

 Research Article

# Assessing Awareness and Implementation of Educational Technology and ICT Tools in Teaching at Selected Engineering Institutes in Western Maharashtra

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## Abstract

The rapid advancement of educational technology (EdTech) and information and communication technology (ICT) has significantly transformed teaching–learning practices in engineering institutes, driven by the increasing demand for flexible, student-centred, and technology-enabled education. Although a wide range of digital tools is available, engineering faculty differ considerably in their awareness, adoption, and effective pedagogical integration of these technologies. In this context, the present study examines faculty awareness and use of EdTech and ICT tools in engineering education through a taxonomy-based framework that categorizes varying levels of technological awareness and instructional application. The primary objective of the study is to assess how engineering educators perceive, access, and utilize digital tools for instructional delivery, assessment, collaboration, and student engagement. A descriptive and analytical research design was employed, and data were collected from engineering faculty using structured questionnaires and reflective inputs. The awareness taxonomy was applied to systematically analyse faculty engagement with ICT tools, ranging from basic familiarity to advanced pedagogical integration. The study also explores the use of commonly adopted digital platforms, including learning management systems, virtual classrooms, collaborative applications, and multimedia resources, along with instructional approaches such as blended learning and flipped learning. The findings indicate that while a majority of faculty members demonstrate moderate to high awareness of EdTech tools, their effective classroom implementation is often constrained by limited training opportunities, time constraints, infrastructural limitations, and resistance to pedagogical change. Nevertheless, educators who actively integrated technology-enabled strategies reported higher levels of student engagement, improved collaboration, and enhanced learning outcomes. The study concludes that structured professional development initiatives, strong institutional support, and a clearly defined awareness framework are essential for achieving meaningful and sustainable integration of EdTech and ICT in engineering education. The insights from this study can inform educators, administrators, and policymakers in strengthening technology-driven teaching practices.

**Keywords:** Educational Technology, ICT, Awareness Taxonomy, Engineering Education, Blended Learning, Flipped Learning

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## 1. INTRODUCTION

The rapid advancement of technology has significantly transformed education, especially in engineering institutes. Integrating educational technology (EdTech) and information and communication technology (ICT) tools into the curriculum has become essential as the demand for skilled engineers continues to grow (Sotiropoulos et al., 2024). These tools enhance the learning experience and prepare students for the technology-driven professional world. However, the awareness and adoption of these tools

vary across institutions, necessitating an in-depth study of their impact and use. These innovations are now seen as key drivers of quality, development, and transformation across various sectors. This shift enables educational institutions to produce graduates ready to meet the evolving demands of the labor market and enhance the higher education system.

The National Educational Technology Forum (NETF), under the National Education Policy (NEP) 2020, is a significant initiative promoting technology integration in education. It aims to encourage research, innovation, and the use of digital technologies across schools, higher education institutions, and teacher training programs. NETF seeks to enhance digital learning, online education, and capacity building for educators and students by providing an open platform for exchanging ideas. The COVID-19 pandemic significantly increased the use of social computing software and active learning strategies with the abrupt transition to fully online teaching and learning (Cabellos et al., 2022).

## 2. LITERATURE REVIEW

The quality of higher education has become a central concern for university administrations worldwide. The integration of modern educational technologies enables institutions to enhance academic services, instructional quality, and institutional effectiveness. Earlier research established that incorporating technological innovations into university teaching significantly improves the efficiency and effectiveness of learning methodologies (Shalgimbekova et al., 2024). The integration of digital tools, when guided by ethical standards and pedagogical alignment, fosters creativity, innovation, analytical thinking, and problem-solving skills. Such a transformation not only improves teaching performance but also cultivates advanced cognitive competencies essential for engineering education.

The inclusion of Information and Communication Technology (ICT) benefits faculty, students, and institutional administration. Technological innovations enhance learning effectiveness by providing multimedia and interactive instructional strategies that accommodate diverse learning styles. Similarly, Shapley et al. (2011) emphasize that digital tools improve student engagement, motivation, and readiness to learn when implemented with fidelity. Beyond student outcomes, technology also enhances educators' professional competence and supports a transition from traditional instruction toward facilitation and instructional design (Timotheou et al., 2022).

Recent scholarship further reinforces these findings. Empirical research conducted after the COVID-19 pandemic indicates that sustained exposure to digital teaching environments has strengthened faculty confidence, pedagogical innovation, and student engagement in higher education (Bond et al., 2020; Mishra et al., 2023). In particular, Bond et al. (2020) conducted a comprehensive systematic evidence map examining research on student engagement and educational technology in higher education. Their findings reveal a strong association between digital technologies and multiple dimensions of student engagement—behavioral, cognitive, and emotional. The study emphasizes that technology-enhanced learning environments promote active participation, collaboration, and deeper learning when pedagogically aligned with instructional objectives. These insights underscore the importance of moving beyond mere technological adoption toward purposeful and engagement-driven integration strategies.

The Technological Pedagogical Content Knowledge (TPACK) framework continues to provide a theoretical foundation for understanding effective technology integration (Mishra et al., 2023). In the context of generative AI and emerging digital systems, educators are increasingly required to balance technological knowledge with pedagogical and contextual awareness (UNESCO, 2023).

Moreover, contemporary empirical studies confirm that digitalization positively influences educational quality and institutional development. For instance, Abdurashidova et al. (2023) demonstrate that innovation and digital transformation significantly enhance teaching effectiveness and student engagement in universities. Similarly, Akpan et al. (2024) highlight the evolving landscape of virtual education technologies and their role in addressing digital divides in the Global South. Systematic reviews also show that ICT improves educational administration, communication efficiency, and institutional governance when supported by strategic policy implementation (Liu et al., 2025). Complementing these findings, despite these advantages, several barriers hinder effective ICT adoption. Limited digital infrastructure, insufficient institutional support, and inadequate professional training remain persistent challenges (Mathebula et al., 2025). Recent empirical work further indicates that although digital tools

enhance student motivation and academic performance, successful integration depends heavily on institutional readiness and faculty professional development (Mekheimer, 2025). The European DigCompEdu framework underscores the importance of developing educators' digital competencies to ensure sustainable and pedagogically sound integration (Redecker & Punie, 2024).

Western Maharashtra, a hub for engineering education, hosts numerous institutes that cater to aspiring engineers. While some institutes have made considerable progress in adopting ICT tools for teaching and learning, others continue to rely on traditional pedagogical methods. The disparity in the use of technology among faculty members and students creates a need to assess the existing levels of awareness and engagement with educational technology. Understanding these variations can provide insights into the challenges faced by educators and students, thereby facilitating the formulation of strategies to enhance the adoption of ICT tools. A structured taxonomy-based approach can help categorize awareness levels among educators and students, allowing for a systematic evaluation of technological adoption.

By classifying users into different categories based on their familiarity and engagement with ICT tools, this study aims to provide a comprehensive analysis of how educational technology is being utilized in select engineering institutes in Western Maharashtra. Such an assessment can highlight areas requiring improvement and suggest targeted interventions to bridge the digital divide in engineering education. Furthermore, the study seeks to examine the effectiveness of ICT tools in fostering interactive and student-centered learning environments. Digital platforms, simulation software, virtual labs, and artificial intelligence-based learning systems have the potential to revolutionize traditional teaching methods (Zou et al., 2025). By addressing these aspects, this research contributes to the ongoing discussion on the role of technology in higher education. The findings of this study will be a valuable resource for educators, administrators, and policymakers in engineering institutes. This research aims to facilitate the seamless integration of educational technology in engineering education by identifying key barriers to technology adoption and proposing strategic solutions. Ultimately, fostering greater awareness and utilization of ICT tools will lead to an improved learning experience and better preparedness of students for the demands of the modern engineering workforce.

## 2.1. Educational Technology and ICT Tools in Engineering Institutes

Modern educational technologies have revolutionized the way content is delivered and learned in engineering institutes. Educators are finding innovative ways to enhance student engagement, facilitate deeper understanding, and improve learning outcomes with the increasing reliance on digital tools. The integration of Educational Technology (EdTech) and Information and Communication Technology (ICT) tools in engineering education has significantly transformed traditional teaching methods. These tools provide an interactive, collaborative, and personalized learning experience, catering to diverse learning styles and improving the overall quality of education.

Learning Management Systems (LMS) have become a fundamental part of digital education in engineering institutes. Platforms such as Moodle, Google Classroom, and Canvas enable instructors to share course materials, administer assessments, track student progress, and foster communication beyond the physical classroom. These systems allow students to access lectures, assignments, and study materials anytime, enhancing flexibility in learning. Additionally, LMS platforms support various multimedia formats, including videos, animations, and interactive content, making complex engineering concepts more accessible. Educators can monitor student engagement and tailor their teaching strategies using built-in analytics.

Blended learning is an instructional approach that combines traditional face-to-face teaching with online educational resources. This method integrates digital and social networks, making learning more accessible and interactive for students. It provides students the opportunity to engage with digital content at their own pace while still benefiting from in-person discussions and hands-on activities. In engineering education, where practical applications are crucial, blended learning ensures that theoretical knowledge is reinforced through interactive digital tools and laboratory sessions. This method also accommodates different learning preferences, making education more inclusive and effective.

Flipped learning is a pedagogical approach where students are introduced to new concepts before attending a physical class. They engage with learning materials such as pre-recorded lectures, readings, and

online modules outside the classroom, allowing class time to be utilized for discussions, problem-solving, and hands-on activities. This approach is particularly beneficial for engineering students, as it fosters active learning and deeper comprehension of technical subjects. By shifting passive content consumption outside the classroom, flipped learning maximizes instructor-student interaction and enhances critical thinking skills.

Virtual Reality (VR) and Augmented Reality (AR) are emerging technologies that provide immersive learning experiences, making abstract engineering concepts more tangible. VR-based simulations allow students to explore complex systems, conduct virtual experiments, and practice skills in a risk-free environment. For example, in civil and mechanical engineering, VR enables students to visualize structural designs and understand material properties more effectively. AR can overlay digital information onto physical models, helping students grasp intricate details of machinery, circuits, and mechanical components. These technologies bridge the gap between theoretical learning and real-world applications, improving retention and comprehension.

Collaboration is a crucial aspect of engineering education, as professionals in the field often work in teams to develop solutions. Digital collaboration tools like Microsoft Teams, Zoom, and Google Meet facilitate seamless communication, document sharing, and virtual teamwork. These platforms enable students to participate in group discussions, work on joint projects, and engage with peers and instructors in real-time. Online whiteboards, such as Jamboard and Miro, allow for brainstorming and problem-solving, making remote collaboration as effective as face-to-face interactions. By incorporating these tools into coursework, educators prepare students for the digital workplace and enhance their ability to work in global teams.

Artificial Intelligence (AI) is playing a transformative role in personalized education. AI-driven platforms analyze student performance and adapt learning materials to meet individual needs, ensuring a more customized learning experience. Adaptive learning platforms such as Smart Sparrow, Knewton, and Coursera's AI-based recommendations adjust content delivery based on a student's strengths and weaknesses. In engineering courses, AI-powered tutoring systems can provide instant feedback on coding exercises, problem-solving tasks, and design projects. This level of personalization enhances student engagement and helps learners overcome difficulties in challenging subjects like mathematics, programming, and circuit analysis.

Gamification incorporates game-like elements such as badges, leaderboards, and rewards into the learning process, making education more engaging. Platforms like Kahoot!, Quizizz, and Duolingo for technical subjects use quizzes and interactive challenges to test students' knowledge in a fun and competitive way. This approach motivates learners and improves retention rates. Engineering students benefit from gamified assessments that encourage logical thinking and innovation. Interactive simulations, such as PhET for physics and MATLAB Simulink for engineering modeling, further enhance hands-on learning experiences.

As technology continues to evolve, the role of EdTech and ICT tools in engineering education will expand. The integration of blockchain for credential verification, cloud computing for data storage, and IoT (Internet of Things) for smart classrooms is already being explored. Future advancements will likely include AI-powered virtual mentors, real-time lab simulations through digital twins, and 3D printing applications in engineering design courses. To maximize the benefits of these tools, institutions must invest in faculty training, infrastructure development, and student awareness programs. By embracing technological innovations, engineering institutes can prepare students for the demands of the digital era while enhancing the quality and accessibility of education.

## 2.2. Impact of ICT Tools on Teaching and Learning

The integration of Information and Communication Technology (ICT) tools in engineering education has significantly transformed teaching methodologies and learning experiences. These tools not only enhance content delivery but also foster deeper engagement, improve collaboration, and streamline assessments. Engineering students benefit from the interactive and personalized approach that ICT tools provide. From virtual labs to AI-powered grading systems, these advancements are reshaping modern education.

One of the biggest challenges in engineering education is helping students grasp abstract and complex concepts. ICT tools such as PhET Interactive Simulations, Labster, MATLAB Simulink, and AutoCAD allow students to visualize and experiment with engineering principles in real-time. Virtual labs enable students to conduct physics, chemistry, and electronics experiments in a safe, controlled, and repeatable environment. Civil engineering students can use Building Information Modeling (BIM) software to simulate structures, while mechanical engineering students can explore thermodynamics and fluid mechanics through computational simulations. These digital resources reduce dependency on physical infrastructure and provide opportunities for remote learning, making education more accessible.

Engineering projects often require students to work in teams, collaborate on designs, and solve real-world problems together. ICT tools such as Google Docs, Microsoft Teams, Zoom, and Miro provide platforms where students can share ideas, edit documents collaboratively, and communicate efficiently. These tools enable seamless real-time collaboration, even among students who are geographically dispersed. Project management software like Trello, Asana, and Jira helps students track project progress, assign tasks, and set deadlines, preparing them for industry-level teamwork. The ability to collaborate virtually is valuable in an era where remote work and global engineering teams are becoming the norm. These platforms help students develop essential teamwork and communication skills for their future careers.

The evaluation process in education has traditionally been time-consuming and labor-intensive for instructors. ICT tools such as Google Forms, Moodle, Microsoft Forms, and Kahoot! offer automated grading systems, reducing the burden of manual assessments. These platforms can instantly analyze student responses, provide immediate feedback, and generate detailed reports on performance trends. Peer-assessment tools like PeerGrade and Turnitin encourage students to review each other's work, fostering critical thinking and self-reflection. Digital rubrics enhance objectivity and transparency in grading, ensuring that students receive fair and constructive feedback. With AI-powered tools like Grammarly, ChatGPT, and Quillionz, educators can also provide instant writing suggestions and improvements, helping students refine their technical writing and communication skills.

One of the biggest advantages of ICT tools is their ability to cater to different learning styles and paces. AI-driven platforms such as Coursera, Khan Academy, and Smart Sparrow use adaptive learning algorithms to tailor educational content based on student performance and engagement levels. These tools identify weak areas and provide customized exercises, ensuring that students' progress is at their own pace. In engineering education, where students often struggle with mathematics-heavy subjects, AI-based platforms can break down complex problems into step-by-step explanations. Chatbots and virtual tutors also assist students by answering queries and guiding them through assignments, making learning more interactive and self-directed.

Gamification has emerged as a powerful method to make learning more engaging and motivating. Tools like Quizizz, Kahoot!, and Duolingo for technical subjects integrate quizzes, leaderboards, and rewards into the learning process, fostering healthy competition and active participation. For engineering students, problem-solving games that simulate real-world challenges help develop critical thinking and innovation skills. Coding platforms like HackerRank, CodeSignal, and LeetCode offer gamified programming challenges that prepare students for technical interviews and problem-solving scenarios. This approach increases student motivation and enhances knowledge retention by making learning fun and interactive.

Modern engineering education focuses on industry-relevant skills, and ICT tools bridge the gap between academia and industry expectations. Platforms such as LinkedIn Learning, Udemy, and Coursera offer specialized courses that help students gain expertise in emerging technologies like AI, machine learning, IoT, and blockchain. Cloud-based software such as AutoCAD, SolidWorks, MATLAB, and Python programming environments allows students to gain hands-on experience with industry-standard tools. Engineering institutes can collaborate with companies to integrate real-world case studies and simulations into their curricula, ensuring that students graduate with practical knowledge that meets industry demands.

One of the biggest advantages of ICT tools is that they enable students to learn anytime, anywhere. Unlike traditional education, where learning is confined to lecture halls, digital platforms provide access to a wealth of knowledge beyond textbooks. Online libraries, open educational resources (OERs), webinars, and MOOCs allow students to explore new concepts independently. Platforms like Padlet, Wakelet, and

Flipgrid enable students to document their learning journeys, share insights, and build digital portfolios, making it easier for them to showcase their skills and accomplishments. By integrating these tools into their coursework, educators encourage lifelong learning and continuous skill development.

The impact of ICT tools on teaching and learning in engineering institutes is profound and ever-expanding. These tools enhance conceptual understanding, collaboration, and assessment, and prepare students for modern industry requirements. With advancements in AI, virtual reality, and adaptive learning, the role of technology in education will continue to evolve, offering more innovative and immersive learning experiences. To fully leverage these benefits, educational institutions must invest in faculty training programs, upgrade their digital infrastructure, and encourage a culture of continuous innovation in teaching methodologies. By embracing ICT tools, engineering institutes can ensure that their students develop the skills, knowledge, and adaptability needed to thrive in a technology-driven world.

### 2.3. Challenges in Implementing Educational Technology

The integration of Information and Communication Technology (ICT) tools into engineering education has revolutionized teaching and learning. However, despite its numerous advantages, significant challenges hinder its seamless adoption. From lack of faculty training and resistance to change to technological constraints and time limitations, educational institutions must address multiple barriers to maximize the potential of ICT tools in engineering education. Understanding these challenges is crucial for implementing effective solutions that ensure the successful use of digital technologies in engineering education.

One of the most significant challenges in implementing educational technology is the lack of adequate training and support for faculty members. Many educators are familiar with traditional teaching methods but may lack the skills and confidence to use digital tools effectively. This can lead to resistance towards adopting new technologies and a reluctance to integrate them into their teaching practices. Without proper training, faculty members may struggle to use Learning Management Systems (LMS), create engaging multimedia content, or facilitate online discussions. Institutions must invest in comprehensive professional development programs to equip educators with the necessary technological competencies. These programs should provide hands-on training, ongoing support, and opportunities for collaboration and knowledge sharing.

Resistance to change is another significant barrier to the adoption of educational technology. Some educators may be skeptical about the effectiveness of digital tools or fear that technology will replace traditional teaching methods. They may be comfortable with their existing teaching routines and hesitant to adopt new pedagogies. Overcoming this resistance requires a cultural shift within educational institutions. Administrators should promote a growth mindset, encourage experimentation, and recognize faculty members who successfully integrate technology into their teaching. Highlighting the benefits of EdTech, such as increased student engagement and improved learning outcomes, can also help alleviate concerns and foster a more positive attitude towards change.

Technological constraints, such as inadequate infrastructure and limited access to devices, can also hinder the implementation of educational technology. Many engineering institutes may lack the necessary hardware, software, and internet connectivity to support digital learning environments. This can create disparities among students and faculty, with some having better access to technology than others. Institutions must invest in upgrading their digital infrastructure, ensuring reliable internet access, providing access to devices like laptops and tablets, and maintaining up-to-date software. Additionally, technical support should be readily available to troubleshoot issues and ensure that the technology functions smoothly.

Time constraints pose another significant challenge for educators who are already burdened with teaching, research, and administrative responsibilities. Learning new technologies and integrating them into the curriculum requires a substantial time investment. Educators may struggle to find time to attend training sessions, develop digital content, and adapt their teaching strategies. Institutions must recognize and address these time constraints by providing release time for professional development, offering support for content creation, and streamlining administrative processes. Additionally, adopting user-friendly technologies and providing templates and resources can help reduce the time burden on faculty members.

Ensuring equitable access to technology for all students is essential but often challenging. Socioeconomic disparities, geographical location, and disabilities can create barriers to accessing digital tools and resources. Some students may not have access to reliable internet or devices at home, making it difficult for them to participate in online learning activities. Institutions must implement strategies to bridge the digital divide, such as providing loaner laptops, offering free Wi-Fi on campus, and developing accessible learning materials. Universal Design for Learning (UDL) principles should be applied to ensure that digital content is inclusive and caters to diverse learning needs.

Maintaining data privacy and security is another critical concern in the digital age. As educational institutions collect and store more student data, it is essential to protect this information from unauthorized access and misuse. Implementing robust cybersecurity measures, complying with data protection regulations, and educating students and faculty about online safety are crucial. Institutions must establish clear policies and procedures for data handling, use secure platforms and tools, and regularly update their systems to mitigate potential risks.

The lack of high-quality digital content tailored to engineering education can also hinder the effective use of technology. While there are many online resources available, not all of them are relevant, accurate, or aligned with curriculum objectives. Educators may spend significant time searching for and curating appropriate digital materials. Institutions can address this challenge by investing in the development of high-quality digital content, collaborating with publishers and EdTech providers, and creating repositories of open educational resources (OERs). Additionally, faculty members should be encouraged and supported in creating their own digital resources, such as videos, simulations, and interactive exercises.

Assessing the effectiveness of technology integration is crucial but can be challenging. Traditional assessment methods may not be suitable for evaluating learning outcomes in technology-rich environments. Institutions must develop new assessment strategies that measure students' digital literacy, collaboration skills, and problem-solving abilities. Using analytics tools to track student engagement and performance can provide valuable insights into the impact of technology on learning. Regular evaluation and feedback are essential for refining teaching practices and ensuring that technology is used effectively.

The implementation of educational technology in engineering education is a complex process with numerous challenges. Addressing these challenges requires a multifaceted approach that includes faculty training, infrastructure development, equitable access, data privacy, and continuous evaluation. By proactively addressing these barriers, educational institutions can create a more supportive and effective digital learning environment for both students and faculty.

### 3. METHODOLOGY

#### 3.1. Participants

The study focused on faculty members at engineering colleges in Western Maharashtra. A total of 100 professors (58.10% female, 41.90% male) participated in the study by completing a prepared questionnaire. These participants provided valuable data regarding their awareness and use of educational technology and ICT tools in their teaching practices.

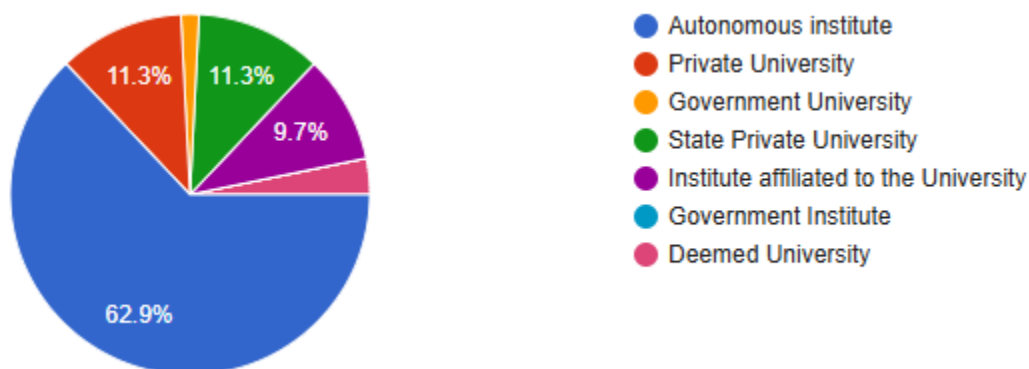
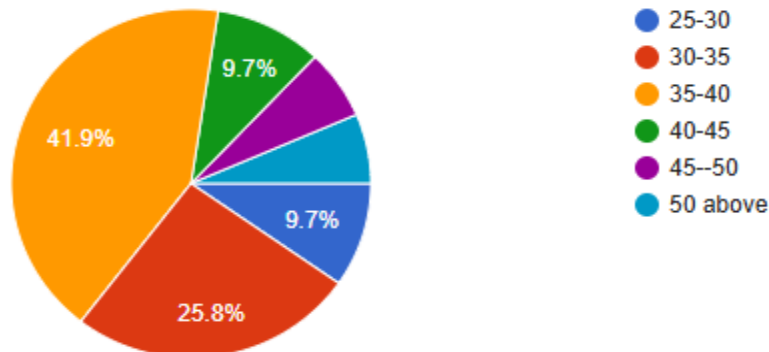


Figure 1. Type of the Institute the Respondents Belong to

The pie chart depicts the institutional affiliation of respondents. A clear majority are from autonomous institutes (62.9%), indicating strong representation from this category. Respondents from private universities and state private universities each constitute 11.3%. Those from institutes affiliated to universities account for 9.7%, while government institutes and deemed universities form only a very small proportion, reflecting comparatively lower participation from these institutions.



**Figure 2.** Age Group of the Respondents

The pie chart shows the age-wise distribution of respondents. The largest group belongs to the 35–40 age range (41.9%), followed by the 30–35 group (25.8%). The 25–30 and 40–45 age groups each account for 9.7% of the respondents. Smaller proportions are observed in the 45–50 and 50 and above categories, indicating comparatively fewer participants from higher age groups.

This study employed a mixed-methods approach to assess the awareness and implementation of educational technology and ICT tools in teaching at select engineering institutes in Western Maharashtra. This approach combines quantitative and qualitative research methods to provide a comprehensive understanding of the current state of technology integration in engineering education.

### 3.2. Quantitative Methods

The structured questionnaire used in this study was self-developed by the authors following an extensive review of prior research on ICT integration, technology acceptance, and digital pedagogy in higher education. Conceptual grounding for the instrument was drawn from established frameworks such as Bloom's Taxonomy, the Technology Integration Matrix (TIM), and the Technological Pedagogical Content Knowledge (TPACK) model (Mishra & Koehler, 2006; Koehler et al., 2014), ensuring both pedagogical and technological alignment.

The questionnaire comprised five sections with a total of 40 items. Section 1, focusing on *Basic ICT Proficiency*, consisted of 8 Likert-scale items assessing faculty familiarity and confidence in using digital tools. Section 2, *ICT in Teaching and Pedagogy*, included 10 items examining the instructional use of ICT in lesson planning and delivery. Section 3, *Student Engagement and Assessment with ICT*, comprised 9 items related to interactive learning, assessment, and feedback practices. Section 4, *Advanced ICT Integration*, included 7 items addressing higher-level pedagogical integration, such as blended and flipped learning. Section 5, *Challenges and Barriers*, consisted of 8 items identifying institutional, technical, and personal constraints. All items were measured using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

The internal consistency of the instrument was examined using Cronbach's alpha. The overall reliability coefficient was  $\alpha = 0.87$ , indicating strong internal consistency. Section-wise reliability values ranged from  $\alpha = 0.79$  to  $\alpha = 0.85$ , demonstrating satisfactory reliability across all dimensions of the questionnaire.

The questionnaire was distributed to faculty members across different departments in engineering institutes in Western Maharashtra. The distribution was conducted both online (using platforms like Google Forms) and in person to ensure a broad reach and high response rate.

### 3.3. Qualitative Methods

In addition to the survey, semi-structured interviews were conducted with 27 faculty members, selected through purposive sampling to ensure representation across different academic disciplines, levels of teaching experience, and varying degrees of ICT usage. The interviews comprised six open-ended questions designed to capture faculty members' lived experiences with ICT integration, their perceived benefits of using digital tools, the challenges they encountered, and the extent of institutional support available to them.

Each interview lasted approximately three to four minutes and was conducted either face-to-face or in an online mode, depending on participant availability and convenience. The qualitative data obtained from the interviews were analyzed using thematic analysis, following Braun and Clarke's (2006) six-phase framework. This systematic approach facilitated the identification of recurring patterns and meaningful themes within the data.

The integration of qualitative insights with survey findings enabled data triangulation, thereby strengthening the credibility, trustworthiness, and depth of the study. By complementing quantitative trends with faculty narratives, the interviews provided a richer understanding of how ICT tools are perceived and implemented in engineering education, as well as the contextual factors influencing their effective adoption.

### 3.4. Taxonomy-Based Assessment

To provide a structured framework for assessing the level of awareness of EdTech and ICT tools among faculty members, a taxonomy was adapted from existing models, such as Bloom's Taxonomy and the Technology Integration Matrix (TIM). The taxonomy categorizes faculty members into different levels based on their knowledge, skills, and application of technology in teaching. The levels include:

- Level 1: Awareness: Faculty members at this level have basic knowledge of EdTech and ICT tools but limited practical experience.
- Level 2: Exploration: Faculty members are beginning to experiment with some EdTech tools in their teaching, but may not be fully proficient.
- Level 3: Integration: Faculty members regularly use EdTech tools to enhance their teaching and integrate them into their instructional strategies.
- Level 4: Transformation: Faculty members effectively use EdTech tools to transform their teaching practices, creating innovative and student-centered learning environments.

The data collected from the questionnaires and interviews were used to categorize faculty members into these different levels, providing a comprehensive overview of the current state of EdTech awareness and implementation in the selected engineering institutes.

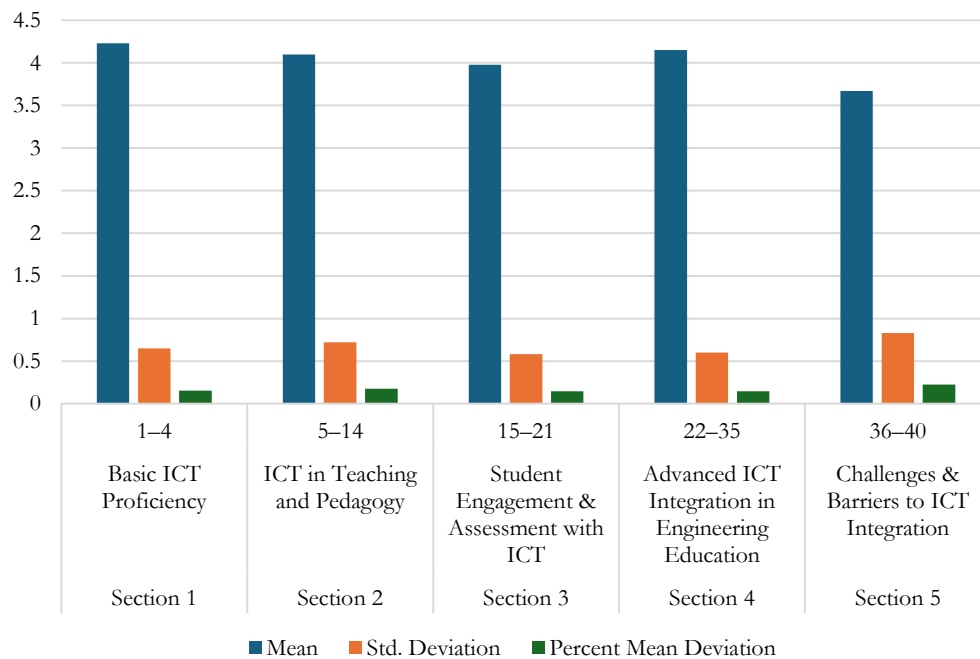
### 3.5. Data Analysis

The data provided represents a section-wise analysis of ICT (Information and Communication Technology) proficiency and integration in education, especially in the context of engineering education. Each section is evaluated using the mean score, standard deviation, and percent mean deviation to understand both the overall trends and the variability among respondents.

Starting with Section 1: *Basic ICT Proficiency*, the mean score is the highest at 4.23. This indicates that most respondents possess strong fundamental ICT skills such as using computers, internet tools, and basic software applications. The standard deviation is moderate (0.65), suggesting that while the majority demonstrate proficiency, a small proportion may still require additional support to reach the same level. The percent mean deviation of 15.38% further confirms that responses are relatively consistent, with limited dispersion around the mean.

Moving to Section 2: *ICT in Teaching and Pedagogy*, the mean score is slightly lower at 4.10, but still high, reflecting a good level of comfort among educators in applying ICT tools for teaching purposes. However, the standard deviation rises to 0.72, indicating greater variation among respondents. This suggests

that while many teachers effectively integrate technology into their pedagogy, others are either in the early stages or face challenges doing so. The percent mean deviation of 17.56% also points to this wider spread of experiences and capabilities.



**Figure 3.** Analysis of the Taxonomy of Awareness of EdTech and ICT Tools

In Section 3: *Student Engagement and Assessment with ICT*, the mean score further drops to 3.98. This suggests that although ICT tools are being used, engaging students effectively and leveraging technology for assessment purposes remains a developing area. Interestingly, the standard deviation is the lowest among all sections at 0.58, indicating that most respondents share a similar experience and that there is general agreement on the challenges and opportunities in this area. The percent mean deviation is also relatively low (14.57%), reinforcing the idea of consistent responses.

Section 4: *Advanced ICT Integration in Engineering Education* shows a strong mean score of 4.15, coupled with a low standard deviation of 0.60. This suggests that the respondents are quite adept at using advanced ICT tools relevant to technical education, such as simulations, modeling software, and specialized engineering applications. The low variability means that most respondents share a similar level of competency in this area, and the percent mean deviation of 14.46% supports the finding of uniformity in the responses.

Finally, Section 5: *Challenges and Barriers to ICT Integration* has the lowest mean score at 3.67 and the highest standard deviation of 0.83. This reveals that although there is an overall recognition of challenges in integrating ICT, the experiences are highly diverse. Some educators may encounter significant obstacles, such as inadequate infrastructure, limited training opportunities, or resistance to technological change, while others may face fewer issues. The high percent mean deviation of 22.63% reflects this wide disparity in experiences and underscores the need for targeted interventions to address these barriers effectively.

Overall, the analysis suggests that while the foundational and advanced ICT skills of educators are generally strong, there is a noticeable need to improve strategies for using ICT to engage and assess students. Additionally, overcoming practical barriers to ICT integration requires focused support tailored to the varying experiences of educators. The results are encouraging in terms of basic and advanced ICT competency, but highlight critical areas for improvement, especially regarding student engagement and addressing infrastructural and systemic challenges.

## 4. RESULTS

The results of the study revealed a mixed picture of EdTech and ICT tool awareness and implementation among faculty members in the selected engineering institutes.

### 4.1. Quantitative Findings

The analysis of questionnaire responses revealed that a substantial proportion of faculty members possessed basic awareness of commonly used EdTech tools, particularly learning management systems such as Moodle and Google Classroom, as well as online video conferencing platforms, including Zoom and Google Meet. These tools were widely recognized as essential components of routine academic practice. In contrast, awareness of advanced technologies such as virtual reality (VR) and augmented reality (AR) was comparatively limited, indicating a gap between exposure to foundational digital tools and familiarity with emerging educational technologies.

Further analysis highlighted considerable variation in the frequency with which faculty members employed EdTech tools in their teaching. While many educators regularly use learning management systems for sharing course materials and maintaining communication with students, fewer faculty members consistently integrate interactive simulations, gamification tools, or AI-enabled learning platforms into their instructional practices. This suggests that EdTech adoption was largely functional rather than pedagogically transformative.

Statistical findings also indicated a positive relationship between faculty members' years of teaching experience and their level of awareness of EdTech tools, implying that more experienced educators may have encountered greater opportunities for technological exposure over time. However, no consistent relationship was observed between teaching experience and actual frequency of EdTech usage, suggesting that higher awareness does not necessarily lead to active or sustained implementation in the classroom.

Faculty perceptions further underscored both the potential and the challenges of EdTech integration. Respondents acknowledged benefits such as increased student engagement, improved collaboration, and easier access to learning resources. At the same time, they identified barriers including inadequate training, time constraints, and limited technological infrastructure, which continue to hinder the effective and meaningful use of EdTech tools in engineering education.

### 4.2. Qualitative Findings

The interview data offered deeper and more nuanced insights into the opportunities and challenges associated with the integration of EdTech in engineering education. Many faculty members expressed a strong willingness to adopt digital tools more effectively but emphasized the need for comprehensive institutional support. In particular, respondents highlighted the importance of hands-on training programmes, practical workshops, continuous mentorship, and timely access to technical assistance to build confidence and competence in using EdTech tools.

Alongside these concerns, several educators shared positive experiences and successful instructional practices enabled by technology. Faculty members described the use of virtual laboratories to provide students with experiential learning opportunities that closely simulate real-world scenarios. Others reported incorporating gamified quizzes and interactive assessments to enhance student motivation and participation. The use of online collaboration platforms was also cited as an effective strategy for facilitating group work, peer learning, and project-based activities beyond the physical classroom.

At the same time, the interviews brought to light certain apprehensions regarding the excessive use of technology in teaching. Some faculty members voiced concerns about reduced face-to-face interaction, diminished interpersonal communication, and the possibility of increased digital distractions among students. These concerns led educators to stress the importance of maintaining a balanced instructional approach, where technology complements rather than replaces traditional teaching methods. Overall, faculty members underscored the need for thoughtful and pedagogically grounded integration of EdTech tools that support meaningful learning while fostering an engaging and supportive classroom environment.

### 4.3. Taxonomy-Based Assessment Results

The taxonomy-based assessment enabled a clear classification of faculty members according to their levels of EdTech awareness and implementation. The findings revealed that the majority of faculty members were positioned at Level 2 (Exploration), indicating that they possessed a basic understanding of EdTech tools and had begun experimenting with their use in classroom practices. These educators were typically in the early stages of adoption, using technology on a trial basis without fully embedding it into their pedagogy.

A comparatively smaller proportion of faculty members were categorized at Level 3 (Integration). This group demonstrated regular and purposeful use of EdTech tools to support instructional delivery, student engagement, and assessment. Their practices reflected a more confident and consistent integration of technology aligned with pedagogical objectives.

Only a limited number of faculty members reached Level 4 (Transformation). Faculty at this level were found to leverage technology to fundamentally redesign their teaching approaches, creating innovative, learner-centered, and technology-rich learning environments. Their practices went beyond substitution or enhancement, emphasizing pedagogical innovation and experiential learning.

At the lower end of the spectrum, a small group of faculty members remained at Level 1 (Awareness). These educators exhibited minimal exposure to EdTech tools and limited experience in applying technology within their teaching practices. Overall, the distribution highlights a gradual progression in EdTech adoption, with most faculty transitioning from awareness to experimentation, while relatively few have achieved advanced levels of pedagogical transformation through technology.

## 5. DISCUSSION

The findings of this study highlight the need for targeted interventions to promote the effective integration of EdTech and ICT tools in engineering education. While there is a general awareness of digital tools among faculty members, there is a gap between awareness and consistent implementation. Addressing the challenges identified by faculty members, such as lack of training, time constraints, and infrastructure limitations, is crucial for bridging this gap.

The taxonomy-based assessment provides a useful framework for understanding the current level of EdTech implementation and identifying areas for improvement. By categorizing faculty members into different levels, it is possible to tailor professional development activities and support services to meet their specific needs.

The study also underscores the importance of balancing technology use with traditional teaching methods. While EdTech tools offer numerous benefits, they should be used strategically to enhance, rather than replace, effective pedagogical practices (Haleem et al., 2021). Creating a supportive learning environment that fosters collaboration, critical thinking, and student engagement remains essential, regardless of the technology used.

Teachers encounter various challenges when integrating educational technology into their practice. A significant hurdle is the time required for planning and implementation, which competes with existing responsibilities. Many teachers report time consumption and feeling like they don't get enough time, especially initially, as it takes time to learn and effectively use new tools. There is also the issue of teacher training and digital skills, as many lack sufficient training or basic knowledge for handling ICT tools, and there is a lack of infrastructure training for teachers.

Inadequate infrastructure presents another major obstacle, encompassing poor internet connectivity, limited network infrastructure, and general network issues. Technical errors and technical disturbances are common, and classrooms often require technical support. Furthermore, the high cost of digital devices and software, sometimes involving subscription fees or paid versions, adds to the financial strain. Student-related challenges include the potential for students' misuse of technology for gaming or social media and general student distraction, which hinders learning. Some express concerns about students' approach, lack of seriousness, and the need for student orientation and increased student interest. There are also concerns about student digital literacy and the need for all students to have lots of hands-on practice.

Pedagogical challenges include the potential for reduced interactions and less one-on-one interaction, as well as the observation that face-to-face communication is poor when relying heavily on technology. Scheduling and restriction of time period can also be difficult, and teachers note that you cannot plan it perfectly unless you teach the course at least once. Finally, issues like compatibility problems, concerns about data privacy and security, and occasional instances where the technology “shows no signal” or is “not comfortable” further complicate the effective integration of educational technology.

To enhance confidence in using ICT (Information and Communication Technology) tools effectively, an institute should offer comprehensive, hands-on training programs tailored to the needs and skill levels of educators (Aleksieva, 2025). These programs could include Basic ICT Skills Training for beginners, covering foundational knowledge like operating systems, Microsoft Office, email, and internet use. Advanced Software Training can develop proficiency in specialized tools such as Excel, SPSS, Python, Adobe Creative Suite, and project management software like Trello and Asana.

Equally important are Digital Literacy and Cybersecurity Awareness sessions to promote safe and efficient digital practices, including online security, data protection, and privacy. Educators can benefit from E-Learning and Educational Technology Training focused on using Learning Management Systems (LMS) like Google Classroom or Moodle, and interactive tools like Kahoot!, Padlet, and digital assessment methods to create engaging digital learning environments. Programming and Coding Workshops would help develop problem-solving skills through languages like Python and JavaScript, and introduce web development and app creation.

Moreover, training in Cloud Computing and Collaborative Tools like Google Drive, OneDrive, Slack, Microsoft Teams, Zoom, and Google Meet is essential for seamless remote collaboration. Digital Content Creation and Communication Skills workshops could include video editing, podcasting, blogging, social media management, and professional digital communication to strengthen digital storytelling and presentation abilities. Real-world application through Hands-On ICT Projects and Hackathons will allow faculty to apply their skills in solving practical challenges using ICT tools.

Educators have also expressed the need for Faculty Development Programs (FDPs), Short-Term Training Programs (STTPs), and workshops focused on the latest AI tools, generative AI platforms, and subject-specific interactive tools. These programs should include practical, hands-on training until educators are capable of independently planning lessons, creating assessments, and even professionally recording and editing educational videos. Specific tools like Microsoft Power BI, Google Classroom, and other emerging platforms should be part of the training curriculum. Teachers suggest activity-based training that includes self-auditing of ICT capabilities, effective lesson planning using ICT, and the integration of AI in education. Overall, comprehensive, regular, and hands-on ICT training programs are essential to empower educators with the confidence and competence needed to thrive in digitally enhanced teaching environments (Msambwa et al., 2023).

## 6. LIMITATIONS

Despite its contributions, this study has certain limitations that should be acknowledged. First, the sample size was limited to 100 faculty members from a specific geographic region, which may restrict the generalizability of the findings to other contexts. Second, the study relied primarily on self-reported data, which may be subject to response bias or social desirability effects. Third, although the questionnaire demonstrated acceptable reliability, future studies may further refine and validate the instrument across diverse institutional settings.

Future research should consider larger and more diverse samples across multiple regions and disciplines. Longitudinal studies could examine changes in ICT adoption over time, particularly in relation to institutional interventions and policy changes. Additionally, future investigations may explore student perspectives, learning outcomes, and the impact of emerging technologies such as generative AI, learning analytics, and virtual laboratories on engineering education.

## 7. CONCLUSION

The integration of educational technology and ICT tools in engineering institutes is essential for fostering an interactive and effective learning environment. Utilizing a taxonomy-based approach to assess awareness levels can help educators and institutions identify gaps and strategically implement ICT tools for improved learning outcomes. Future research should focus on evaluating the long-term impact of these technologies in engineering education.

This study provides empirical evidence on the current state of awareness and implementation of educational technology and ICT tools among engineering faculty in Western Maharashtra using a taxonomy-based assessment framework. Beyond identifying levels of awareness and usage, the findings offer several practical implications for key stakeholders.

For researchers, the taxonomy-based approach used in this study offers a scalable framework that can be replicated or extended to other regions, disciplines, or longitudinal investigations examining technology adoption over time. Future studies may build upon this work by exploring causal relationships between institutional support mechanisms and higher levels of technology integration. For educators and instructors, the findings highlight the need to move beyond basic awareness toward meaningful pedagogical integration of ICT tools. The study emphasizes the importance of continuous hands-on training, peer mentoring, and reflective teaching practices to effectively leverage digital tools for student engagement and assessment.

For policymakers and institutional leaders, the results underline the importance of targeted investment in digital infrastructure, structured faculty development programs, and supportive technology policies aligned with the objectives of NEP 2020. Strategic planning that prioritizes both access and capacity-building can significantly enhance technology adoption at the institutional level.

For curriculum developers, the study suggests the need to embed technology-enhanced learning outcomes explicitly within engineering curricula. Integrating blended learning, virtual labs, and digital assessment strategies into curriculum design can ensure alignment between learning objectives, pedagogy, and assessment in technology-rich learning environments.

Overall, the study demonstrates that effective ICT integration is not merely a technological issue but a pedagogical and institutional transformation that requires coordinated efforts across stakeholders.

## 8. RECOMMENDATIONS

To fully realize the potential of educational technology in engineering institutes, a strategic and sustained approach to implementation is essential. One of the key priorities is faculty capacity building. Regular workshops, hands-on training sessions, and professional development programs can equip educators with the skills and confidence required to use ICT tools effectively and meaningfully in their teaching practices. Equally important is investment in technological infrastructure. Engineering institutes must ensure the availability of reliable internet connectivity, adequate digital devices, and access to updated software and learning platforms. A robust infrastructure provides the foundation necessary for both faculty and students to engage seamlessly with technology-enabled learning environments.

Adopting a blended learning approach can further enhance teaching and learning outcomes. By thoughtfully combining traditional face-to-face instruction with digital tools and online resources, educators can address diverse learning preferences, promote flexibility, and encourage active student participation. Such an approach allows technology to complement, rather than replace, conventional pedagogical practices. Finally, continuous research and development in the area of EdTech is crucial for long-term effectiveness. Ongoing studies that evaluate the impact of digital tools on teaching strategies and student learning outcomes can provide valuable insights for refining pedagogical practices. Together, these strategies can support the sustainable integration of educational technology and contribute to more engaging, inclusive, and effective engineering education.

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