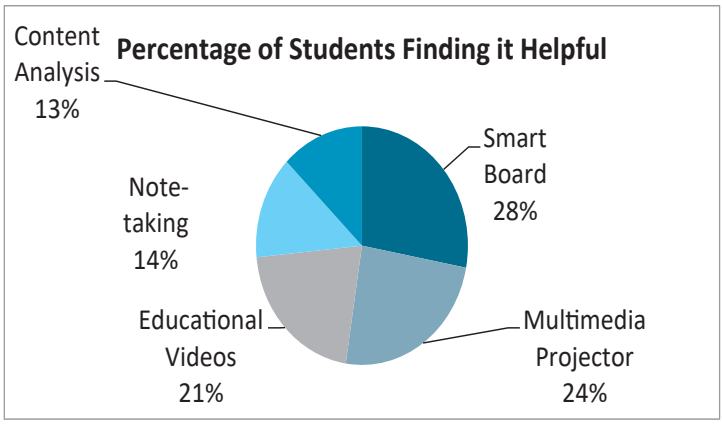


Figure 10 **Most Helpful Smart Technologies for Learning**
Source: Field Survey 2024

The pie chart reveals that 40% of students consider smart boards the most helpful technology for making lessons interactive and memorable, with one student noting, "Smart boards help make lessons more dynamic… I remember them better." Multimedia projectors (35%) and educational videos (30%) are also highly valued for delivering clear visuals and relatable content. Although 20% find digital note-taking useful, accessibility limits its use, and 18% appreciate internet-based content despite technical challenges. These findings highlight the key role of interactive and visual technologies in enhancing student engagement and understanding in smart classrooms.

4.3.4 ICT Related Teacher Training

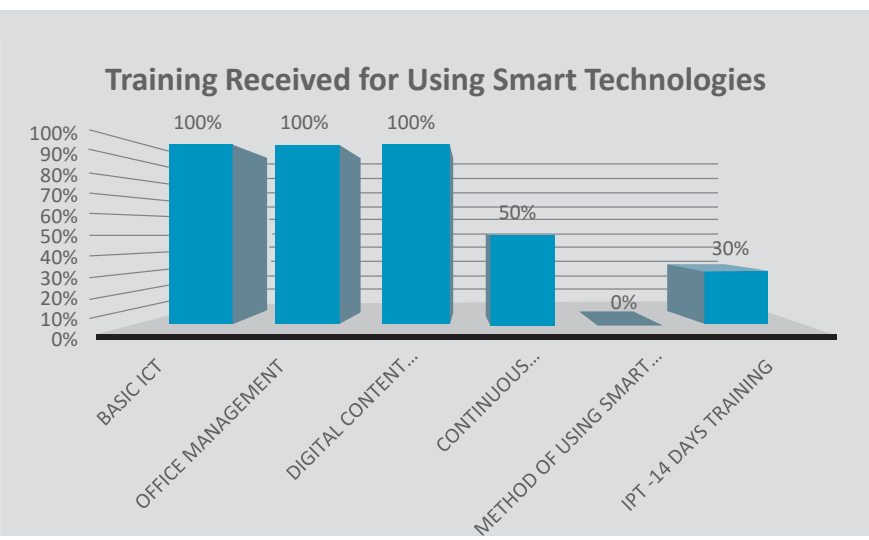


Figure 8. ICT Related Teacher Training

Source: Field Survey 2024

The bar chart shows that while all teachers have received training in Basic ICT, Office Management, and Digital Content Development, only 50% participated in Continuous Professional Development, and none received training on using smart boards—highlighting a critical gap. One teacher noted, "Without specific guidance on using smart boards, integrating these tools into daily teaching remains challenging," while another added that despite training, many struggle with real-time application due to limited hands-on experience. Only 30% attended IPT-14 Days Training, reflecting a need for more structured, ongoing support. Teachers also reported that ICT training was government-organized only for teachers, not staff, leaving many to seek training individually without institutional support.

4.4 Occurring Changes in Classroom Teaching Learning Due To The Use Of Smart Technologies

The introduction of smart classroom technologies in Cumilla's tertiary colleges has transformed teaching from traditional lectures to interactive, participatory sessions, with 100% of respondents noting increased engagement. One teacher explained, "Our classes are no longer one-way lectures. Students actively participate using digital tools, making learning more effective." Additionally, 75% recognized the value of multimedia like videos and slides, with a student saying, "Smart screens and digital content make learning more interesting and help me understand complex topics." Moreover, 60% of students valued the ability to revisit digital materials, as one shared, "I can review notes and recorded sessions later, which helps me prepare better for exams." These findings underscore the positive impact of smart technologies on educational experiences.

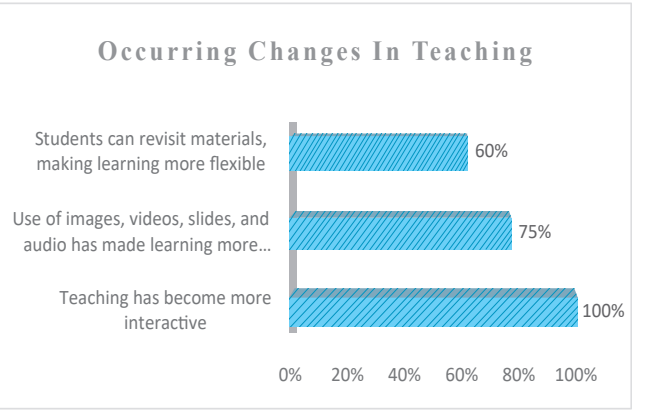


Figure 9. Occurring Changes in Teaching
Source: Field Survey 2024

4.5 Learning Outcomes Due To The Use Of Smart Technologies

Figure 10.Learning Outcomes by Using Smart Classroom Technologies
Source: Field Survey 2024

The integration of smart classroom technologies in Cumilla's tertiary colleges has notably enhanced learning outcomes, with 75% of students reporting better understanding of topics. One student shared, "With interactive lessons and visual explanations, I grasp concepts much faster." Additionally, 59% observed improved problem-solving skills, supported by a teacher's comment that students now "engage in discussions and practical problem-solving activities more effectively." Although only 20% linked these technologies to improved exam results, 35% noted increased interest and participation, with a student stating, "Learning feels more engaging with digital tools, making me more motivated." These findings indicate that smart technologies foster deeper comprehension, critical thinking, and engagement—key factors for long-term academic success.

5. Implementation Challenges and Way Forward

The integration of smart classroom technologies in tertiary colleges offers enhanced interactive learning and improved student engagement. However, challenges such as limited maintenance funding, infrastructure constraints, digital accessibility issues, and low student participation hinder their full potential. This chapter examines these key obstacles, emphasizing the urgent need for solutions to ensure the sustainable and effective use of smart technologies in higher education.

5.1 Technical Issues or Limitations Faced By The Teachers While Using Smart Technologies

The successful use of smart technologies in classrooms relies not only on tool availability but also on teachers' effective usage. However, many educators in the selected colleges face challenges such as inadequate training, poor internet connectivity, frequent equipment failures,

and lack of technical support. These issues disrupt lessons and diminish teachers' confidence and motivation to adopt digital methods. This section examines these technical difficulties and their impact on the quality of smart classroom instruction.

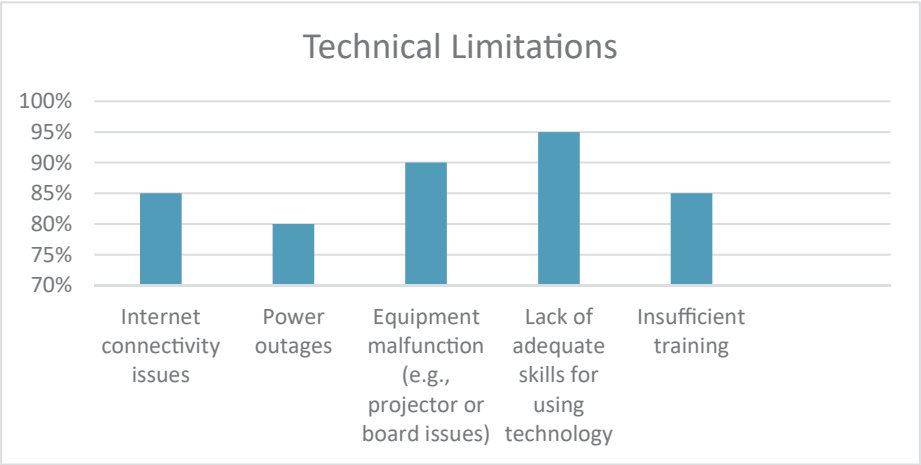


Figure 11. Technical Limitations Of Using Smart Classroom Technologies
Source: Field Survey 2024

The implementation of smart classroom technologies in Cumilla's tertiary colleges faces significant technical challenges, with 95% of teachers reporting insufficient skills to operate digital tools effectively. One teacher expressed frustration: "While the technology is useful, many of us struggle with operating smart boards and digital tools, making lessons difficult to deliver smoothly." Equipment malfunctions (90%), such as projector failures, and connectivity issues (85%) further disrupt classes, as another faculty member noted, "Sometimes the projector stops working mid-lecture… we have to revert to traditional methods." Power outages (80%) and inadequate training (85%) also hinder technology use, with one teacher stating, "We received the technology, but there was little hands-on training." These findings highlight the urgent need for enhanced training, infrastructure upgrades, and technical support to maximize the benefits of smart classrooms.

5.1.2 Issues Related to Internet Speed or Connectivity

Reliable internet speed and connectivity are crucial for effective digital education, yet many users—especially in rural areas—face persistent challenges with slow and unstable internet. These issues disrupt the use of smart classroom technologies, limit access to online resources, and hinder real-time interaction, thereby affecting teaching quality and learning outcomes. This section explores these connectivity obstacles and considers potential solutions to improve digital learning environments.

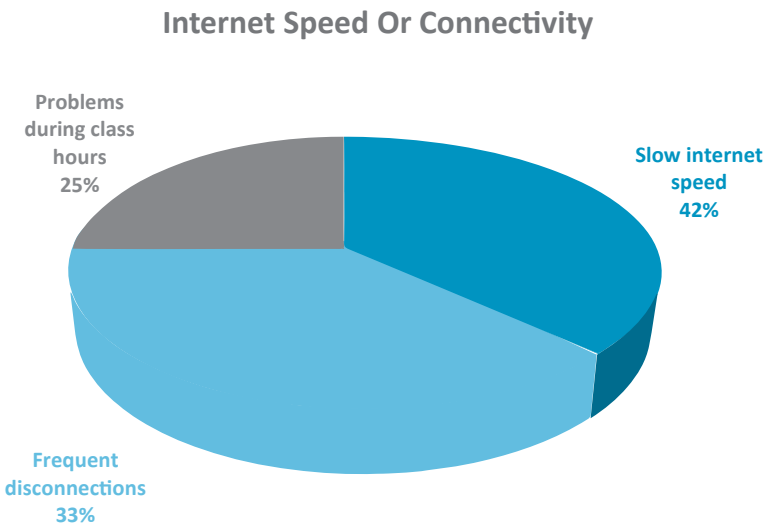


Figure 12. Internet Speed and Connectivity in Smart Classroom
Source: Field Survey 2024

The pie chart illustrates the key internet connectivity issues faced during class hours in the study colleges. The most commonly reported problem was slow internet speed (42%), followed by frequent disconnections (33%), and general problems during class hours (25%). These findings underscore that while internet infrastructure is in place, consistent performance remains a challenge. As one teacher noted, "The internet often slows down or disconnects right when we're using multimedia, which disrupts the flow of the lesson."

5.1.3 Opinion about the availability of technical support and maintenance facilities at your institution

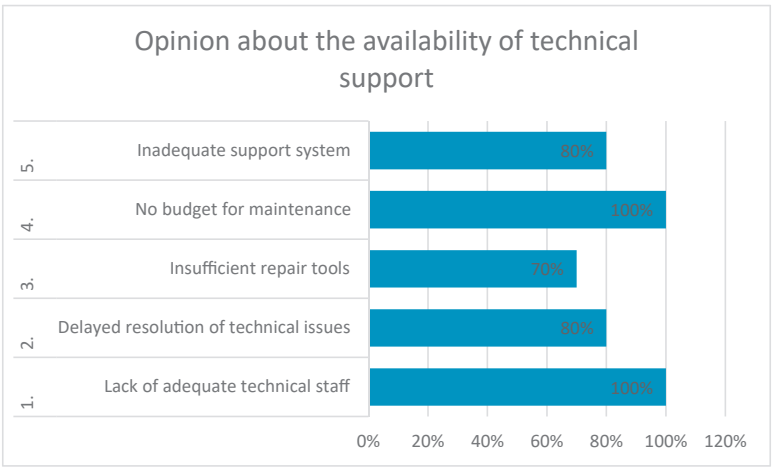


Figure 13. Availability of technical support in Smart Classroom
Source: Field Survey 2024

The effectiveness of smart classroom technologies in Cumilla's tertiary colleges is severely hampered by maintenance and support deficiencies. With 100% of institutions lacking adequate technical staff and maintenance budgets, teachers often face prolonged delays in fixing equipment issues. One teacher noted, "We have the equipment, but when something goes wrong, there's no one available to fix it immediately." Additionally, 80% reported slow issue resolution and inadequate support systems, while 70% highlighted the lack of repair tools. As one faculty member explained, "Classes get disrupted, and there's no efficient system to get repairs done quickly." These challenges emphasize the urgent need for dedicated funding, skilled technical staff, and responsive support to ensure sustainable smart classroom operations.

5.2 Limitations Noticed In Student Participation

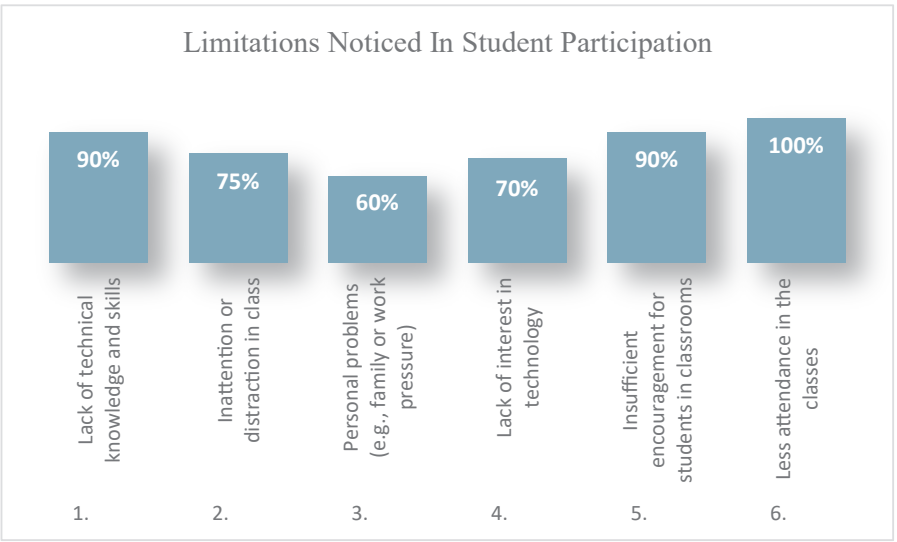


Figure 14.Limitations Noticed in the student participations
Source: Field Survey 2024

Students in Cumilla's tertiary colleges face several challenges that limit the effectiveness of smart classroom technologies. Low attendance (100%) remains a major issue, with one teacher noting, "Even with smart boards and interactive tools, many students prefer to skip classes." Limited technical skills (90%) also hinder usage, as a student admitted, "Sometimes, I struggle to use the digital tools, and there's no one to guide us properly." Insufficient encouragement from teachers (90%) and distractions in class (75%) further reduce engagement, with a faculty member observing, "Some students get distracted by online content instead of focusing on the lesson." Additionally, personal factors like lack of interest (70%) and work or family pressures (60%) affect participation. A student shared, "I work part-time, and balancing studies with my job makes it hard to concentrate, even in a smart classroom." These challenges highlight the need for better training, motivation, and support to fully realize the benefits of smart technologies.

6. Challenges in Implementing and Maintaining ICT Equipment Under the CEDP Project

The implementation of ICT equipment under the CEDP project in Cumilla's tertiary colleges has faced several significant challenges that undermine its effectiveness and sustainability. Institutional readiness is a critical issue, with insufficient faculty training and limited student access to personal smart devices hindering full utilization. The retrofitting of existing classrooms into smart classrooms reduced seating capacity to 40, excluding many students and limiting equitable access. The online admission system also contributes to irregular attendance, especially among distant students, further weakening engagement.

Financial constraints pose major barriers: no dedicated maintenance budget exists, resulting in delayed repairs and equipment underutilization. Additionally, late-supplied ICT equipment was often of poor quality, affecting performance and durability. Internet connectivity, while initially supported by the project, faces sustainability challenges as colleges struggle to cover recurring costs. High maintenance expenses for essential devices like photocopiers add further financial pressure. Overall, these infrastructural, financial, and logistical challenges highlight the urgent need for comprehensive planning, budget allocation, and ongoing support to ensure the long-term success of ICT integration in tertiary education.

6.1 Sustainability of Smart Classroom Technologies

While the CEDP project successfully introduced smart classroom technologies, ensuring their long-term sustainability remains a major challenge. Key factors include the need for dedicated maintenance budgets integrated into regular institutional funding, and strong institutional ownership with active management involvement in planning and resource allocation. Strategic partnerships with private companies and local authorities can provide technical support and training beyond the project's end. Ongoing professional development for teachers is also critical to maintain effective technology use. Without a comprehensive sustainability plan addressing funding, institutional commitment, and external support, the long-term impact of these smart classroom interventions may be compromised.

6.2 Way Forward

6.2.1 Introduce Continuous Professional Development (CPD) for Teachers

To ensure effective use of smart classroom technologies provided under the CEDP project, a structured, ongoing professional development program for teachers is essential. One-time training is insufficient; instead, a comprehensive CPD framework is recommended, including initial orientation, quarterly hands-on training, biennial refresher courses, monthly peer learning sessions, and personalized one-on-one mentoring. This approach enhances both technical skills and pedagogical adaptation, transforming traditional teaching into interactive, student-centered learning. The combined efforts of project units, college authorities, ICT experts, and education boards are vital to sustaining teachers' proficiency and maximizing the impact of digital tools on education.

Table 1: Recommended Structure for Teacher Capacity Building in Smart Classroom Usage

Component	Description	Frequency	Responsible Authority
Initial Orientation	Basic introduction to smart classroom devices and software	At the initial	Project Implementation Unit / College Authority
Hands-on Training	Practical sessions on using interactive boards, digital content, and LMS tools	Quarterly	ICT Experts / Trainers
Refresher Courses	Re-training to update skills and introduce new features or content strategies	Every 2 years	Education Board / Project Partner
Peer Learning Sessions	Informal group discussions or experience-sharing among teachers	Monthly	Department Heads / Coordinators
One-on-One Mentoring	Individualized support for teachers needing special guidance	On-demand or bi-monthly	ICT Coordinators / Lead Teachers

6.2.2 Suggestions for The Improvement of the Existing Technical Facilities

Enhancing the existing technical facilities is crucial for maximizing the effectiveness of smart classroom technologies. Addressing infrastructure gaps, ensuring regular maintenance, and providing adequate support can significantly improve the teaching-learning experience. This section explores key suggestions for upgrading technical facilities to create a more efficient and accessible digital learning environment.

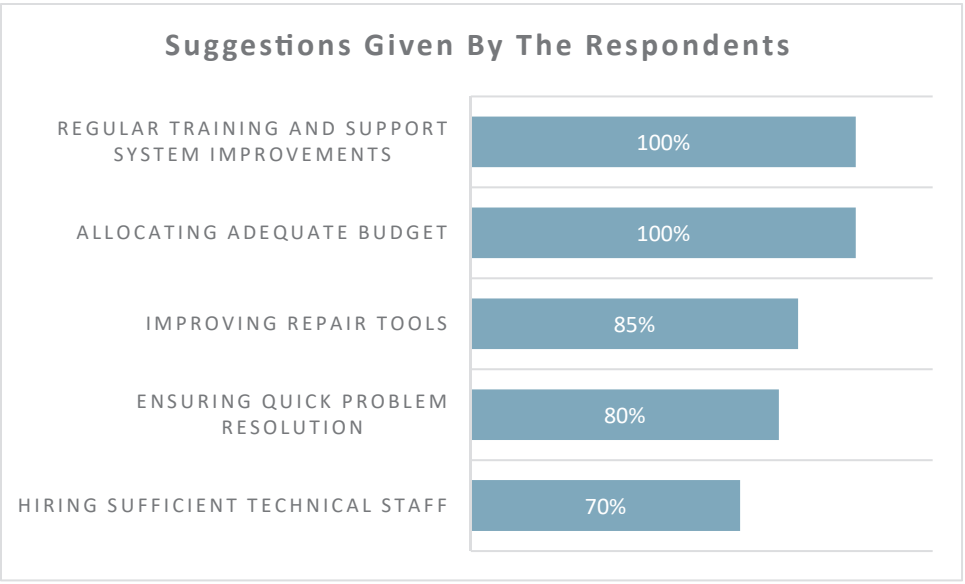


Figure 15. Suggestions Of Using Smart Classroom Technologies
Source: Field Survey 2024

The study's findings highlight the urgent need to improve the implementation and sustainability of smart classroom technologies in Cumilla's tertiary colleges. All respondents emphasized the importance of allocating adequate budgets and providing regular training

with support systems. One faculty member remarked, “Without proper funding, these smart technologies will eventually become obsolete,” while another noted, “Regular training would help us maximize the benefits of smart learning.” Quick resolution of technical issues (80%) and hiring sufficient technical staff (70%) were also strongly recommended to prevent disruptions. A teacher expressed frustration, saying, “When the projector or smart board stops working, classes are affected for days.” Additionally, 85% stressed the need for better repair tools, with one staff member stating, “With proper repair kits, we could solve many problems without waiting for external support.” These findings underscore the critical role of institutional commitment, financial investment, and proactive maintenance to enhance teaching effectiveness and student engagement through smart technologies.

6.2.3 Opinion of The Teachers Regarding Smart Classroom Usage Can Further Enhance Education

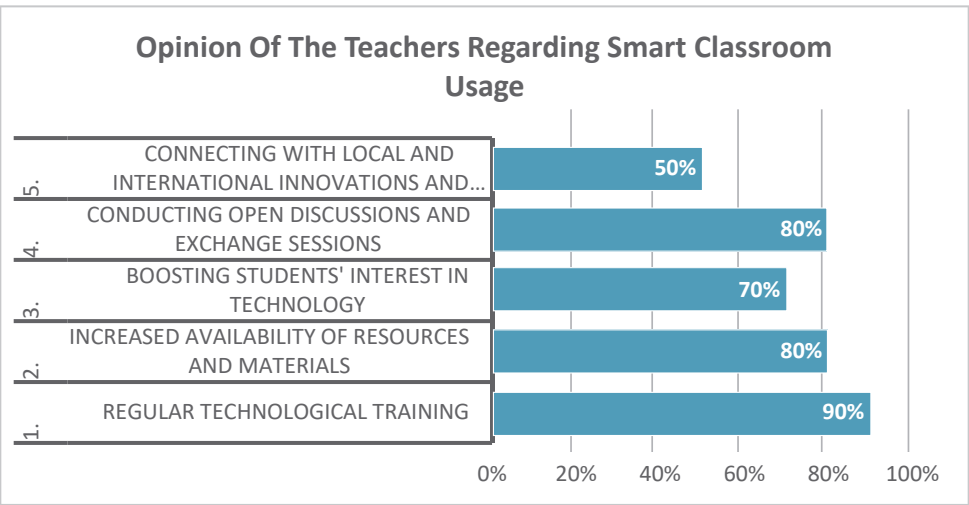


Figure 16. Opinion of Teaching byf Using Smart Classroom Technologies
Source: Field Survey 2024

The survey reveals a strong consensus on the need for regular technological training, with 90% of respondents highlighting its importance for enhancing teaching effectiveness. As one participant noted, “Continuous training helps us adapt to new tools, ensuring better learning experiences.” Additionally, 80% emphasized the need for more resources and materials to effectively integrate technology. Student engagement was also seen as vital, with 70% stressing the importance of boosting interest in technology; a teacher remarked, “When students are interested, they become more eager to learn.” Furthermore, 80% supported open discussions among educators to share best practices, while 50% showed moderate interest in connecting with global innovations. These findings highlight training, resource availability, student enthusiasm, and collaboration as key factors in optimizing technology use in education.

7. Conclusion and Recommendations

7.1 Conclusion

The integration of smart classroom technologies has initiated a significant transformation in the educational environment of tertiary colleges affiliated with the National University. These technologies have revitalized traditional teaching methods, fostering more interactive and engaging learning experiences. However, the successful implementation and sustainability of these innovations depend on several interconnected factors. Faculty preparedness and continuous training are essential to effectively harness digital tools, while equitable access to technology is critical to bridge the existing digital divide, especially for underprivileged students. Adequate infrastructure, including reliable classrooms and internet connectivity, provides the necessary foundation for these technologies to thrive. Furthermore, institutional commitment and ownership are vital to maintaining and advancing smart classroom initiatives beyond initial implementation.

This transformation, while promising, faces persistent challenges such as insufficient funding for maintenance, resistance to change, scheduling conflicts, and disparities in internet accessibility. Addressing these challenges is crucial to ensure that smart classroom technologies fully realize their potential in enhancing academic performance and student engagement. Ultimately, sustained efforts in training, infrastructure development, and institutional support will determine whether these technological advancements translate into lasting improvements in higher education.

7.2 Key Recommendations

Based on the findings of the study, the following key recommendations are proposed to enhance the effectiveness and sustainability of smart classroom technologies in tertiary colleges:

- Introduce standardized entry tests for honors program admissions to ensure student readiness and motivation.
- Align student intake with available classroom capacity and faculty resources to optimize learning environments.
- Increase the number of smart classrooms and expand seating capacity to accommodate all academic cohorts.
- Construct dedicated examination halls to prevent interruptions during classes and exams.
- Recruit additional faculty members, particularly in honors and master's programs, to address teacher shortages.
- Conduct regular training programs on digital pedagogy, blended learning, and content creation for teachers.

- Establish a national maintenance fund under the National University to support ICT infrastructure upkeep.
- Introduce a minimal technology fee for students to cover routine equipment maintenance costs.
- Provide low-cost devices or financial subsidies to underprivileged students to promote digital inclusion.
- Collaborate with Internet Service Providers (ISPs) to expand affordable internet access, especially in rural areas.
- Organize awareness campaigns, seminars, and orientations to foster positive attitudes toward technology adoption.
- Provide incentives for innovative teaching practices using smart classroom tools.
- Implement structured timetables for smart classroom use and avoid class-exam scheduling conflicts.
- Monitor usage and performance to evaluate the impact of smart classroom technologies.
- Establish feedback mechanisms to continuously improve teaching and learning practices based on user input.

7.3 Recommendations for Future Projects (Sustainability Focus)

- To ensure long-term sustainability of smart classroom interventions, the following strategic measures are recommended:
- Institutionalize smart technology as part of college strategic planning and budgeting processes.
- Establish local maintenance strategies and funding lines within each college to address recurring ICT needs.
- Build public-private partnerships with technology firms and government agencies for ongoing technical support and upgrades.
- Ensure continuous digital training for faculty members through integration into annual professional development activities.
- Utilize real-time monitoring and evaluation tools to make data-driven decisions and timely interventions.
- Develop scalable ICT models that can be expanded based on student enrollment growth and technological advancements.

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