Holistic Learning in Engineering: A NEP-Driven Exploration of Emerging Technologies for Education Transformation

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***Abstract*— The New Education Policy (NEP) introduced by the Government of India aims to revolutionize engineering education by promoting a more holistic and contemporary approach. This paper explores the integration of emerging technologies, such as artificial intelligence (AI) and machine learning (ML), Internet of Things (IoT), and data analytics and visualization, into engineering education. The study examines how these technologies can help to enhance learning experiences by offering flexibility, personalization, and hands-on engagement. Through effective collaboration, skill development, and experiential learning, these pedagogies prepare engineering students to meet the evolving demands of the modern world. The successful implementation of these technologies requires careful planning, faculty training, and addressing challenges related to accessibility and inclusivity. The findings highlight that the integration of these emerging technologies aligns with the NEP's vision, thereby empowering engineering education to cater to diverse student needs and equip them with future-ready skills.**

***Keywords*— New Education Policy, Engineering Pedagogy, Emerging Technologies**

***JEET Category*—Practice**

I. INTRODUCTION

THE field of education is undergoing a significant transformation driven by advancements in technology and evolving pedagogical philosophies. The introduction of the NEP by the Government of India marks a pivotal shift in the approach to education, particularly in engineering. This policy emphasizes holistic, interdisciplinary, and experiential learning, challenging conventional modes of instruction. The integration of emerging technologies like Artificial Intelligence (AI) and Machine Learning (ML), Internet of Things (IoT), and Data Analytics and Visualization has the potential to revolutionize engineering education.

Relying solely on the conventional education system and assessing students solely based on their writing abilities is no longer adequate to meet the demands of today's industries (Bharadia, 2018).

To nurture technical skills, innovative learning-based approach in the classroom, coupled with innovative assessments, plays a crucial role. This approach is more effective than conventional written assessments because it can help to enhance students' ability to grasp problems and devise effective solutions (Patel, 2018).

At its core, this paper seeks to address the following questions:

- How do emerging technologies complement the NEP's vision of holistic learning in engineering education?
- What are the potential benefits of incorporating these technologies in fostering well-rounded engineering graduates?
- How can the integration of emerging technologies bridge the gap between theoretical knowledge and practical application?
- What challenges and opportunities arise from the convergence of holistic learning and emerging technologies, and how can these challenges be navigated effectively?

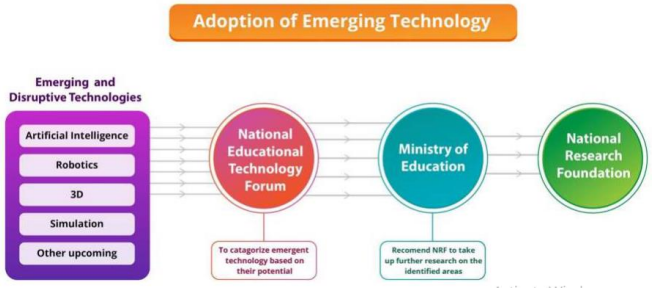

Fig. 1. Adoption of Emerging Technologies in Engineering Education (Ref: https://www.education.gov.in/shikshakparv/docs/NEP_2020_CIET_Behera.pdf, Date: 30-08-2023)

The Government of India has embraced a range of emerging technologies through the NEP to revamp engineering education as shown in Figure 1. These technologies have been selected based on their potential and

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industry needs, all in pursuit of national growth and development. The Government of India's commitment to transforming its education system aligns seamlessly with the nation's aspirations for growth and progress. Recognizing the vital role of engineering education in driving innovation and economic development, the government has undertaken a strategic approach to integrate emerging technologies into the educational landscape. This vision converges with industry requirements, as modern industries demand not only technical expertise but also skills in critical thinking, innovation, and collaboration. To bridge the gap between education and industry, the government has recognized the significance of emerging technologies and their potential to cultivate a skilled and adaptable workforce.

This paper delves into the impact of these technologies on engineering pedagogy, comparing them with conventional methods and highlighting the outcomes that they bring forth. By examining the transformative potential of these technologies, it is aimed to provide insights into how they align with the NEP's objectives of fostering adaptability, critical thinking, and collaboration. Additionally, this paper will discuss the challenges and considerations associated with integrating these technologies, ultimately emphasizing the importance of strategic planning and faculty development to ensure successful implementation.

The research looked into a problem where engineering students were feeling unmotivated and not interested in their studies, which was causing them to do poorly in their classes (Lathigara et al. 2021). The study found that if it is figured out what students need in terms of their education and emotions early on and help them with those things, they will become more engaged in their studies and do better academically (Lathigara et al. 2021).

Through a comprehensive exploration of these emerging technologies in the context of engineering education, this paper seeks to contribute to the ongoing discourse surrounding educational reform and the future of engineering pedagogy in alignment with the NEP's visionary goals.

II. Literature Review

The landscape of education has been rapidly evolving with the integration of emerging technologies. This section provides an in-depth review of the existing literature, shedding light on the transformative impact of these technologies on education.

The emergence of learning platforms has redefined the way education is delivered and received. Suggested platforms (Bhadri et al., 2022), as have opened up avenues for self-paced learning, catering to a diverse range of learning styles. Learning (Bhadri et al., 2022) combines the best of both online and conventional classroom settings, fostering interactive and collaborative environments. The NEP of India recognizes the potential of these platforms, aligning with its goal of flexible and accessible education (Patra et al., 2022).

At RK University, E-courses are created with various effective learning methods, study materials, online tests, updates, and discussions that students and teachers can access anytime through the internet. This platform can be used not only for conventional classroom teaching but also for blended learning. In blended learning, teachers integrate hands-on activities in physical classrooms with additional activities and project work in the online course (e-course) (Patel, 2019).

AI and ML have garnered substantial attention in educational research. The personalized learning capabilities of AI (Sagarika et al., 2021), allow educators to tailor content to individual student needs, optimizing learning outcomes. Furthermore, AI-driven assessment tools (Sagarika et al., 2021), provide real-time feedback, aiding both students and teachers in the learning process. The integration of AI and ML aligns with NEP's emphasis on continuous assessment and learner-centered education (Estrada-Molina, 2022).

The integration of IoT in education has opened up new avenues for hands-on learning (Hadgraft, 2020). IoT's ability to connect devices and collect real-time data, as discussed (Bongomin, 2020), enhances student engagement by offering practical applications of theoretical concepts. Additionally, the collaborative opportunities presented by IoT (Hadgraft, 2020), align with the NEP's vision of nurturing teamwork and adaptability. By enabling students to work on projects involving real-world data, IoT aligns with the NEP's emphasis on experiential learning (Roy, 2023).

Data analytics and visualization have transformed the way educators and students interact with data (Bienkowski, 2012). Donoghue (2021) emphasizes that these tools empower students to extract insights from complex datasets, fostering critical thinking and problem-solving skills. The visual representations of data explored (Krum, 2013), enhance communication and aid in conveying intricate concepts effectively. The NEP's focus on holistic understanding and communication skills resonates with the potential benefits of data analytics and visualization (Anand, 2021).

Innovation based learning serves as a motivational catalyst for the learning process (Lathigara, Tanna and Bhatt, 2021). It fosters the development of various valuable skills such as soft skills, logical thinking, and practical knowledge (Tanna et al., 2023). This aligns with the idea that engineering education should strive to bridge the gap between theoretical knowledge and practical application (Tanna et al., 2020), particularly in the more advanced courses offered in the higher semesters of engineering branches (Tanna et al., 2022).

The integration of emerging technology courses at the freshman level enhances student motivation and provides early exposure to dynamic industry trends, thereby bridging the gap between academia and industry. Such initiatives align with NEP’s vision of holistic, multidisciplinary learning, enabling students to make informed career choices

from the very beginning of their engineering journey (Malhotra, Kumar, & Gupta, 2023).

Service-learning, as highlighted in NEP 2020, is a powerful pedagogy that bridges classroom knowledge with real-world applications while fostering civic responsibility and social engagement. It aligns with the NEP's vision of holistic, multidisciplinary, and experiential education by cultivating ethical, reflective, and community-oriented engineers. Such integration strengthens the broader goals of transforming engineering education in India (Dustker, Bandi, & Oakes, 2022)

In theory, the reviewed literature highlights the transformative potential of emerging technologies in reshaping education. These technologies align with the goals of the NEP by offering personalized, experiential, and interdisciplinary learning experiences that equip students with the skills and mindset needed to thrive in the modern world.

III. Implementation of Emerging Technologies in Engineering Education

"Education must move towards less content and more towards learning about how to think critically and solve problems, how to be creative and multidisciplinary, and how to innovate, adapt and absorb new material in novel and changing fields." ~ NEP 2020

The NEP 2020 provides guidance on holistic and multidisciplinary education, creating optimal learning environments and support systems for students, and nurturing motivated, energized, and capable faculty. This policy is instrumental in addressing the challenges within the education system.

The main objectives of this study are:

- Enhancing learning experiences through flexibility, personalization, and hands-on engagement
- Fostering effective collaboration, skill development, and experiential learning

This study aims to enhance engineering education by improving learning experiences and fostering collaboration, skill development, and experiential learning through the integration of emerging technologies which is discussed as below:

Enhancing Learning Experiences

Flexibility in learning can be achieved by adopting blended learning models that integrate both online and offline environments, allowing students to learn at their own pace. Adaptive learning platforms can further tailor the educational experience by adjusting content difficulty based on individual student performance. Another key strategy is to implement a modular curriculum, which offers students the opportunity to select learning paths aligned with their personal interests and career aspirations. Personalization can be enhanced through AI-driven learning analytics, which track student progress and provide customized feedback and resources. Hands-on engagement is critical in engineering education, and emerging technologies can play a significant role to help them for the progress in right direction and providing practical learning experiences without the need for physical resources. Additionally, incorporating these technologies into the curriculum can bridge the gap between theory and practice, as students work on real-world problems that require the application of their knowledge.

Fostering Collaboration, Skill Development, and Experiential Learning

Collaboration among students can be significantly enhanced by leveraging collaborative platforms such as Microsoft Teams, Slack, or Google Workspace, which facilitate group projects and discussions, even in remote settings. Peer-led learning sessions, where students teach and learn from each other, can further reinforce understanding and collaboration skills. Skill development, particularly in the context of preparing students for the modern workforce, can be achieved by establishing partnerships with industry leaders. These partnerships can offer students internships, workshops, and opportunities to solve real-world problems, directly linking their education to industry needs. In addition to technical skills, it is important to focus on soft skills development through courses and workshops on communication, teamwork, and leadership. Experiential learning opportunities should be a core component of the engineering curriculum. Furthermore, participation in hackathons and engineering competitions can encourage creativity, innovation, and the application of skills in a competitive environment.

By implementing these strategies, the study's objectives of enhancing learning experiences and preparing engineering students for the evolving demands of the modern world can be effectively achieved.

The quote presented by IUCEE, "We are teaching. Are they learning?" is a fundamental concern for educators. To enhance the effectiveness of teaching and learning, emerging technologies play a pivotal role in fostering students' knowledge development. This approach is designed to ensure that students not only receive instruction but also actively engage in the learning process, with a particular focus on nurturing critical thinking skills as highlighted in Figure 2.

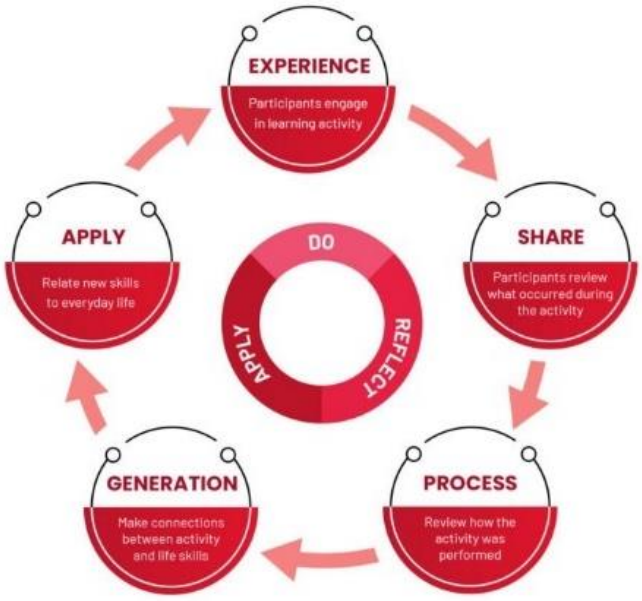

Fig. 2. Experiential learning
(Ref: https://www.harvestinternationalschool.in/experiential-learning/ , Date: 30-08-2023)

Here are some emerging technologies that could be integrated into engineering pedagogy in line with the NEP:

At RK University, we utilize a variety of LMS tools, including Canvas, Moodle, Google Apps, Kahoot, and SurveyMonkey, to effectively create and manage courses, quizzes, and assessments. These tools enable us to efficiently deliver online courses, monitor student progress, and promote interactive learning experiences.

One of the key tenets of the NEP is to provide quality education that is accessible to a wider range of students. Online and blended learning platforms play a crucial role in achieving this by breaking down geographical barriers and enabling students to access courses and resources remotely. This is particularly significant in the context of engineering education, as it allows students from various parts of the country to enrol in specialized programs without the need for relocation.

Moreover, these platforms align with the NEP's goal of promoting interdisciplinary learning. Engineering education has evolved beyond traditional isolated discipline; instead, it encourages collaboration. Online platforms facilitate the integration of diverse subjects, enabling engineering students to engage with other domains such as humanities, social sciences, and entrepreneurship. This approach nurtures a holistic understanding of complex real-world challenges.

Blended learning, which combines online and face-to-face interactions, fosters an interactive and collaborative learning environment. Students can access pre-recorded lectures and learning materials online, allowing them to learn at their own pace. This flexibility is in harmony with the NEP's emphasis on individualized learning, catering to students' diverse learning speeds and preferences. Classroom time can then be utilized for discussions, problem-solving, and practical applications, enhancing the overall learning experience.

In the context of engineering, where hands-on experience is vital, virtual labs offered through online platforms provide an innovative solution. These labs simulate real-world experiments and scenarios, enabling students to gain practical skills and theoretical knowledge in a controlled digital environment. This approach not only addresses the limitations of physical lab setups but also aligns with the NEP's call for experiential and applied learning.

At RK University, we have strategically integrated specific courses with NPTEL Massive Open Online Courses (MOOCs). Through dedicated mentoring and guidance, our approach has yielded significant success in steering our students towards a well-rounded and globally competitive education. This collaborative effort allows students to access high-quality content, engage in rigorous learning, and develop the skills and knowledge needed to excel on a global scale.

However, successful integration of online and blended learning platforms in engineering pedagogy requires careful planning and faculty development. Educators need to adapt their teaching methods to engage students effectively in the digital space, focusing on fostering critical thinking, problem-solving, and analytical skills. Technical support and infrastructure enhancements are also essential to ensure a seamless learning experience for all students.

In conclusion, online and blended learning platforms are transformative tools in engineering education, aligning seamlessly with the principles of the NEP. They facilitate accessibility, interdisciplinary learning, personalized education, and practical experience—all of which are crucial for producing well-rounded and skilled engineers ready to tackle the challenges of the modern world. Here are the details about various emerging technologies and their implementation:

A. Artificial Intelligence (AI) and Machine Learning (ML)

These technologies integrated into engineering curricula to enhance learning experiences. AI-powered tools provided personalized learning paths, identified students' strengths and weaknesses, and offered real-time feedback on assignments.

The integration of Artificial Intelligence (AI) and Machine Learning (ML) into engineering education holds significant promise for enhancing the learning experience and preparing students for the challenges of modern engineering. AI revolutionized how students engaged with educational content by enabling personalized learning pathways. Through the analysis of individual learning patterns and performance, AI systems adapted the curriculum to suit students' strengths and weaknesses, ensuring a more effective and tailored learning experience. This approach aligned well with the goals of engineering education under the NEP, which emphasized the need for a flexible and learner-centered approach.

Furthermore, AI-driven assessment tools provided instant feedback on assignments and assessments, helping students identified areas where they need improvement. Educators then used this data to adjust their teaching strategies and provided targeted support to students, fostering a deeper understanding of complex engineering concepts. This

approach aligned with NEP's focus on continuous assessment and formative feedback, enabling a more holistic understanding of students' progress.

At RK University, we are using different AI-driven tools like Google Apps, Quizlet, ScribSence, etc. for making learning more effective, efficient, and accessible to a broader audience. This supported both students and educators in their quest for improved learning outcomes. We are also using IIT Bombay virtual labs for different practical subject practices to offer students and educators the opportunity to conduct experiments and simulations online, making practical learning more accessible and cost-effective. These labs covered various scientific and engineering disciplines, providing realistic simulations and a wide range of learning resources. IIT Bombay Virtual labs promoted safety, flexibility, and remote collaboration while allowing students to repeat experiments and integrate them into their curricula. Additionally, Virtual Labs supported research endeavours and offered assessment tools for evaluating student performance, making them a valuable resource for enhancing science and engineering education.

In engineering disciplines that required practical experience, AI-powered simulations and virtual labs provided a valuable solution. These technologies created controlled environments where students experimented, designed, and troubleshooted without the constraints of physical resources. This is particularly crucial for universities facing limitations in laboratory facilities. As NEP aims to make education accessible to all, AI-powered virtual labs helped bridge the gap for students who lack access to conventional lab setups.

Moreover, AI and ML techniques played a significant role in engineering research and innovation. From optimizing designs to processing and visualizing vast datasets, these technologies offered students the opportunity to engage in cutting-edge research projects. This aligned with NEP's vision of encouraging research-oriented learning and fostering a culture of innovation among students.

Incorporating AI and ML technologies into engineering education also addressed the growing demand for industry-relevant skills. Graduates who are familiar with AI concepts and applications are better prepared for the evolving job market, where AI skills are increasingly sought after in various engineering domains. By integrating AI and ML into the curriculum, institutions can better equip students for the demands of the future workforce.

However, successful implementation requires overcoming challenges such as faculty training, infrastructure, and staying updated with the rapid advancements in AI and ML. As AI continues to reshape industries, engineering education that embraces these technologies not only aligns with NEP's goals but also equips students with the skills and mindset needed to thrive in the dynamic and technologically driven world of engineering.

B. The Internet of Things (IoT)

IoT technologies integrated into engineering labs to enable hands-on experience with real-time data collection and analysis. Students worked on projects involving data from connected devices, enhancing their problem-solving skills.

In the backdrop of the NEP, the fusion of Internet of Things (IoT) technologies presented a transformative opportunity to revolutionize engineering education. This emphasised on experiential and multidisciplinary learning finds a perfect ally in these technologies, which offered a tangible bridge between theoretical knowledge and real-world applications. By integrating IoT devices and sensors into engineering curricula, students engaged with dynamic data streams from the physical world, fostering a deeper understanding of concepts and encouraging problem-solving rooted in practicality.

At RK University, we provided students with practical experiences in IoT to tackle real-life challenges. Our approach included offering IoT courses that equipped students with the skills needed to solve tangible problems. To immerse students in the world of problem-solving, we organized full-day hackathons where they applied IoT knowledge. These hands-on experiences empowered students to create mobile apps and web applications while applying engineering theory concepts. Students from different branches have participated in these events in terms of collaboration with computer science students which helped all students to work effectively while applying their extraordinary domain specific knowledge for practical solutions.

Our students' enthusiasm for learning and problem-solving is evident through their active participation in various state and national-level events. Their achievements, including winning prizes and cash rewards from government bodies, reflect their commitment to mastering IoT technology and their passion for addressing real-world issues. These accomplishments showcased the value of practical learning and the joy it brings to our students.

Furthermore, Engineering students collaborated with peers to create integrated systems that addressed multifaceted challenges these moved them towards multidisciplinary approach. For instance, computer science students have collaborated with mechanical engineering students to design and deploy smart devices that optimize energy usage within buildings. This cross-disciplinary collaboration nurtures adaptability, communication, and teamwork – qualities essential in today's interconnected work environments.

However, successful integration of IoT into engineering education required careful planning. Institutions needed to invest in IoT infrastructure, hardware, and software, ensuring seamless access to devices and data. Educators undergoes for training to design IoT-based projects that effectively conveyed engineering principles while promoting critical thinking and creativity. Moreover, ethical considerations related to data privacy, security, and sustainability addressed to impart responsible engineering practices.

In conclusion, the convergence of IoT with the NEP's aspirations for innovative education opened doors to transformative learning experiences in engineering. By leveraging real-world data and interdisciplinary

collaboration, institutions empowered students to become adept problem-solvers, proficient in applying theoretical knowledge to real-world scenarios. As IoT continues to shape industries, integrating it into engineering pedagogy prepared students for the dynamic challenges of the modern world while aligning with the principles of the NEP.

C. Data Analytics and Visualization

Teaching students how to gather, analyse, and visualize data can be essential in various engineering disciplines. Students can learn to make data-driven decisions and communicate their findings effectively.

In the context of the NEP, the incorporation of Data Analytics and Visualization into engineering education offers a transformative avenue to bridge the gap between theoretical learning and practical application. These tools resonated profoundly with the NEP's emphasis on experiential learning and multidisciplinary approaches, fostering a deeper understanding of complex engineering concepts through hands-on engagement with real-world data.

At RK University, we have integrated Data Analytics into coursework, so that students can explore engineering challenges through the lens of data-driven decision-making. For example, computer engineering students can analyse performance data to find patterns, which helps them design better systems. This hands-on interaction with data not only imparted practical skills but also cultivated a mindset that embraced evidence-based problem-solving, in alignment with the NEP's vision.

Visualization complemented Data Analytics by offering a powerful means to communicate complex engineering concepts. Visual representations of data, such as graphs, charts, and interactive models, enabled students to effectively communicate their findings and insights. By integrating Visualization tools, such as software for 3D modelling or interactive dashboards, students created compelling visual narratives that can help to enhance their ability to convey intricate engineering information to both technical and non-technical audiences, aligning with the NEP's focus on effective communication skills.

In conclusion, the fusion of Data Analytics and Visualization with the NEP's vision enriches engineering education by offering immersive, multidisciplinary, and experiential learning experiences. By leveraging real-world data and empowering students to communicate complex concepts visually, these tools equip aspiring engineers with skills essential for success in the digital age. As our institution embraced the transformative capabilities of Data Analytics and Visualization, this pave the way for engineering graduates who can navigate intricate challenges while embracing the principles of the NEP.

Here is a summary of the tools mentioned, categorized by their type and application used at our place:

Artificial Intelligence (AI) and Machine Learning (ML)

- Google Apps
- Quizlet
- ScribSence
- AI-driven assessment tools

Online and Blended Learning Platforms

- Learning Management Systems (LMS): Canvas, Moodle
- Online Platforms: Google Apps, Kahoot, SurveyMonkey
- Virtual Labs: IIT Bombay virtual labs, NPTEL MOOCs

Data Analytics and Visualization

- Data Analytics Tools: Python, R, SQL
- Visualization Tools: Tableau, Power BI

Internet of Things (IoT)

- IoT Devices and Systems: Used in interdisciplinary projects, e.g., smart home automation projects

Implementation Considerations

- Faculty Training and Development: Workshops, seminars, online courses
- Infrastructure Enhancement: High-quality hardware and software, upgraded internet connectivity
- Curriculum Alignment: Revised curriculum to include modules on emerging technologies, practical assignments, and interdisciplinary projects

These tools and platforms are leveraged to provide a holistic, flexible, and experiential learning environment in line with the National Education Policy (NEP) goals.

Here's a detail of the tools currently used in engineering education at RK University:

- Canvas: An online learning management system for course management.
- Moodle: Another online platform for managing courses and content.
- Google Apps: Tools like Google Drive, Docs, and Sheets for collaborative work.
- Kahoot: An interactive tool for creating quizzes and engaging students.
- SurveyMonkey: A platform for creating and distributing surveys.
- IIT Bombay Virtual Labs: Online labs for simulating real-world experiments.
- NPTEL MOOCs: Online courses offered by the National Programme on Technology can help to enhance learning.
- Quizlet: A tool for creating flashcards and study sets.
- ScribSence: A collaborative writing and note-taking tool.
- Python, R, SQL: Programming languages and tools for data analysis.
- Tableau, Power BI: Tools for data visualization and creating interactive dashboards.
- IoT Devices: Internet-connected devices used in various engineering projects.

These tools helped in creating a blended learning environment, combining online and offline educational experiences.

In the context of engineering education, several AI-driven assessment tools effectively integrated to enhance the learning experience and provided valuable feedback for

both students and educators. Here is a concise overview of various tools and some background information that have facilitated our efforts in advancing engineering education.

- Google Apps: Tools like Google Forms used for creating quizzes and surveys that automatically graded responses and provided instant feedback. This helped in assessing students' understanding of the material in real-time.
- Quizlet: This platform offered AI-driven flashcards and quizzes that adapted to the student's learning pace. It helped in reinforcing concepts and providing immediate feedback, which is crucial for continuous learning and improvement.
- ScribSence: An AI-based tool that aided in improving writing skills by providing real-time suggestions and corrections. It is particularly useful for engineering students who need to enhance their technical writing abilities.
- IIT Bombay Virtual Labs: These virtual labs provided AI-powered simulations for various engineering experiments. They offered realistic lab experiences, enabling students to conduct experiments and received instant feedback on their performance, even without physical lab resources.
- AI-Powered Simulations: These tools created controlled environments where students experimented, designed, and troubleshooted engineering problems. They provided a practical learning experience and helped in developing problem-solving skills by offering immediate feedback and suggestions for improvement.
- Data Analytics and Visualization Tools: Platforms like Tableau and Power BI used to teach students how to analyse and visualize complex data sets. These tools provided immediate feedback on data manipulation and presentation, helping students understand and communicate their findings effectively.

These AI-driven tools not only help to enhance the assessment process but also complementary slightly matched with the goals of the National Education Policy (NEP) by providing personalized, interactive, and practical learning experiences. They supported continuous assessment and formative feedback, fostering a deeper understanding of complex engineering concepts

While emerging technologies have shown significant potential in enhancing the teaching-learning environment, they should be viewed as complementary to conventional teaching methods. These technologies alongside traditional approaches can provide a more robust and effective educational framework, rather than entirely replacing conventional methods. Here is details about how these technologies leveraged effectively:

Artificial Intelligence and Machine Learning: Practical Application and Problem-Solving

At RK University, the integration of AI-driven tools like Google Apps, Quizlet, and ScribSence, along with IIT Bombay's virtual labs, has significantly complementary helped to enhance learning outcomes. These tools supported effective communication, real-time collaboration, personalized learning, and efficient feedback, fostering teamwork and project management skills. The virtual labs offered realistic simulations across various scientific and engineering disciplines, promoting safety, flexibility, and accessibility. They allowed students to conduct and repeat experiments remotely, integrating practical learning into the curriculum. This combination of technologies not only improved theoretical understanding but also enhances practical skills, making education more inclusive and preparing students for the challenges of modern engineering. Additionally, continuous feedback and faculty training ensured the ongoing effectiveness and innovation of these educational practices.

Internet of Things (IoT): Interdisciplinary Knowledge and System Integration

IoT provided students with opportunities to work on interdisciplinary projects that require knowledge of hardware, software, and network systems. This helped them understand system integration and the broader applications of their technical skills. Example: Students at RK University have engaged in projects such as a smart automated dustbin and a smart attendance system, where they designed and implemented systems managed through a mobile app. These projects provided hands-on experience in embedded systems, wireless communication, and user interface design. As a result, students developed versatility in various technological domains, enhancing their practical skills and preparing them for real-world engineering challenges.

Data Analytics and Visualization: Data Interpretation and Communication Skills

Data analytics and visualization empowered students with the ability to interpret complex data sets and communicate findings effectively. These skills are critical for making data-driven decisions and presenting insights in a clear, understandable manner. Example: A course on data analytics included a project where students analyse a large dataset from a real-world source, such as social media trends and public health records. They used tools like Python, R, and SQL to clean, process, and analyse the data, then employ visualization tools like Tableau and Power BI to create intuitive, interactive dashboards. This process helped them to develop technical skills in data manipulation and visualization while also enhancing their ability to tell compelling stories through data.

D. Key Considerations for Implementing Emerging Technologies in Engineering Education

Implementing emerging technologies in education requires a well-structured approach that aligns with the goals of the NEP and maximizes the benefits of these technologies. Based on the experiences of implementation at RK University, following thing outlines the key steps and considerations for effectively integrating these technologies into engineering educational institutions.

1) Needs Assessment

Before implementing any technology, conduct a comprehensive needs assessment to identify specific goals and areas for improvement. Survey students and faculty to understand their needs and align these with the objectives of the NEP. This initial assessment forms the foundation for the strategic implementation of emerging technologies.

Implementation Steps:

1. Conduct surveys and focus groups with students and faculty.
2. Analyse current educational outcomes and identify gaps.
3. Align technological needs with educational objectives and NEP goals.

2) Faculty Training and Development

Faculty members are crucial to the successful integration of emerging technologies. Provide extensive training through workshops, seminars, and online courses to ensure educators can effectively utilize these technologies.

Implementation Steps:

1. Organize regular training sessions on new technologies.
2. Provide access to online courses and certification programs.
3. Facilitate peer-to-peer learning and collaboration among faculty.

3) Infrastructure Enhancement

A robust technological infrastructure is essential. Ensure that the institution has adequate hardware, software, and internet connectivity to support online and blended learning, AI applications, IoT devices, and data analytics tools.

Implementation Steps:

1. Invest in high-quality hardware and software.
2. Upgrade internet connectivity to support high bandwidth requirements.
3. Regularly maintain and update technological infrastructure.

4) Curriculum Alignment

Integrate emerging technologies into the curriculum to enhance learning outcomes. Collaborate with faculty to design practical assignments and projects that incorporate these technologies.

Implementation Steps:

1. Revise curriculum to include modules on emerging technologies.
2. Develop interdisciplinary projects that require the use of new technologies.
3. Ensure practical applications of technologies are included in coursework.

5) Content Development

Develop or curate digital content tailored to the integrated technologies. This content should be interactive, promote critical thinking, and support experiential learning.

Implementation Steps:

1. Create interactive learning materials and AI-driven assessments.
2. Use multimedia resources to cater to various learning styles.
3. Develop data analytics resources to enhance data interpretation skills.

6) Accessibility and Inclusivity

Ensure technologies are accessible to all students, regardless of background or abilities. Design content and experiences to accommodate different learning needs and provide equal opportunities.

Implementation Steps:

1. Implement universal design principles in content creation.
2. Provide assistive technologies for students with disabilities.
3. Ensure all students have access to the necessary devices and internet connectivity.

7) Pilot Programs and Evaluation

Conduct pilot programs to test the effectiveness of new technologies. Gather feedback from participants to identify strengths and areas for improvement.

Implementation Steps:

1. Launch pilot programs with a select group of students and faculty.
2. Collect and analyze feedback from pilot participants.
3. Refine implementation strategies based on pilot results.

8) Continuous Improvement

Stay updated with advancements in technology and continuously refine the implementation strategy. Incorporate feedback and monitor outcomes to ensure alignment with NEP goals.

Implementation Steps:

1. Regularly review and update the technology integration plan.
2. Monitor technological advancements and educational trends.
3. Encourage continuous professional development for faculty.

9) Assessment and Quality Assurance

Regularly assess the impact of integrated technologies on learning outcomes. Collaborate with quality assurance teams to ensure the implementation meets educational standards.

Implementation Steps:

1. Use data analytics to track student progress and engagement.
2. Conduct regular evaluations of technology integration.
3. Work with quality assurance teams to maintain high standards.

By following these detailed considerations, educational institutions can effectively implement emerging technologies, enhancing the learning experience, and preparing students for the future. This approach ensures that the integration is systematic, inclusive, and aligned with the overarching educational objectives.

E. Enhancing Learners' Skills Through Emerging Technologies: Insights for the Teaching Community

Emerging Technologies definitely enhances learner's skill sets, but what how it enhances, so that teaching

community can benefit with this novel approach. To address this regarding how emerging technologies enhance learners' skill sets, particularly to benefit the teaching community, here are some insights:

1) Personalization and Flexibility

Emerging technologies, such as AI and ML, allow for personalized learning experiences tailored to individual students' strengths and weaknesses. This means that educators can offer more targeted instruction, helping each student to progress at their own pace and according to their unique needs. This flexibility can lead to better engagement and outcomes, ultimately benefiting the teaching community by making instruction more effective.

2) Experiential Learning

Technologies like IoT and virtual labs provide hands-on learning opportunities that connect theoretical knowledge with practical application. This approach aligns with modern pedagogical trends that emphasize experiential learning, where students are more engaged and better prepared for real-world challenges. Teachers can leverage these tools to create more dynamic and interactive learning environments, which can significantly enhance students' critical thinking and problem-solving skills.

3) Collaboration

The integration of online and blended learning platforms facilitates collaboration among students. This not only broadens students' knowledge base but also fosters teamwork and thinking process—skills that are increasingly valuable in the modern workforce. For educators, these platforms can simplify the process of incorporating interdisciplinary projects into their curriculum, enriching the overall learning experience.

4) Continuous Assessment and Feedback

AI-driven assessment tools provide real-time feedback to students, allowing for continuous improvement and a deeper understanding of subject matter. This continuous assessment aligns with modern educational frameworks, which prioritize ongoing formative feedback over traditional summative assessments. Educators benefit from these tools by being able to monitor student progress more closely and adjust their teaching strategies accordingly.

5) Skill Development and Industry Readiness

By integrating technologies like data analytics, AI, and IoT into the curriculum, students develop industry-relevant skills that make them more competitive in the job market. This not only helps to enhance the employability of graduates but also reflects positively on the educational institutions and their faculty, who are seen as forward-thinking and aligned with industry needs.

In conclusion, the teaching community can benefit significantly from the integration of emerging technologies as they allow for more personalized, experiential, and collaborative learning experiences, all of which contribute to the development of well-rounded, industry-ready graduates. These technologies support educators in delivering more effective instruction and in meeting the evolving demands of modern education.

Also, the implementation of emerging technologies in education demands careful planning, faculty support, infrastructure development, and continuous evaluation. By aligning with the NEP's principles, educational institutions can harness the transformative power of these technologies to provide students with personalized, experiential, and advanced learning experiences that prepare them for the challenges of the modern world.

IV. Result Analysis

The impact of utilizing Emerging Technologies in education was assessed among B.Tech. Computer Engineering students in their 2nd and 6th semesters for the academic years 2020-21 and 2022-23, as outlined in Table I, using key factors (Level, Grades, Grade Points, Percentage, No of Students for the proposed study, Passing Ratio in Group) as outlined by Ganesh in 2018. The results for the academic year 2020-21 indicate that approximately 20% of students achieved grades equal to or higher than B+ without the use of the Emerging Technologies approach. In contrast, the results for the academic year 2022-23, where the Emerging Technologies approach was implemented, reveal that around 49% of students achieved grades equal to or higher than B+.

From Table I, it is clear that 61.82% of students scored below a C+ in the 'without emerging technologies' category, indicating that a significant portion of students were not benefiting from the teaching-learning environment. When emerging technologies were introduced, this percentage dropped to 30.92%, showing an improvement in grades. This suggests that either the conventional teaching methods used in AY 2020-21 were not effective or the students did not receive the best possible conventional teaching methods during that year. While the integration of emerging technologies in AY 2022-23 did enhance the learning environment, it is important to remember that these technologies should complement, not replace, traditional teaching methods. The effectiveness of teaching methods, both new and traditional, is crucial for improving student outcomes.

TABLE I
Score Analysis of Engineering Students

Level	Grade	% Student without Emerging Technologies (AY 2020-21)	% Student with Emerging Technologies (AY 2022-23)
Outstanding	A+	1.82	14.55
Excellent	A	7.27	16.36
Very Good	B+	10.91	18.18
Good	B	18.18	20.00
Above Average	C+	14.55	9.09
Average	C	27.27	14.55
Poor	D	10.91	3.64
Fail	F	9.09	3.64

This comparison is visually presented in Figure 3. This assessment underscores that students have shown a greater preference for and enthusiasm toward the Emerging Technologies approach over the conventional learning method.

Figure 3 represent the given data in Table I i.e., for pictorial representation and to show how the proposed approach has resulted in a notable and statistically

significant improvement in student performance. This helps to draw conclusion from a thorough analysis of the data collected from the same group of students before and after the implementation of the proposed pedagogy. As depicted in Figure 3, a notable and statistically significant improvement in results has been observed for the proposed approach.

Figure 4 illustrates a substantial increase in the number of students achieving grades (>=70%) when using the Emerging Technologies-based approach as compared to the conventional approach.

In this experiment, two groups were established to assess the impact of the proposed approach on student knowledge: the control group, which followed the Conventional approach (grades for A.Y. 2020-21, found in the last second column of Table I), and the experimental group (grades for A.Y. 2022-23, found in the last column of Table I). These two groups were meticulously matched against each other.

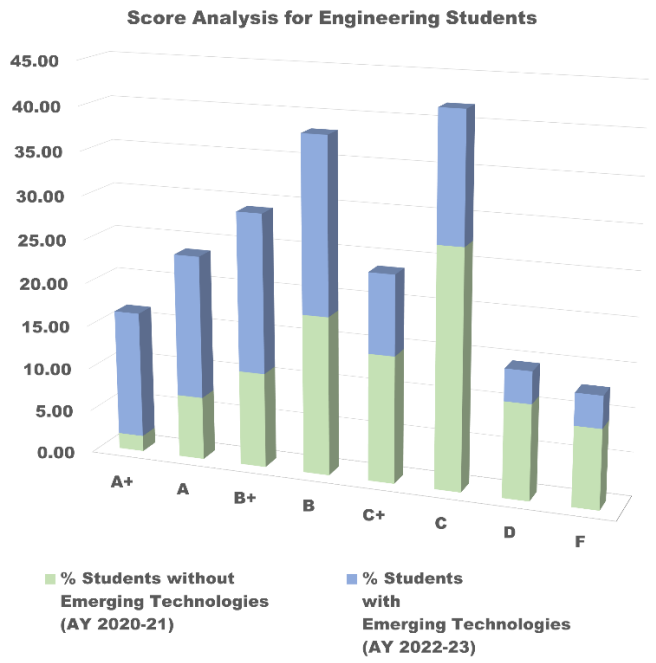

Fig. 3. Score Analysis Comparison

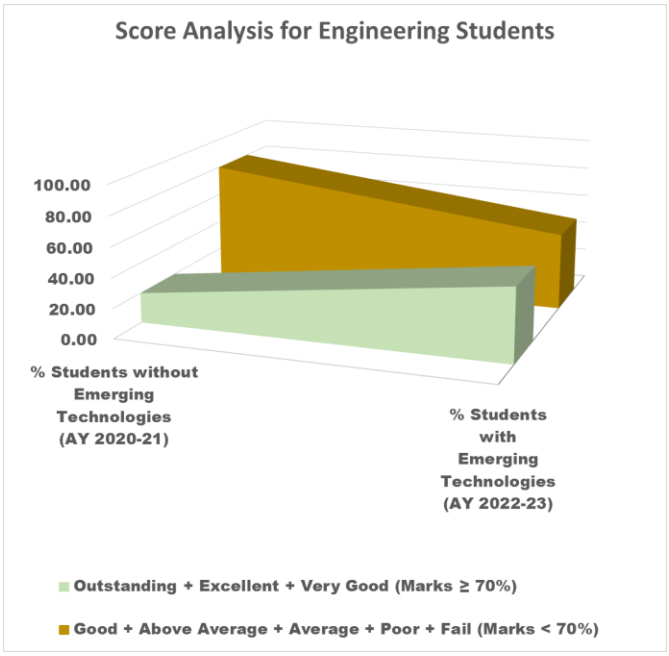

Fig. 4. Result Analysis Comparison between ">=70% Students Group" & "<70% Students Group"

TABLE II
THE PAIRED SAMPLES STATISTICS OF CONVENTIONAL AND EMERGING TECHNOLOGIES APPROACH

Level	Without Emerging Technologies		With Emerging Technologies	
	Mean	Standard Deviation	Mean	Standard Deviation
Grades >= 70%	6.67	4.57	16.36	1.82
Grades < 70%	16.00	7.20	10.18	7.11

To analyse the data, a factual analysis was applied to determine the mean and standard deviation of the scores. Because the grades for both the Conventional and Emerging Technologies-based approaches were obtained from the same group of students in two different semesters, a paired t-test was employed to assess the significant differences between the grades for both examinations. This paired t-test was used to test the hypothesis. When we refer to "the same batch of students in two different semesters," we mean that the same group of students was studied over two academic terms. Specifically: Second Semester: The students were taught using traditional teaching methods. Data on their performance was collected at the end of this semester. Sixth Semester: The same group of students was then taught using the proposed new teaching pedagogies. Again, their performance data was collected at the end of this semester.

By comparing the performance data from these two semesters, we can assess the impact of the new teaching pedagogies. Using the same batch of students ensures that the comparison is fair and that any observed differences in performance are due to the change in teaching pedagogies rather than differences between different groups of students.

Table II presents the combined results of the tests for the Conventional and Emerging Technologies approaches. The

overall conclusion reveals that there is more than a two-fold improvement in grades (>=70%) when using the Emerging Technologies approach compared to the Conventional approach.

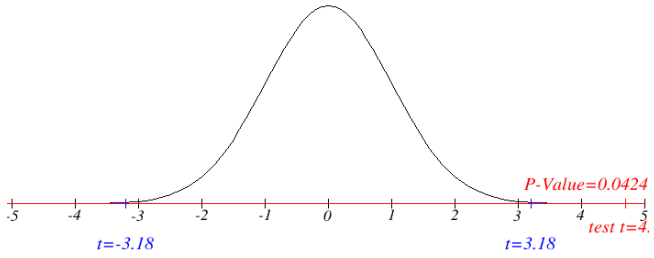

Fig. 5. Results of Paired Samples t-Test over Grades (>=70%)

In this study, the hypothesis testing employed a paired sample t-test. The anticipated outcome was a higher mean value for the Emerging Technologies approach compared to the Conventional approach.

The null hypothesis (H0) stated: "There is no significant difference in the mean for the Emerging Technologies approach compared to the Conventional approach."

The alternative hypothesis (H1) stated: "There is a significant difference in the mean for the proposed Emerging Technologies approach compared to the Conventional approach."

Table III and Figure 5 present the results of the paired t-test for grades (>=70%). At a 5% significance level, all null hypotheses were rejected. The t-test results, indicated by the p-values, clearly demonstrate that the use of the Emerging Technologies approach has led to a substantial improvement compared to the Conventional approach.

Therefore, it can be concluded that there is a statistically significant difference between the mean scores of the Conventional approach and the Emerging Technologies approach. Consequently, it is evident that the Emerging Technologies approach significantly enhances students' technical skills. Recent studies have consistently demonstrated that the integration of emerging technologies in engineering education significantly enhances student learning outcomes. In a controlled study comparing traditional teaching methods with proposed pedagogies showed a remarkable improvement in their final score. The data revealed that the use of these technologies not only increased engagement and motivation but also facilitated deeper understanding of complex concepts through interactive and adaptive learning experiences. Consequently, the clear and consistent correlation between the use of emerging technologies and improved academic performance underscores the conclusion that these innovative pedagogical tools are the primary drivers of the observed enhancements in student final marks. Effective collaboration has significantly expanded students' knowledge in their respective fields, leading to improved academic performance.

TABLE III
RESULTS OF PAIRED SAMPLES T-TEST OF CONVENTIONAL AND EMERGING TECHNOLOGIES APPROACH

Level	Paired Differences (%)		t-test result
	Mean	Standard Deviation	(2-tailed)
Grades >= 70%	9.70	2.75	0.042

A. *Results of Paired Sample t-Test for Grades < 70%*

This details the results of the paired sample t-test conducted to evaluate the impact of emerging technologies on students' grades. Specifically, for students scoring below 70%, the results showed a notable difference between the conventional approach and the approach utilizing emerging technologies.

In the conventional approach, the mean percentage of students scoring below 70% was 16.00% with a standard deviation of 7.20. After the implementation of emerging technologies, this mean decreased to 10.18% with a standard deviation of 7.11. This indicates a reduction in the number of students performing poorly when emerging technologies were integrated into the teaching methodology.

The paired sample t-test results showed the following for grades below 70%:

Mean Difference: -5.82, Standard Deviation: 4.64, p-value: 0.038

This p-value indicates a statistically significant difference, suggesting that the use of emerging technologies had a positive effect in reducing the number of students scoring below 70%, thus improving overall performance.

The implementation of emerging technologies in the educational approach significantly reduced the percentage of students scoring below 70%. The paired sample t-test results reinforce the effectiveness of these technologies in enhancing student performance and ensuring a higher rate of academic success.

These results collectively highlight the positive impact of integrating emerging technologies into educational practices, fostering better learning outcomes and reducing the incidence of low performance among students.

The mentioned objectives of the study for enhancing learning experiences through flexibility, personalization, and hands-on engagement has been largely achieved through the integration of emerging technologies. However, the results also underscore the ongoing importance of traditional teaching methods in creating a balanced and effective educational environment.

B. *Flexibility and Personalization in Learning*

The introduction of emerging technologies has significantly contributed to creating a more flexible and personalized learning environment. This is reflected in the improved academic outcomes, with the percentage of students achieving grades equal to or higher than B+ increasing from 20% in 2020-21 (without emerging technologies) to 49% in 2022-23 (with emerging technologies). This indicates that

these technologies have enabled students to engage with the material at their own pace and according to their learning preferences. However, it is important to recognize that traditional teaching methods provide a foundational structure that supports and complements these flexible learning approaches, ensuring that students receive a well-rounded education.

C. Hands-On Engagement and Experiential Learning

The integration of technologies such as virtual labs and simulations has played a critical role in enhancing hands-on engagement and experiential learning, leading to a significant reduction in the percentage of students scoring below a C+ (from 61.82% to 30.92%). These tools have allowed students to interact with complex concepts in a more practical and immersive manner, thereby improving understanding and retention. Nonetheless, traditional hands-on approaches, such as laboratory work and in-person projects, remain vital for providing students with tactile, real-world experiences that technology alone cannot fully replicate.

D. Effective Collaboration and Skill Development

The study further examined how emerging technologies could enhance collaboration and skill development. While the overall improvement in grades (particularly the increase in students achieving grades >=70%) suggests that students have benefited from these technologies, the role of traditional teaching methods in fostering collaboration and communication skills cannot be overlooked. Traditional methods, including group discussions, peer reviews, and in-class teamwork, continue to be essential for developing the interpersonal skills that are crucial in engineering and other collaborative fields.

In conclusion, the results indicate that while the integration of emerging technologies has significantly enhanced flexibility, personalization, and hands-on engagement in the learning process, these advancements work best when complemented by traditional teaching methods. The blend of both approaches has proven effective in improving student performance, ensuring that students not only adapt to modern technological tools but also retain the critical thinking, problem-solving, and collaborative skills developed through conventional educational practices. This balanced approach is key to preparing students to meet the evolving demands of the modern engineering landscape.

E. Causal Relation Between Emerging Technologies and Student Performance

The causal relationship between the use of emerging technologies and the improvement in student performance was established through statistical analysis, including a paired sample t-test. This test compared the mean performance of the same group of students under both conventional and technology-integrated teaching methods. The results showed a statistically significant improvement in grades when emerging technologies were used.

The mean grades of students scoring 70% or higher increased from 6.67% in the conventional approach to 16.36% with the integration of emerging technologies. Additionally, the t-test results, with a p-value of 0.042, confirmed that the improvement was statistically significant, leading to the rejection of the null hypothesis that there was no significant difference between the two approaches.

This improvement can be attributed to several factors associated with emerging technologies, such as increased engagement, motivation, and deeper understanding of complex concepts through interactive and adaptive learning experiences. Consequently, the clear and consistent correlation between the use of these technologies and improved academic performance underscores the conclusion that these innovative pedagogical tools are the primary drivers of the observed enhancements in student final marks.

In short, the assessment methods differed significantly between the two groups, with the integration of emerging technologies showing a marked improvement in student performance. The causal relationship is evident through statistical analysis, highlighting those emerging technologies not only help to enhance technical skills but also foster a deeper understanding and greater engagement among students. This evidence strongly supports the continued integration of such technologies in educational settings to optimize learning outcomes.

F. Post Implementation

1) Student Feedback

Student feedback has been taken with the feedback questions focusing on learning through emerging technologies with small rating-based questions like:

1. How would you rate your overall satisfaction with learning through emerging technologies in this course? (Scale: 1-10)
2. On a scale of 1 to 5, how useful did you find AI and ML technologies in aiding your learning?
3. Please rate the effectiveness of IoT devices in enhancing your engagement with course materials. (Scale: 1-5)
4. How helpful were data analytics and visualization tools in facilitating your understanding of complex concepts? (Scale: 1-5)
5. Considering your learning experience with emerging technologies, how likely are you to recommend their use in future courses? (Scale: 1-10)

These questions provide students with the opportunity to express their satisfaction levels and perceptions regarding the integration of emerging technologies in their learning experience, which can help instructor by offering valuable quantitative data for analysis.

It's great to hear that around 89% of the students who provided feedback showed positivity towards implementing emerging technologies in engineering education. This level of enthusiasm and support from students is often a promising sign for the proposed approach. It suggests that students are receptive to incorporating new and innovative technologies into their learning experience and believe that

it can enhance their understanding of concepts in technical courses.

Students are more likely to follow rules when they have a hand in creating or designing those rules themselves (Biswal, 2023).

Many students who enrol in engineering courses have great potential, skills, and capabilities. However, a lack of motivation can cause them to lose their enthusiasm and become less engaged in their studies (Patel, 2017).

This positive feedback can serve as a strong motivation to further develop and implement the proposed approach in engineering education. It's essential to continue gathering feedback and monitoring the impact of these emerging technologies on students' learning outcomes and engagement to ensure that the educational goals are being met effectively. Additionally, addressing any concerns or challenges that may arise during the implementation process will be crucial for the success of this initiative.

Overall, the positive response from students is a promising indicator of the potential benefits of integrating emerging technologies into engineering education, and it can help in garnering support from educators and administrators as well.

2) Facilitator Reflection

The facilitator's feedback was highly positive, indicating that the integration of emerging technologies in engineering education, particularly for technical courses, had a significant impact. Key points of praise included increased student engagement, better alignment with real-world applications, personalized learning opportunities, expanded access to educational resources, global reach, continuous improvement through feedback, and help to enhance preparedness for future career demands.

CONCLUSIONS

Implementation of emerging technologies involves advanced learning with AI & ML, IoT and Data Analytics and Visualization for secure credentialing, which go beyond traditional learning models. These technologies have shown they can greatly improve teaching and learning. However, they should be used together with traditional teaching methods, not replace them. By blending these new tools with traditional approaches, we can create a more effective and balanced educational system. Also, these technologies are integrated into the curriculum to enhance interactivity, personalization, and practical application. Additionally, the evaluation of these technologies' impact includes both quantitative metrics (e.g., improved exam scores) and qualitative feedback (e.g., increased student engagement and comprehension).

These emerging technologies support holistic learning in engineering by providing practical, hands-on experiences and enhancing theoretical understanding. This also highlight that these technologies are aligned with the National Education Policy (NEP) by creating a more dynamic and effective learning environment. By combining these advanced tools with established learning frameworks, we can say that emerging technologies are a significant factor in improving student final score along with skills.

In summary, integrating emerging technologies into engineering education supports the NEP's vision for a holistic and modern approach. These technologies improve learning through personalization, hands-on engagement, and collaboration. However, it is crucial to combine these innovations with traditional teaching methods, as both are important for a well-rounded education. Successful implementation requires careful planning and addressing accessibility challenges. Overall, this blend of new and traditional methods equips students with the skills they need for the future and aligns with the NEP's goal of transformative education.

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