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# Posters

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# Problem-Based Learning Using CAN/CUBE Satellites in Engineering Education

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**Abstract.** Project-based learning (PBL) empowers students through active engagement in real-world projects. This paper explores the effectiveness of using CubeSats (CAN/CUBE satel-lites) in PBL activities for education. We introduce PBL and its benefits, then delve into the characteristics of CubeSats and their suitability for PBL projects. Building on our experience conducting several workshops related to CAN SATELLITES, we describe various PBL activities that can be designed using CubeSats. These activities engage students in real-world applications of undergraduate engineering subjects. We showcase a specific PBL project using CubeSats, outlining its goals, activities, and outcomes. Furthermore, the paper explores how PBL with Cu-beSats integrates with various engineering subjects and how student learning can be assessed. We conclude by emphasizing the effectiveness of this approach in improving education and in-spiring future generations. Several students involved in our workshops have even received cop-yrights related to CAN SATELLITE projects, highlighting the innovation potential.

**Keywords:** PBL, CAN Satellite, Projects, Self-Learning

## 1 Introduction

The traditional, lecture-based approach to education is steadily giving way to a more engaging and impactful methodology: Project-Based Learning (PBL). A 2020 study published in the Journal of Educational Psychology found that students engaged in PBL projects demonstrated significantly higher critical thinking and problem-solving skills than those in traditional classrooms[1]. This shift towards PBL is particularly crucial in the education of engineering subjects where fostering innovation and application is paramount.

The dynamic nature of engineering fields makes PBL a powerful tool. A 2021 study in the International Journal of STEM Education highlights that PBL projects encourage students to integrate scientific principles, technological tools, and engineering design, leading to a deeper understanding of STEM concepts and their real-world significance[2]. Furthermore, PBL cultivates essential 21st-century skills like critical thinking, problem-solving, communication, and collaboration, as emphasized in a 2019

report by the Partnership for 21st Century Learning[3]. These skills are critical for success in the ever-evolving world of science and technology.

This paper explores the potential of CAN/CUBE satellites (miniature, low-cost satellites) as a powerful tool for PBL in education. We will examine how these versatile platforms can be leveraged to design engaging projects that ignite students' curiosity challenge them to apply their knowledge and foster a passion for exploration in the vast field of Engineering.

### **1.1 Problem-Based Learning**

Project-Based Learning (PBL) revolutionizes the traditional classroom by placing students at the helm of their learning journey [1]. It transcends rote memorization and passive learning, instead engaging students in meaningful and open-ended projects [1]. These projects require students to investigate real-world problems actively, collaborate with peers, and ultimately create solutions [2].

At the core of any PBL project lies a compelling driving question that sparks curiosity and motivates students to delve deeper [3]. This open-ended nature allows for the exploration of diverse approaches and solutions [3]. Furthermore, PBL projects are designed to mirror authentic scenarios encountered in the real world. This fosters a sense of purpose and relevance as students see the practical applications of what they're learning [4]. The teacher acts as a facilitator, guiding students through the project but empowering them to take ownership of their learning process [5]. Students actively participate in research, problem-solving, decision-making, and, ultimately, creating a final product [6]. Collaboration is often encouraged in PBL projects, fostering communication, teamwork, and the ability to share ideas effectively [7].

### **1.2 CAN/CUBE Satellites and PBL Activities**

The realm of Engineering is currently experiencing a surge in the use of CAN/CUBE satellites (CubeSats), which are miniature satellites revolutionizing PBL possibilities. These satellites provide a unique platform for students to engage in real-world applications of engineering concepts, mainly because of their defining characteristics. Their small size and low cost make them highly accessible for educational purposes. Standardized in size, ranging from 10x10x10 cm (1U) to larger configurations, these compact satellites can be launched as secondary payloads on various rockets, significantly reducing launch costs compared to traditional satellites.

These activities offer students valuable experience in various engineering fields, including engineering for satellite design and construction, physics for understanding orbital mechanics and radio communication principles, computer science for programming on-board computers and developing data analysis software, and mathematics for calculations, data analysis, and signal processing. CAN/CUBE satellites thus offer a powerful platform for PBL in education, igniting students' curiosity and empowering them to tackle challenges at the forefront of space exploration.

## **2 Impact**

PBL using CubeSats significantly impacts education in engineering subjects by enhancing problem-solving skills, increasing engagement and self-directed learning, fostering innovation, and providing end-to-end solution design experience. Students working on CubeSat projects encounter real-world engineering challenges and technical hurdles throughout the design, build, and launch process, requiring them to solve problems, troubleshoot issues, and iterate on their designs based on results.

Overall, the impact of PBL with CubeSats leads to a deeper understanding of engineering concepts, improved critical thinking and problem-solving skills, and a heightened sense of accomplishment. Students gain valuable technical and practical skills, develop a passion for engineering fields, and become better prepared for the challenges and opportunities of the future workforce. The potential for achieving student copyrights further underscores the potential for innovation and real-world impact through PBL with CubeSats.

## **3 Learnings and Challenges**

The CAN Satellite and Kite Satellite projects provided students valuable learning experiences while presenting several challenges. These projects offered students hands-on opportunities to engage in sensor interfacing, programming, communication protocols, and data analysis. Despite these valuable lessons, the projects also presented challenges for the students. Self-directed learning proved difficult for some, underscoring the need for adequate guidance and support structures to help students navigate independent learning. Technical hurdles, such as interfacing sensors, programming modules, or integrating components, also posed challenges that required access to troubleshooting resources and mentorship.

Project completion rates varied due to time constraints, team dynamics, or unforeseen technical difficulties. Continuous mentoring throughout the project is essential to address these challenges, including regular progress checks and guidance on self-directed learning strategies. Providing clear instructions, tutorials, and access to relevant resources can aid students in navigating the project more independently.

A phased approach, breaking down the project into smaller, achievable phases with clear milestones, can enhance student engagement and provide a sense of accomplishment. This approach also allows for focused learning and troubleshooting within each phase. Facilitating balanced group formation and offering support for team dynamics can improve collaboration and project completion rates.

By acknowledging these challenges and implementing strategies to address them, future iterations of the projects can further enhance student learning and engagement while fostering innovation and critical thinking in education.

## 4 Key Takeaways

One key takeaway is that CAN/CUBE satellites democratize space exploration due to their small size, affordability, and readily available components. This accessibility allows students to engage in real-world space exploration projects, sparking their curiosity and motivating them to pursue engineering careers.

The PBL approach creates a hands-on, stimulating learning environment. The CAN/CUBE satellite project enables students to apply engineering concepts practically enhancing their problem-solving skills, collaboration, and critical thinking. This methodology integrates various engineering disciplines: students measure environmental parameters in science, apply engineering principles to design and build the satellite, utilize technology through electronics and communication modules, and apply mathematics for data analysis and signal processing.

The project enhances learning outcomes, including developing scientific inquiry, technical abilities, and engineering design skills. Students also strengthen their collaboration and communication skills through teamwork and achieving project goals. Overall, the combination of CAN/CUBE satellites and PBL presents a powerful approach to education, empowering students to take ownership of their learning, deepen their understanding of scientific concepts, and prepare for future challenges and opportunities in engineering fields.

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# Small Steps, Big Impact: Catalyzing Educational Leadership with Micro-improvements

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**Abstract.** For the 1.4 million government schools in India, education leaders at various levels—school, district, state, and nation—play a crucial role in influencing student outcomes. Therefore, it is essential that their capacity building includes a ‘How to Do/Act?’ component which the micro-improvement (MI) approach presents by breaking down large goals into actionable, iterative steps aligned with education policies. This paper presents the application of MI approach, enabled by digital public infrastructure (DPI), for education leaders across diverse contexts.

**Keywords:** Educational leadership, capacity building, micro-improvement approach, digital public goods, digital public infrastructure, National Education Policy.

## 1 Introduction

Student outcomes in the government schools hinge on education leaders [1] at the center, state, district, block, cluster and schools (academic and administrative) [2-3]. The National Education Policy (NEP) 2020 [4] emphasizes capacity building of these education leaders to include ‘How to do/act?’ component. Rooted in improvement science [5-6], the micro-improvement (MI) approach addresses this by promoting incremental change through action-oriented, iterative steps, allowing them to apply new knowledge on relevant problems through targeted solutions [7]. The process involves four key actions: observing issues, analyzing data, mentoring, and planning improvements [8]. The MI approach fits as the steps (F) in the Beckhard-Harris change model, which suggests that meaningful change requires dissatisfaction (D), a shared vision (V), and clear steps (F) to overcome resistance (R) [9].

$$D \times V \times F > R \quad (1)$$

This paper explores the application of MI approach in enhancing educational leadership through Digital Public Infrastructure (DPI).

## 2 Micro-improvement as a Building Block

The MI building block incorporates the key principles of Digital Public Goods (DPG) as outlined in the NEP 2020 [4]. Grounded in Inclusivity, Evolvability, Interoperability, and Configurability, MI ensures equitable access, adaptability, and seamless integration across diverse platforms, fostering a scalable and sustainable model for continuous improvement in education systems.

When integrated into Digital Public Infrastructure (DPI)—which encompasses essential systems like identity verification and data exchange—MI's impact is significantly amplified. This integration enhances access to educational resources, scales improvements efficiently, and provides sustainable support for effective educational leadership. For instance, the MI project capability operates as a DPG within DPI platforms like the Digital Infrastructure for Knowledge Sharing (DIKSHA), ensuring that educational resources are accessible to all leaders. This framework not only promotes equitable access to learning materials and professional development opportunities but also reduces costs associated with traditional training and resource dissemination. Additionally, it offers real-time data collection and analytics capabilities, enabling education leaders to make evidence-based decisions [10-11].

## 3 Designing and implementing programs using the MI Building Block

Need-based programs, leveraging the MI building block, consist of a series of micro-improvement projects that outline structured action steps and provide relevant learning resources, supporting the implementation and documentation of outcomes. At the state level, education leaders guide the execution of these programs, while district, block, and cluster-level teams offer operational support to ensure effective monitoring, project understanding, and successful implementation across schools. Such programs have been designed and implemented in the states of Nagaland, Telangana and by National Council of Education, Research and Training (NCERT). This is outlined in the table 1 given below.

**Table 1.** Characteristics of Micro-improvement in Programs.

MI Characteristics	Literacy and Numeracy Fest	Nu- Vidya Amrit Mahotsav	PillalaKosam
<b>About the Program</b>	Focused on building teacher capability in teaching-learning of foundational literacy and numeracy (FLN)	NCERT program focused on innovative pedagogy undertaken by over 6 lakh education leaders across 27 states/UTs [12]	Bi-monthly thematic Parent-Teacher Meetings (PTMs) in Telangana
<b>Relevance &amp; Achievability</b>	The MI projects were 1 month long	The education leaders had to implement	Series of MI projects designed as a +1 to the

	projects with a specific objective like teaching phonics or addition.	innovative learning strategies on identified challenges	teaching- strategies on identified challenges	previous PTM to form meaningful relationships with parents and enable them to support their children at home.
<b>Adaptability &amp; Sustainability</b>	Education leaders could customize activities and teaching plans for each project.	Education leaders applied innovative pedagogy where they found it relevant.		School leaders worked with the teachers to plan the PTM under specific themes.

### 3.1 Micro-improvement Program in Nagaland, India

In 2022, Samagra Shiksha (SSA) Nagaland used the micro-improvement approach on DIKSHA to enable small improvements in their 1764 schools with grades 1-5. This started with a micro-improvement project on inculcating love for reading in students which received 1090 different projects under Nagaland Reading Festival were initiated [13]. In 2023, the education leaders were implementing a series of micro-improvements that led to 8596 micro-improvements in the state under Literacy and Numeracy Fest (LNF) [14]. The state has a designated committee looking into the design, implementation, monitoring and evaluation of the program.

The committee identified the implementation focus areas for the school leaders/teachers such as phonics, reading fluency, teaching addition, word problems, setting up libraries and much more. Each of these areas were further divided into monthly micro-improvement projects which were designed to include guided action steps and learning materials. School leaders/teachers would access these projects, customize and implement them. They could also document and share their implemented projects and its impact. The purpose of these monthly projects was to put in concerted efforts across the state on selected themes for capacity building. The committee would monitor the district and block wise performance weekly and address any context specific challenges. It also organized an end of year evaluation of all received projects to evaluate the quality of implementation in schools and then leveraged to recognize and appreciate teachers/school leaders. In the survey and interviews conducted to evaluate program effectiveness, teachers and school leaders shared that the approach helped them practice pedagogical skills and measure the tangible changes at school and classroom level. The program continues to be implemented in the academic year 2024 as well.

## 4 Learnings and Way Forward

The implementation of the Micro-improvement (MI) approach revealed valuable insights, particularly in fostering ownership among education leaders. In Nagaland, the adaptability of MI projects allowed leaders to tailor improvements to their specific

needs. This flexibility should remain central, enabling the integration of new practices into daily routines and promoting lasting leadership change. The programs also highlighted the need for customizable tools to address specific challenges. For administrators, access to school data is crucial to track progress, evaluate impact, and motivate leaders. Data visibility must be prioritized to sustain engagement in micro-improvements.

To further strengthen its effectiveness, the following key recommendations are proposed. Firstly, it is essential to focus on designing capabilities that align with DPG and DPI principles. These tools should be open-source, accessible, and adaptable to diverse educational contexts. Secondly, the foundational components of the building blocks should be universal and adaptable promoting wider adoption. Thirdly, the MI approach can drive long-term systemic change by focusing on measurable improvements and tracking milestones, within the education sector and various administrative frameworks.

**Disclosure of Interests.** The authors have no competing interests to declare that are relevant to the content of this article.

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# AR and VR Enhances Learning Microbiology

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**Abstract.** Extended reality is a broad term comprising VR/AR/MR technology. Microbiology is a branch of science that deals with microorganisms. As they are invisible to unaided eyes it's challenging for the students to understand to overcome this problem AR and VR technology are boon to the education system. This study aims to examine various aspects of AR and VR and how they enhance learning Microbiology by sharing the experience of using AR in Class 8 for teaching microorganism-related topics in class. A pre-test of the students was taken to know the prior knowledge of the students and AR intervention was performed and a post-test was taken to understand the effect of the intervention on students. The study found that the mean score of the student's pre-test was 10.9 and the post-test was 15.2 of 30 students of experimental group and the mean score of pre-test control group was 10.9 and standard deviation 5.4 and results of post-test control group show the Mean score of 13 and Standard deviation 4.6. Students scored better in teacher-prepared achievement test while using AR technology for topic related to microbiology. This technology also helps students in developing skills like spatial visualisation, innovative thinking, problem-solving, critical thinking and empathy. This technology provides an immersive and interactive experience of microorganisms which helps the students to learn and engage with content effectively.

**Keywords:** Microbiology, AR, Students, teaching-learning process.

## 1 Introduction

Recently, the term XR (extended reality) technology, which more broadly integrates VR/AR/MR technologies or XR is a broad term that is the centre of attention [1]. Microbiology is a scientific study of microorganisms not visible to our naked eyes. They are found in diverse environments including soil, air, water and the bodies of living organisms. Microorganisms are everywhere and learning about microbiology helps students understand the role of microorganisms in the natural world. Some educators may believe that the subject is too challenging for students as the things that we can see are much easier to correlate with what had been written in the textbook or the subject matter that is taught in school. Students, due to a lack of proper and concrete ideas stir their imaginations in the wrong direction, leading to misconceptions about the facts. To find the solution or to avoid this AR (Augmented Reality) and VR (Virtual Reality) technologies can be used in the teaching-learning process.

## 2 Study Design

This study examines the various aspects related to AR and VR and how they enhance learning microbiology in these studies various review papers are used to support the study by providing adequate evidence the online database and repository were searched to collect the relevant information and articles then articles retrieved from different sources were thoroughly read to understand the subject under consideration key points were taken from various articles used to support this paper. The Pre-Test Post-test control group design was used to check the effectiveness of the AR technology in teaching Microorganism related content to standard 8 Students. Teacher prepared achievement test was used to check the effectiveness of using AR and VR to teach Microbiology and comparing it with the traditional method of teaching microbiology.

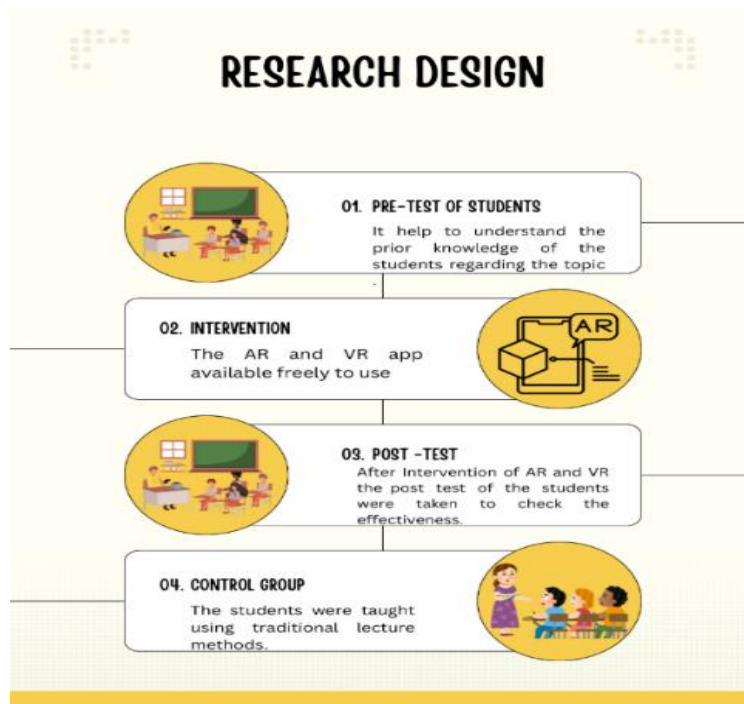


Fig. 1. Research Design

## 3 Discussion – Literature

This section starts with the meaning of the term augmented and virtual reality. The later part explains the importance of AR and VR in Education and leads towards learning microbiology using AR and VR. The word “Augmented” means to make large or enlarge in size, number, strength or simply we can say increase or to supplement. So, this makes us understand that Augmented reality enables the user to see highly detailed or

enlarged 3D images in real-life settings. AR is an experience that involves the superimposition of digital elements such as graphics, audio, and other sensory enhancements onto video streams of the real world with real-time interaction between the user and the digital elements [2]. On the other hand, the word “Virtual” refers to something online or offline on a Computer, TV, Mobile phone, Smartphone etc. Virtual reality (VR) is a simulated experience that can be similar to or completely different from the real world. It is an advanced, human-computer interface that simulates a realistic environment. The participants can move around in the virtual world. They can see it from different angles, reach into it, grab it and reshape it [3].

### **3.1 AR and VR in Microbiology**

In a traditional education system, the teaching and learning process was teacher-centric which resulted in a low attention span and focus of students. Technology-enhanced learning has improved the education system. As the students have become tech-savvy the educator can utilize this by teaching with technology to enhance interaction, engagement and understanding within the classroom [6]. AR and VR have an impact on the world of education by creating an immersive learning experience, helping students to better understand and engage with the subject matter.

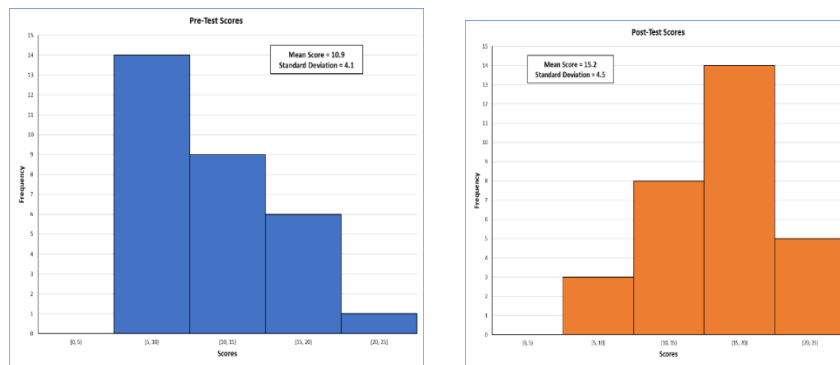
According to Al-Ansi [4] the technology can take students to locations that are physically restricted. It allows interaction with 3D models or designs in orientations and scales not previously possible. The concepts and content that are taught in microbiology are related to microscopic microorganisms which seems to be an abstract concept as microorganisms are invisible to the naked eyes which increase the difficulty of the student to understand it. These topics need imagination so AR and VR can be game changers in learning microbiological concepts as VR can help to make the environment related to a concept and AR can help to show the concept of microbiology in a real-life setting. Technology in the field of biology has changed traditional teaching and learning, increasing the awareness of teachers at all educational levels [5]. Studies suggest that educators can tackle particularly challenging theory for students by complementing traditional representation with immersive experiential approaches [8].

According to [9] the microorganism’s name learning application was developed which consists of two modules the first is learning which includes AR technology that scans the marker image and displays a digital layer of microorganism in three dimensions and the other is training which include gamification consisting of quiz question, timer and score which help in knowledge acquisition and content understanding.

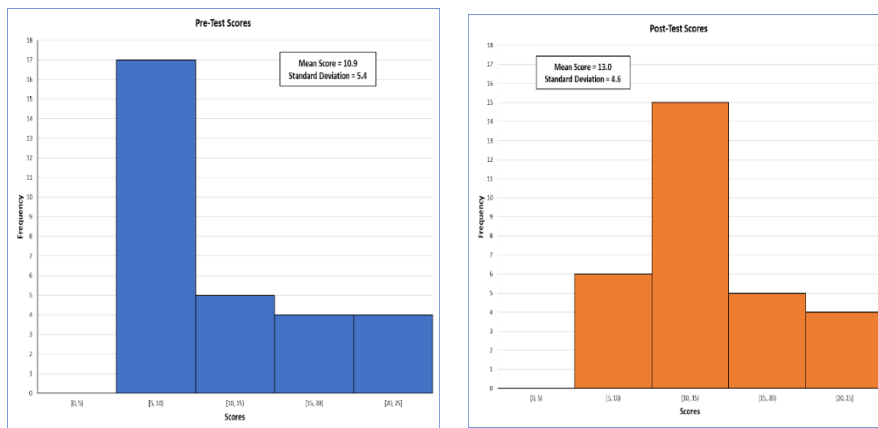
### **3.2 Data Interpretation**

- The Fig 2 shows the result of pre and post-test on experimental group with AR and VR intervention for teaching Microbiology. Mean score of the pre-test was 10.9 and Standard deviation was 4.1 comparing with the post test result of experimental group the graph shows the mean score of the post-test was 15.2 and Standard deviation 4.5.

- While teaching the students of control group with traditional method the Fig 3 shows the pre-test and post test result of control group. Mean score of pre-test control group was 10.9 and standard deviation 5.4 and results of post-test control group show the Mean score of 13 and Standard deviation 4.6.



**Fig. 2.** Pre-test and post-test graph of experimental group



**Fig. 3.** Pre-test and Post-test graph of control group

### 3.3 Experience of Microbiology learning using AR and VR

The AR is a very valuable tool this was implemented in the teaching-learning process for an internship as a part of practicum under course work of B.Ed. -M.Ed. integrated where the topic Microorganism and us was taught to the students of 8th standard using AR and the feedback and evaluation were taken after the lesson which showed that the Pre-test Mean Score was 10.9 and the post-test mean score was 15.2. These scores were compared to the control group they were taught using traditional method the same topic and mean score of post-test was 13. When we compare the post-test mean score of experimental and control group we can see the difference in mean score of post-test. This

shows that the student's understanding of the topic has been increased by using AR as an intervention. The interactive way of the teaching-learning process using AR grabbed the attention of students. According to Zhou [7] AR and VR systems help learners recognize a microscopic structure and grasp the required operational skills by simulating operations using an interactive process. In the future, such technology-assisted education would be a successful learning platform in an open learning space.

## 4 Conclusion

The extended reality comprises of AR and VR technology which is a helpful tool in enhancing Microbiology learning as Microorganisms are invisible to the Naked eye. It's difficult to teach through traditional education settings the concepts of microbiology which are abstract as it requires a lot of imagination skills for students to understand. To overcome this difficulty technology like AR was used as an intervention. This technology enables students to see and access locations that are physically inaccessible. It allows interaction with 3D models or designs in orientations and scales not previously possible. This technology also helps students in developing skills like spatial visualisation, innovative thinking, problem-solving, critical thinking and empathy. VR can make the environment related to a concept and AR can show the concept of microbiology in real life setting. This technology provides an immersive and interactive experience of microorganisms which helps the students to learn and engage with content effectively. Which can revolutionize the teaching and learning process of Microbiology. This not only provides a safe and controlled environment to create simulations replicating real-life scenarios which are difficult in traditional classroom settings but can also provide personalized instructions and track students' progress using Gamifications in AR and VR apps. The shift of Mean score in the post-test and comparing with mean score of control group shows the effectiveness of the AR which was used for teaching 8 standard students the topic of Microorganism and us.

**Disclosure of Interests.** The author has no competing interests to declare that are relevant to the content of this article.

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# Managing Skill-development Courses for Large Audiences in Undergraduate Engineering

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**Abstract.** Our study examines the feasibility of large-scale, hands-on, skill-building courses for engineering students in India, showcasing course design and pedagogical strategies in two foundation courses for undergraduate engineering students. Large classroom teaching is unavoidable in Indian colleges and universities with a growing learner population and intake, and this leads to a question about whether effective hands-on learning is possible in large first-year classes. For the demonstration, we chose two introductory courses for writing and design and prototyping, aiming to foster students' communication skills, thinking tools, and social awareness, which are essential in engineering education. Also, both have faced three challenges: (i) large audiences, (ii) multi-focused topics, and (iii) a mission to make learning an enjoyable experience. Our work provides an overview of designed course structures and learning goals and shows challenges in large classes and five key strategies: (1) peer learning, (2) authentic materials/tasks, (3) stimulating meta-cognition, (4) step-wise guidance, and (5) structured assessment.

**Keywords:** Introductory engineering course, Large class, Higher education, First-year writing course, MUSIC model, Skill-building

## 1 Introduction

For the last two decades in higher education, active learning methods have been expanded across levels, subjects, and class sizes; teaching large classes—motivating and engaging many learners—has been highlighted [1,2]. Our study examines the feasibility of large-scale, hands-on, skill-building courses for engineering students in India, showcasing course design and pedagogical strategies. For the demonstration, we chose two first-year B.Tech. courses, Design, Innovation and Prototyping and Introduction to Writing - 1 & 2, offered from 2022 to 2024.

## 2 Cases: First-year undergraduate, Foundational & Large

Our design course, Introduction to Design, Innovation and Prototyping (henceforth the Design course), involves conceptualizing and translating new ideas to reality by integrating learnings from prototyping trades towards the final deliverable (Table 1).

**Table 1.** Educational Units and Learning Objectives of the Design Course.

Course	Educational Units	Learning objectives
Design, Innovation & prototyping	Understanding perspectives Making sense of a product Prototyping trades Design project	Apply design process as iterative; creative problem-solving; Acquire prototyping trades and develop related skills; Imbibe workshop/ shop floor practices and safety standards; Appreciate the journey of an idea to a feasible product; Identify opportunities for value addition by design; Be inquisitive about material properties; Employ design tools and methods to offer value-added solutions for specific needs

A sequence of two writing courses, Introduction to Writing - 1 & 2 (henceforth the Writing course), 2 credits, were designed for the incoming undergraduate students, all of whom are in the B.Tech program at our institute (Table 2).

**Table 2.** Educational Units and Learning Objectives of Writing Courses.

Course	Educational Units	Learning objectives
Introduction to Writing - I	Descriptive writing Narrative writing Reflective writing Assessing audience & sources	Write stepwise; Cooperate with people in group task; Write an effective email; Describe a topic with sensory appeal; Use storytelling techniques to engage readers; Think forward with reflections; Assess the credibility and relevance of information.
Introduction to Writing - II	Analytical reading & writing Expository writing Multimodal writing Persuasive writing	Identify/analyze the main claim; Write opinion letters; Make an annotated bibliography; Explain an object to the target audience; Create tables/charts optimal to text; Use rhetorical strategies for logos, ethos & pathos; Impactful and professional self-introduction

### 3 Challenges: Engaging a Large Class for Multidisciplinary Learning with Understaffing

The recent increase in Indian higher education in the number and the size could not be matched by that of instructors, and the gap has been the most noticeable in 1st-year courses. Should it be possible to give attention to individual students and engage them as active participants in the learning process? Our challenge was as in Table 3.

**Table 3.** Common Learning Skills Between ES 115 and HS 191/192.

Sem e- ster	Course	Related areas or required skills/components		
		Communication	Thinking Tools	Social Awareness
1st	Design, Innovation & Prototyping	2D/3D visual media design vocabulary	Balancing creativity and objectivity	Understanding the requirements of all stakeholders
1st & 2nd	Introduction to Writing	Academic communication	Reflective and critical thinking	Cultural literacy; appreciating values

### 4 Strategies to Engage Learners in a Large Class

In both courses, lectures and practice sessions were designed to provoke meta-cognition on par with the MUSIC Model of Motivation [5,6], and enough emphasis was placed on its value and implication of their learning. We will address our strategies from both the courses that are on par with the MUSIC model.

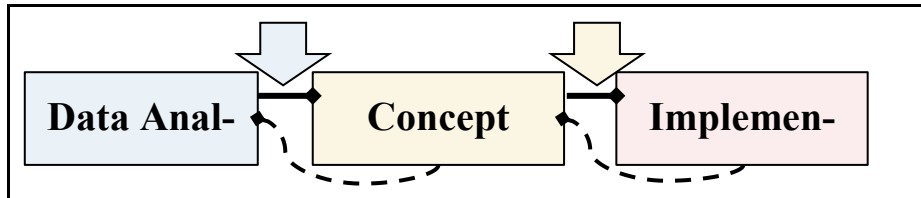
**Fostering Motivation through ‘eMpowerment’ and ‘Usefulness’** First, both courses empowered students to choose topics for the project they would work on. Choosing a topic based on their interest and expertise promoted their passion and in-depth investigation. In addition, when each educational unit began, substantial time was spent on discussing the value of relevant subjects and topics

**Real-life Materials and Examples to Maintain Students’ Interest** Our courses’ learning goals and objectives are relatively general as they are the first set of courses for freshmen in engineering; it was important for us to introduce real and practical examples in the lessons that students could easily comprehend. For their later career trajectory, students also practiced a professional self-introduction such as an elevator pitch and a video cover letter.

**Peer-assisted Learning from Classmates and Senior Mentors** The activities students pursued included jigsaw, where all group members brought knowledge of different prototyping skills so that the whole group worked together to integrate pieces of knowledge for the group project (the Design course).

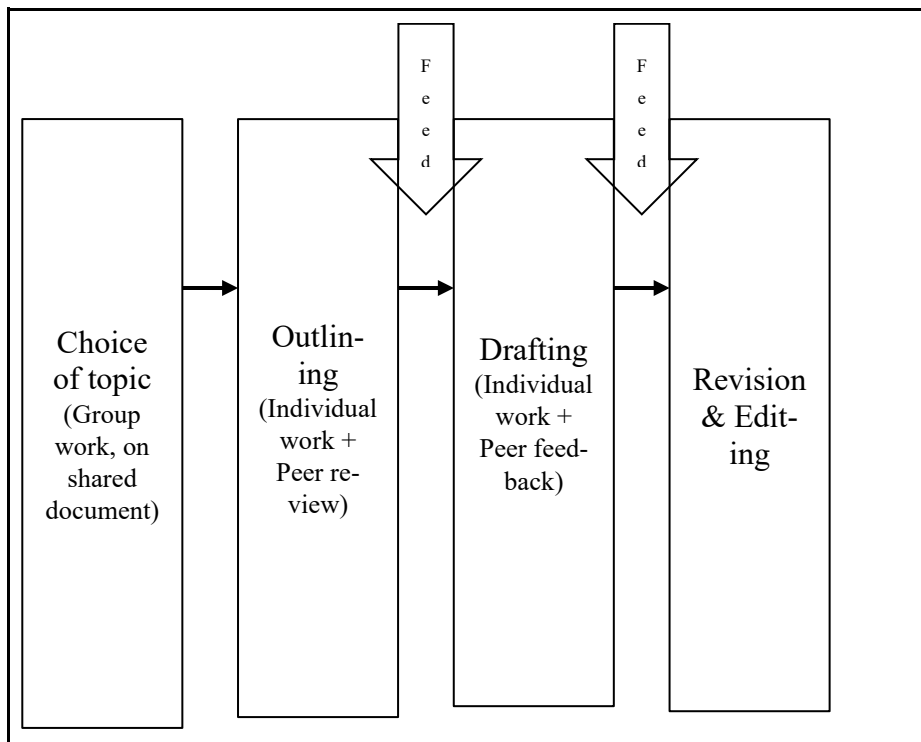
At the beginning of the Writing course, a diagnostic test was conducted. Based on the outcome, tutors from the institute writing provided 1-on-1 assistance, and peer mentors (senior students) looked after two mentees.

Step-by-step Guidance Through Formative Assessments Projects and outcomes were divided into smaller steps so that students were encouraged to “fail” on a small scale with timely feedback, and projects were broken down into smaller tasks to maintain students’ focus; facilitate self-evaluation and revision, as shown in Fig. 1.



**Fig. 1.** Three stages of the design process

As for the Writing course, manages the flow of ‘Choice of Topic’, ‘Outlining’, ‘Drafting’, and ‘Revision and Editing’ as in Fig. 2.



**Fig. 2.** In-class writing activities of an educational unit.

Systematic Evaluation with Clear Expectations Table 4 illustrates the rubric for a end-of-the-module assignment of the unit ‘Multimodal Writing’; where students evaluate raw data and use visualization for effective display of analyzed patterns. Strategic use of multimedia tools was taught through lessons on ‘expressing knowledge’, ‘textual and graphic components of presentation’, ‘target audience assessment’, and ‘designing charts and tables out of numbers’.

**Table 4.** A Sample Rubric for the Multimodal Writing assignment.

<b>Crite- ria</b>	<b>File &amp; for- mat</b>	<b>Para- graphs</b>	<b>Name and ti- tle</b>	<b>Motiva- tion &amp; methods</b>	<b>Data- Graphi c</b>	<b>Data- Text</b>	<b>Con- clu- sion</b>
Score	2-0	2-0	2-0	2-0	3-0	3-0	1-0

For each criterion, detailed descriptions of the formats and expected content were clearly articulated. In each learning unit, an evaluation rubric was announced with the assignment, and scores were distributed based on the importance of each criterion.

The Design course rubrics needed to be designed to evaluate the learnings from the course, adherence to the design process, and the quality of the outcome as a valid solution to the problem chosen.

## **5 Discussions: Implications and Shortcomings**

Our underlying principle was to motivate students and create a learning space for them to test their boundaries without fear or emotional charging. The strategies helped them to become autonomous while anticipating the possibility of students feeling abandoned during decision-making for the projects. By dividing the class into sections (the Writing course) and functional groups (the Design course); the students/groups could receive timely feedback.

Our attempts to resolve the challenges came in five categories: First, we fostered Motivation through student autonomy and clear communication, Second, real-life materials and authentic examples were used to maintain students’ interest. Third, peer-assisted learning was arranged by classmates, senior mentors, and tutors. Fourth, guidance for a project and a task was designed with a small assessment with detailed feedback. Last, evaluations were constructed systematically using a rubric, and the instructor’s expectations were explicitly communicated in advance. The pedagogical and course-design strategies aimed to maximize the courses’ hands-on nature and, consequently, students’ learning outcomes.

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# Digital Competency among Prospective Teachers: An Analysis Using the DigCompEdu Framework

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**Abstract.** According to Council Recommendation on Key Competences for Lifelong Learning- 2018, Digital competence involves the "Confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society". This study aims to find the level of digital competency of prospective teachers based on DigCompEdu framework, which is designed for educators to develop the skills and knowledge they need to use digital technologies effectively in their teaching and learning practices. DigCompEdu framework is a scientifically sound framework describing what it means for educators to be digitally competent. In the present study, Descriptive survey design has been conducted among 430 prospective teachers having different subject specialization of various teacher training colleges of Kerala. Convenient sampling was followed for selecting the sample. Data analysis was done through quantitative mode. The findings showed that there is a positive approach among the sample for digital competencies and its understandings. The DigCompEdu framework can be used by educators to self-assess their digital competence and to identify areas where they need further development. The findings of the study can be used for understanding the level of prospective teachers towards the digital competence and ways through which the digital competence can be developed. Recommendations include the incorporation of comprehensive digital literacy modules in teacher training curricula, ongoing professional development opportunities, and the creation of supportive learning environments that foster continuous digital growth. This research underscores the importance of equipping future educators with the necessary digital skills to thrive in a technologically enriched educational landscape.

**Keywords:** Digital Competency, DigCompEdu framework, Prospective teachers.

## 6 Introduction

In the twenty first century, the internet and digital technology have permeated every aspects of our life. It is required of today's educators to incorporate digital technologies in to their lessons to enhance the quality of teaching. Digital competency is essential for prospective teachers to prepare students for the future, to enhance teaching and learning, to foster collaboration, to engage students in their learning, and to stay up-to-

date on the latest trends and technologies. The world is becoming increasingly digitalized, and schools are expected to prepare students for success in this digital world. Prospective teachers need to be able to use digital technologies effectively in their teaching and learning practices in order to prepare students for the future.

NEP 2020 emphasize the importance of digital literacy and competencies for all learners. Government has providing digital infrastructure facilities to schools across India. The scheme includes the provision of digital devices such as computers, laptops, and other mobile devices and free and open source software. Also providing training for the teachers on the usage of these devices for their teaching learning purposes.

Different models and frameworks have been developed to date in the measurement and diagnosis of digital competence. In America, the International Society for Technology in Education (ISTE) standards and performance indicators serve as an important guide for teachers to implement technology in their teaching practices” (Tondeur et al., 2017). DigEuLit model aims to define, structure and select tools related to digital competence for educators and students and funded by European Commission (Amaro, Oliveira, & Veloso, 2017).

DigCompEdu framework is designed to help educators to develop the skills and knowledge they need to use digital technologies effectively in their teaching and learning practices. It is a scientifically sound framework developed in the year 2017. The framework is divided in to six areas namely: Professional development, Teaching and Learning, Assessment, Empowerment, Collaboration, and Engagement.

DigCompEdu framework is focus on the specific digital competencies required for the educators. It is uniquely tailored to the educational context, addressing both the professional and pedagogical needs of teachers. It is suitable for various educational settings, starting from school education to higher education and for diverse cultural and policy environments.

In addition to that, this framework follows a personalized growth path making professional development measurable and targeted.

Gender and subject specialization significantly influence how individuals engage with technology in educational settings. Gender disparities in digital competency can arise from differences in availability, interest, confidence in using technology, training received, etc. Addressing these gaps is crucial for ensuring equal opportunities for all teachers irrespective of their subject specialization. Promoting digital competency equally across genders fosters inclusivity and helps to prevent unequal participation in technology driven education and careers.

Different subjects of study require distinct digital skills and tools. It allows students and teachers to effectively apply technology in their studies and future careers.

## **6.1 Statement of the problem**

Due to the application of digital technology, the educational environment has undergone tremendous reformation in recent years starting from pre-primary to higher education. Both pre and in-service teaching period have an crucial role in mastering the digital technologies. There are different frameworks on finding the digital competencies of teachers. The DigCompEdu framework is one among them and it can be used

by educators to self-assess their digital competence and to identify areas where they need further development. It can also be used by schools and other educational organizations to develop professional development programs for educators. Prospective teachers are the future teachers who are capable for implementing the digital technology in their professional career, so that the quality of education can be enhanced. Hence the present study was entitled as, “Digital Competency among Prospective Teachers: An Analysis Using the DigCompEdu Framework”

## **6.2 Research Questions**

1. What are the levels of digital competency of prospective teachers based on the DigCompEdu framework
2. Does the digital competency of prospective teachers differ based on their gender and subject of study?

## **6.3 Objectives of the study**

1. To identify the levels of digital competency of prospective teachers based on the DigCompEdu framework.
2. To study the difference in digital competency of prospective teachers based on their gender
3. To study the difference in digital competency of prospective teachers based on their subject of study
4. To correlate the different areas of digital competency of prospective teachers suggested by DigCompEdu framework.

## **7 Methodology**

The present study employed descriptive study design which explores the digital competency of prospective teachers based on DigCompEdu framework. The sample for the study included the prospective teachers. Total sample for the present study was 430.

### **7.1 Sample selected for the study**

Total sample involved in this study were 430 of various training colleges of Kannur University Convenient Sampling Technique was adopted.

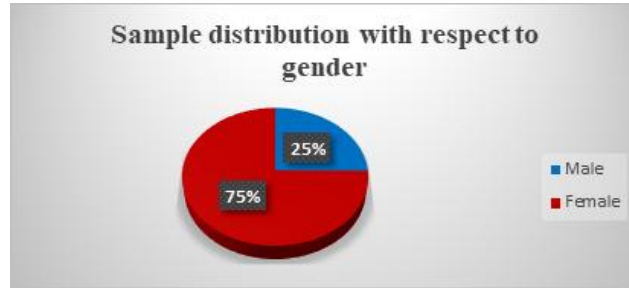


Fig. 4. Sample distribution with respect to Gender

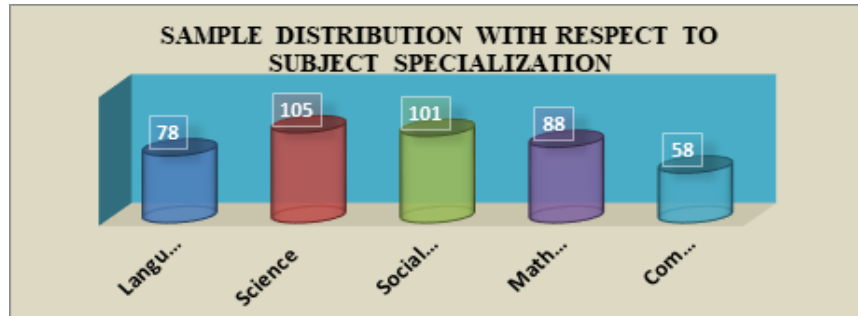


Fig. 5. Sample distribution with respect to subject specialization

## 7.2 Tool used.

DigCompEdu framework is divided into six areas such as: Professional development, Teaching and Learning, Assessment, Empowerment, Collaboration, and Engagement. The framework covers five competence areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. This instrument is composed of twenty-two items, which are distributed into the six areas of competence analyzed in DigCompEdu.

Table 2. Areas of digital competency with number of items

SI No.	Areas of Competency	Number of items
1	Professional commitment	4
2	Digital resources	3
3	Teaching and learning	4
4	Assessment	3
5	Empowering students	3
6	Facilitating the Digital Competency of students	5

DigCompEdu constitutes a competency model of six areas (see Table 1) incorporating the different competencies that education professionals must develop to promote productive, inclusive, and integrative learning strategies through the use of digital tools.

Within each competence area, the framework uses a 4-stage progression model ( $A_1$  = Novice,  $A_2$  = Explorer,  $B_1$  = Integrator,  $C_1$  = Leader).

## **8 Discussion and Implication of the study**

DigCompEdu framework demonstrates strong reliability and validity for assessing digital competencies. Teachers require high levels of digital competency, according to Petersson (2017), and it's widely acknowledged that teacher education has become more difficult as a result. The capacity to seamlessly integrate technology to inspire students to emulate such individual use. Additionally, pedagogically, it focuses on how ICT might increase student's learning opportunities in their particular field.

According to Tondeur et.al 2017, "empirical evidence shows that preservice teachers often still do not feel adequately prepared to effectively incorporate technology in to their classrooms, due to the gap between technical and pedagogical skills amongst them".

When discussing the competencies required of students in an educational setting, the terms 'Digital Competence', 'Digital Pedagogy', 'Digital Literacy', 'ICT Competence', and 'Pedagogical Digital Competence' are frequently used interchangeably and lack clear definitions as suggested by Petersson 2018.

"The majority of student teachers perceived their level of DigComp as excellent. These conclusions are supported by published study findings, indicating the high level of DigComp of pre-service teachers" (Ata & Yıldırım, 2019; Eryansyah et al., 2020; Liza & Andriyanti, 2020).

However, it's possible that participant's self-reported DigComp is not the true representation of their real proficiency with the technology in the classroom (Gudmundsdottir & Hatlevik, 2020) or of their sustained usage of it (Stemberger & Konrad, 2021). Based on the available data, the five DigComp areas analyzed had a statistically significant mean that was greater for student instructors who assessed their DigCompEdu level as excellent than for those who ranked it as moderate.

The DigCompEdu framework can be used by educators to self-assess their digital competence and to identify areas where they need further development. It can also be used by educational organizations to develop professional development programs for educators. Digital competency is essential aspect of the 21<sup>st</sup> century learning. The findings of the study can be used for understanding the level of prospective teachers towards the digital competence and ways through which the digital competence can be developed.

## 9 Conclusion

Due to the application of digital technology, the educational environment has undergone tremendous reformation in recent years starting from pre-primary to higher education. Both pre- and in-service teaching period have a crucial role in mastering the digital technologies. To achieve and disseminate the quality education, one of the requirements in the 21<sup>st</sup> century is the knowledge and application of digital technology. Prospective teachers showed an excellent digital competency level emphasizing the importance of teacher education institutions in meeting the essential requirement for implementing the digital education.

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# Testing Foundational Literacy and Numeracy – developing and implementing the Neev app

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**Abstract.** We describe Neev, an offline, audio-enabled mobile assessment for Foundational Literacy and Numeracy (FLN) aligned to constructs from the Early Grade Reading Assessment (EGRA) and Early Grade Mathematics Assessment (EGMA) toolkits [1, 2], and responsive to India’s National Education Policy 2020 and NIPUN Bharat mission [3, 4]. Neev standardizes multilingual administration via recorded prompts and captures student voice responses for centralized, blind scoring. The app uses React Native with robust offline storage and secure, asynchronous synchronization to a central database; a web-based scoring interface supports rater training and quality audits. In pilots across multiple states and languages, Neev reduced facilitator-dependence during administration, improved instruction consistency, and produced verifiable audio traces enabling quality assurance. Feasibility indicators included high completion rates, low data loss, and manageable synchronization delays. Audio evidence surfaced systematic reading errors—omissions, substitutions, and hesitations—that informed item refinement. Offline capture plus centralized scoring offers a scalable path for high-fidelity FLN measurement in low-connectivity contexts [5].

**Keywords:** FLN, EGRA, ORF (Oral Reading Fluency).

## 1 Introduction

Children’s enrollment has risen, yet basic reading and arithmetic remain weak for many early-grade learners, as repeatedly documented in national surveys [5]. Conventional school tests presuppose reading fluency, making it difficult to separate conceptual gaps from decoding issues. Foundational Literacy and Numeracy (FLN) frameworks and tools such as EGRA and EGMA foreground oral evidence of skill and emphasize early measurement of Oral Reading Fluency (ORF) and number sense [1, 2]. In India, NEP 2020 and NIPUN Bharat elevate FLN as a national priority and call for early, reliable assessment to guide remediation [3, 4]. We present Neev, an offline, audio-enabled assessment app that standardizes administration across languages with recorded prompts and captures student voice for centralized, blind scoring—aimed at improving consistency, verifiability, and operational scalability for FLN assessment in low-connectivity contexts [1–4].

## 2 System & workflow

**Client.** The mobile app is built for offline-first operation with local persistence; multi-lingual recorded prompts ensure consistent administration and reduce facilitator variance [1, 2].

**Capture.** For reading subtasks (including ORF), the child reads aloud and the audio is stored with session metadata, then synced automatically when connectivity is available.

**Scoring interface.** Centralized raters use a secure web-based console to review audio files, applying EGRA/ORF rules for correct-words-per-minute (CWPM) and accuracy [1]. Numeracy tasks are auto-evaluated from click data; only number recognition uses audio for deferred human scoring. Double-scoring and periodic audits support reliability.

**Roles.** Facilitator (on-site), Scorer (remote), Supervisor (QA).

**Safeguards.** Crash recovery, file-integrity checks, retry queues, and encryption ensure data security. This architecture decouples on-site facilitation from evaluation, enabling delocalized scoring and quality assurance aligned to policy expectations for timely, reliable FLN measurement [3, 4].

## 3 Assessment Design

**Reading.** Letter-sound, familiar words, non-words, connected-text ORF (60-second window), and reading comprehension; scoring records CWPM and accuracy with error types (substitution, omission, hesitation) as per EGRA conventions [1].

**Numeracy.** Number recognition (audio response, scored later by raters) and other early-grade tasks such as number comparison, basic operations, missing patterns, word problems that are auto-evaluated from on-screen clicks, aligned to EGMA-style constructs [2].

**Administration.** One-to-one delivery with standardized video instructions and audio questions; child-initiated replay supports comfort without altering scoring rules [1].

**Quality.** Inter-rater agreement via double-scoring a stratified subset; rater training and calibration mirror practices recommended in EGRA/EGMA documentation [1, 2].

## 4 Field Deployment & Feasibility

Table 1. Deployment Snapshot

Stat- es	Grade s	Lan- guages	Stu- dents	Facilita- tors	Ev- alua- tors	Win- dow
3(E ndline)	2,3	Hindi, Odiya, Ma- rathi(Only Baseline)	~40000	80-100	55 - 60	July 2024 - Mar 2025

#### 4.1 Feasibility indicators

Session completion = completed / started = 95%

Audio integrity = playable / captured = 88%

Median sync latency = 1 h

Stability = crashes per 100 sessions = 4

Inter-rater Reliability Cohen's kappa ( $\kappa$ ) = 0.91

### 5 Findings & Practical Learnings

- Administration. Recorded audio-video instructions and questions improved instruction consistency across languages and geographies and significantly reduced dependence on highly skilled facilitators on the ground, aligning with the standardization principles underpinning EGRA/EGMA [1, 2].
- Evidence. Audio traces enabled blind, centralized scoring and surfaced systematic reading errors that informed item and prompt refinement; this supports timely remediation, a key FLN policy objective [3, 4].
- Operations. Main frictions were device familiarity, mic handling, and intermittent connectivity; mitigations included in-app help features, and auto-back-up mechanisms for syncing data, resulting in near zero data loss by the end.
- Perception. Positive child engagement with tablets often offset test anxiety in diverse contexts; this echoes field observations reported in national learning studies regarding comfort and familiarity factors [5].

### 6 Ethics & Data Protection

- **Consent.** One-to-one assessments with school/parental consent and child assent where applicable.
- **Protection.** Audio used only for scoring/research; encrypted at rest and in transit; role-based access; pseudonymized IDs; defined retention/deletion. This aligns with recommended practices for safeguarding minors' data while enabling reliable early-grade assessment and remediation planning [3, 4].

### 7 Limitations & Next Steps

The results reported here demonstrate feasibility (the system and workflow function reliably in field conditions) rather than population-representative learning outcomes and they pertain to participating partner implementations and sites. Variation in accents and background noise make scoring of audio-recorded tasks harder, and human scorers may shift in correctness over time; both issues require periodic calibration and quality checks [1]. Next, we will pilot AI-assisted pre-scoring to triage audio for human review, and conduct cost-and-time analyses for routine, large-scale use—aligned with national FLN implementation timelines [3, 4]. For numeracy, most tasks are auto-evaluated

from on-screen clicks; only the number-recognition task uses audio responses that require deferred human evaluation.

## 8 Conclusion

An offline, audio-enabled workflow that captures oral evidence and centralizes scoring can improve standardization, verifiability, and timeliness of FLN assessments in low-connectivity environments [1–4]. Feasibility indicators and auditability via audio provide a practical path to early identification and remediation consistent with national priorities [3, 4], while also enriching research and monitoring with high-fidelity process data [5].

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# Enhancing Students' Learning by DIY Experiments: Image Processing for Solid Mechanics

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**Abstract.** Conventional methods of performing solid mechanics experiments often rely on conventional deflection measurement techniques such as dial gauges, which can be cumbersome, less accurate, and prone to human error. These methods may not effectively engage students or provide the precision required for detailed analysis of the experimental results. So, to enhance the learning outcome, we integrated image processing techniques in solid mechanics experiments by using easily accessible mobile phone cameras. We designed undergraduate-level solid mechanics deflection measurement related experiments and used free open-source image processing-based software for the same. The image processing technique allowed precise, real-time measurement of beam deflections without the need for any physical contact with the beams, thus reducing potential sources of error and simplifying the experimental setup. Students found the non-contact beam deflection measurement method more accessible, engaging, and easier to use compared to the conventional one. This not only enhanced the learning experience of the students but also provided a more effective way of conducting solid mechanics experiments.

**Keywords:** Image processing · Non-contact measurement · Tracker · Solid mechanics · Experiments · Pedagogy.

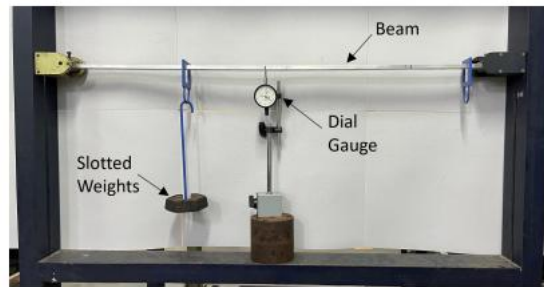
## 1 Introduction

A beam is a structural element that primarily resists loads applied transverse to its axis. The loads cause bending and shear stresses, and the beam's ability to withstand these stresses is a fundamental aspect of its design and analysis. Understanding beams and their behaviour under various loads and support conditions is essential for ensuring safety and performance. Conventional methods for measuring beam deflection, such as the use of dial gauges, offer precise measurements but are limited by the difficulty in capturing deflection profiles along the entire length due to their physical contact with the beam. To address these limitations, non-contact methods like image processing have been explored as effective alternatives. To give an example, R. Greenberg et al. used image processing technology in high school science classes, focusing on teachers' adoption and implementation [1]. In this paper, we used image processing-based technique to measure static deflection at any point along the length of a beam for solid mechanics experiments. The images were obtained using easily accessible mobile

phone cameras and processed using the Tracker software [2]. By placing markers at various locations along the beam and capturing their positions through high-resolution cameras, it was possible to accurately track deflection profiles without physical contact with the structure. We illustrated undergraduate-level experiments to verify fundamental principles in solid mechanics, such as Maxwell's reciprocal theorem, superposition principle, and large deflection beam theory.

## 2 Solid Mechanics Experiments:

**Conventional Approach** Conventional approach of conducting solid mechanics experiments involved use of dial gauges and slotted weights to measure deflections and apply loads at various positions along the length of a beam. Fig. 1 shows a conventional experimental setup.



**Fig. 1.** Conventional experimental setup for beam deflection measurement using a dial gauge and the loads are applied using standard slotted weights

Solid mechanics experiments based on load and deflection measurement can be easily verified by using a steel ruler and by providing appropriate loading conditions. We first validated experiments such as Maxwell's reciprocal theorem, superposition principle, and large beam deflection theory by conventional way. Fig. 1 shows an example of how these experiments were performed using dial gauges and slotted weights to measure the deflections and applied loads respectively. The deflections were measured by attaching a marker pen along the length of the beam and using a graph paper to mark the position of the marker corresponding to each load. The difference between the initial and the final position of the beam provided deflection value. The experimentally obtained deflection values were compared with the estimate of the deflection obtained theoretically from Euler-Bernoulli Beam theory and the method described by Bisshop and Drucker [3].

## 3 Solid Mechanics Experiments: Proposed Approach

Unlike conventional methods where beam deflection is measured using dial gauges and graph paper, we designed new experiments in which the beam deflection was measured using image processing techniques.

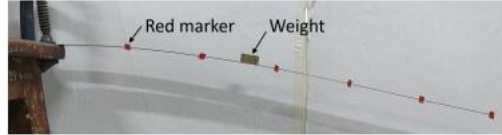


Fig. 2. A photograph of a cantilever with some externally applied loading and markers to obtain the deflection using image processing.

We used Tracker, a free open-source image processing tool as an alternative for measuring the deflection. As shown in Fig. 2, appropriate markers such as coloured tape or thread need to be placed at the respective points that can help in clearly identifying these points along the length of the beam. A large number of markers at various locations can be placed along the length of the beam with no additional cost as compared to the conventional approach of using dial gauges. White background created by using cardboard helped create better contrast between the markers and the surrounding area. Lighting was set to avoid direct reflection of light from the marker towards the camera. The deflection at any point along the length of the beam due to an applied load can be determined by subtracting the deflection of the beam at that point due to the beam's self-weight from the measured deflection. The proposed image processing-based technique is limited by the resolution of the image taken, and hence the accuracy of deflection measurement.

#### 4 Learning Objectives and Outcomes

The learning objectives behind implementation of image processing techniques in conducting solid mechanics experiments were as follows.

- Learning the principles and benefits of non-contact measurement techniques, comparing them to conventional contact-based methods
- Exploring full-field deflection measurement, learning how to capture and analyze deflections across the entire beam rather than at discrete points
- Improving students' understanding of experimental accuracy by comparing conventional deflection measurement techniques with image processing methods
- Exploring how automation and digital tools enhance the efficiency of data collection and analysis.

All these experiments described previously were newly designed specifically for using image processing techniques. Those were successfully conducted as a part of the Solid Mechanics Laboratory course for second-year undergraduate students of Mechanical Engineering in the Autumn Semester 2023 at IIT Bombay. These experiments were performed by around 110 students in groups of about five students each. They used their smartphones to obtain images; processed them using Tracker software and successfully verified the fundamental solid mechanics principles. Another separate batch of about 110 students performed the same experiments using the conventional way. Active participation of students while performing the experiments was observed by

instructors and teaching assistants. The image processing-based approach was found to be more engaging compared to the conventional one. This new approach enhanced students' understanding of measurement technologies, improving accuracy in experimentation, and providing hands-on experience with modern digital tools. This integration helped students connect theory with practice, fosters critical thinking, and prepared them for future challenges in both academic and industrial settings where advanced image processing techniques are becoming increasingly important.

## 5 Summary

The conventional deflection measurement approach using dial gauges is cumbersome and prone to human error. In this paper, we proposed an alternative image processing-based approach to detect the deformation of a beam in a noncontact manner for solid mechanics experiments. It was observed that these newly designed experiments involved greater student participation in setting up the experiments as compared to conventional ones, thereby providing them a better hands-on experience with improvement in overall learning outcomes.

**Acknowledgments.** The authors would like to thank Prof. Krishna Jonnalagadda and Mr. Shanideo Jadhav for providing access to the facilities in Solid Mechanics Lab in the Department of Mechanical Engineering, IIT Bombay, India.

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# Enhancing Students' Learning by DIY Experiments: Optical Methods for Solid Mechanics

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**Abstract.** Structures or machine part that has complex designs are often difficult to analyze using conventional experimentation methods and require specialized experimental techniques such as photoelasticity, digital image correlation, and moiré pattern. These advanced techniques also require sophisticated equipment that is typically not possible to obtain in institutes due to its cost. We present optical methods that can be used for stress measurement using minimal expense and resources. Digital image correlation and the moiré fringe pattern method are simplified such that students can do this experiment by themselves. These methods made use of easily available materials/equipment like plastic sheets, erasers, mobile phones, and computers. Unlike the commercial setups that are used to only demonstrate the experiments to students, these modified experiments allow students to be actively involved in preparing samples, setting up the experiment, and getting the measurements. These experiments also helped students learn various solid mechanics concepts more effectively. Having such experience, students were able to design and perform experiments without any additional help.

**Keywords:** Solid mechanics, Digital image correlation, Moiré pattern.

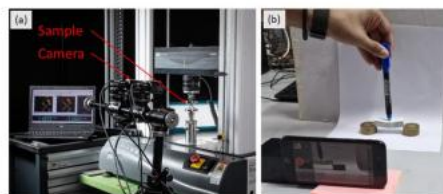
## 1 Introduction

Performing hands-on experiments, while learning science and engineering is crucial to develop the clarity of concepts. Doing various experiments and testing the theories gives better intuition of the phenomenon and the ability to use it in a real-life engineering problem. Many educational institutes in developing countries do not have the facilities and resources to engage engineering students in experimental learning. Lack of such practical understanding of the problem significantly reduces the employability of engineering students. Various ways were suggested by researchers [1] to reduce the cost of the equipment. Teachers have used Arduino and smartphone-based systems to make it more accessible. In contrast to the conventional way, only a demonstration is performed using an industrial or research-grade setup. Using such an inexpensive method enables every student to experiment by themselves. These experiments were developed during the COVID-19 lockdown period where students performed these experiments at home. However, considering the student involvement and their learning, these experiments were continued even after the lockdown.

Measurement of stress is an analysis that mechanical and civil engineer needs to conduct over a structure or machine components. Using a strain gauge is a popular method that measures the stress at a given point. There are also methods like digital image correlation (DIC), photoelasticity, and moiré fringes that measure the strains over an area. However, performing these experiments requires expensive equipment. The article describes the experiments that were developed and deployed to teach these methods to the students. A simple version of DIC and moiré pattern are developed for strain and stress measurement. The experiments are designed in such a way that it does not require any specialized equipment. These experiments were conducted during Autumn 2021 under the mechanical design engineering second-year lab course at the Indian Institute of Technology Bombay. The class consisted of 110 students divided into 22 groups. Each group experimented and prepared the report as a group activity.

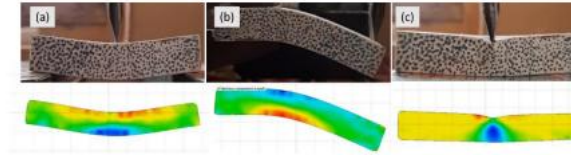
## 2 Strain Measurement using Digital Image Correlation

A typical DIC setup consists of a specimen that is loaded on a universal testing machine (UTM). While the specimen is loaded, the pattern is deformed along with the sample. A video of the sample is captured while it is being loaded. Software is used to analyze the sequence of the images to calculate the deformations. By analyzing the deformations, strain, and stress can be calculated over the area. Details of working and practical considerations of the method are described in [2]. The commercial and simplified setup for DIC is shown in Fig 1. A specialized camera is replaced with a mobile phone camera and the sample is prepared using rubber (eraser) that has a cuboid shape. The required randomized patterns are prepared by drawing dots on the side face of the eraser. While applying the load, a video is recorded that is further used to analyze the strains. Students are provided a lab manual that consists of a conceptual explanation and objectives of the experiment. The details of the experiment are expected from students to work out.



**Fig. 1.** (a) A commercial DIC setup [3] that consists of a specialized camera and sample placed on UTM. (b) A simplified experimental setup that uses a mobile phone to capture the video and an eraser as a sample.

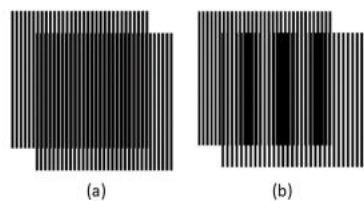
The captured image can be analyzed using software like Ncorr [4] (open-source software) or ZEISS INSPECT Correlate [5] (Commercial software) to get the strain field. Standard cases that have well-known solutions like cantilever beam, simply supported beam, and point load on a sample are performed by the students. The results student obtained are similar to their analytical solutions.



**Fig. 2.** shows the three cases that were carried out by students. Fig. 2. (a) Simply supported beam, (b) cantilever beam, and (c) point load on the surface.

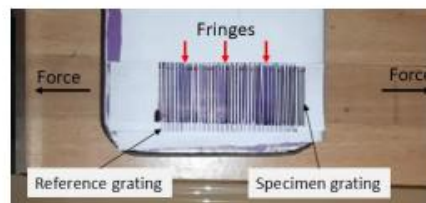
### 3 Strain Measurement using Moiré Pattern

A moiré pattern is obtained when two sets of lines or patterns are overlapped. These patterns are used to measure the strain in solid mechanics. This measurement is performed by keeping one grating on the sample and another pattern in front of it, as reference grating. This grating was prepared by manually drawing lines on a transparent plastic sheet. When the grating on the specimen is deformed, fringes are observed. By calculating the number of fringes, the value of the deformation is obtained [6]. Fig 3 shows the fringe pattern for deformed and undeformed grating. Fringes are visible when the grating on the specimen is deformed.



**Fig. 3.** (a) Two gratings overlapped, (b) the fringes when one of the gratings is deformed.

Students were expected to measure strain for uniaxial tension. A thin plastic sheet being flexible, it can be easily elongated and strain measured using a ruler. The measured value was verified using the strain calculated using the moiré fringe method. Two gratings having the same pitch are prepared by drawing lines on a plastic sheet. A reference grating is fixed on the surface while specimen grating is elongated. Figure 4 shows one of the cases where three fringes are visible while elongating the specimen grating.



**Fig. 4.** Fig. 4. A reference grating is fixed and specimen grating is deformed while applying force. Three fringes are visible while applying deformation to the specimen grating.

As students prepare the setup by themselves it gives them a better understanding of the phenomenon. Inaccuracy of hand-made grating taught them the types of error that may introduced due to inconsistent pitch and line thickness. Students were only taught using this method for strain in one direction. However, some students found that it can also be used to measure the rotations which is also another application of moiré fringes but was not covered during the lab.

## 4 Summary

Two optics-based strain measurement experiments were developed that can be performed without using specialized equipment. The overall cost of the setup was less than 100 INR/group as a student do have their laptop and smartphones. Students learned to set up an experiment for strain measurement using these methods. Such type of methods are useful when the institute is resource-constrained. However, applicability is not limited to such cases but it also gives more freedom to students to explore various ideas. Introducing such ideas encourages innovative problem-solving skills. Students do not need to worry about handling delicate, expensive, and complex equipment while exploring their ideas. Having such tools always available to them enables students to work out more creative and out of box ideas.

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# The Intersection of Technology and Citizenship: Social Media and Civic Engagement Among Mumbai Youth

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**Abstract.** Legal literacy in India remains significantly low, especially among Generation Z and Alpha, despite efforts to raise awareness through legal aid services, digital platforms, and educational institutions. This study investigates the potential of social media, specifically Instagram, to serve as a tool for fostering legal awareness among teenagers. Focusing on the controversial Romeo and Juliet law, a proposed legal reform to decriminalize consensual teenage sexual relationships, the research explores how social media posts influence civic engagement and legal understanding. Utilizing the theory of planned behaviour and framing theory, this study conducted a content analysis of Instagram posts tagged with relevant hashtags between August 2023 and December 2023, following the Public Interest Litigation filed by the Supreme Court in August 2023. Results indicate that while the number of posts on this issue was low, the content generated significant discussions among teens, encouraging deeper engagement with legal concepts that had previously been culturally taboo. The findings highlight the transformative role of social media in enabling teenagers to explore complex legal issues, moving from passive to active civic participants. However, the study also points to improved digital literacy and policies to mitigate misinformation. This research suggests that educational institutions can leverage social media platforms to bridge the gap between teenagers and legal discourse, promoting greater civic engagement and legal awareness.

**Keywords:** Social Media, Teenagers, Social Change

## 1 Introduction

Legal literacy in India is considerably low with electoral literacy as low as 39%<sup>1</sup>, considering the gravity, state-wise budgets are allocated to ensure the establishment of legal aid clinics, legal clubs and digital platforms to facilitate the cascading of legal knowledge. However the efforts and resources don't match the gap, and a considerable chunk remaining outside its gamut. Blending the two concepts, the present experiment envisages using a case study to identify how Instagram can leverage the spread of apt legal awareness.

According to National Family Health survey 2019- 2021, 10% of females have sex before age 15 and 39% before age 18 while for males it stands to be 1% who had sex

before age 15, and 6% before age 18. This gap when foreseen from the lens of legal framework in India, has led these innocent physical relationships ending up to tragic statutory rapes generally, for boys in the Indian society. When two minors engage in consensual sexual relationship, in a paradox, they both stand as victims and perpetrators of each other, although ground level reality results in boys being overwhelmingly treated as offenders and girls as victims. The consent of a minor is held immaterial by POCSO Act. Boys are punished for engaging in sexual intercourse with minor girls by calling it statutory rape although these activities are broadly consensual. Such rise in fake cases had obliged the Supreme Court to file a Public Interest Litigation (PIL) on 19th August 2023 inviting public opinions for implementation of Romeo and Juliet Law to decriminalize teen sex. The PIL sought in the above case engulfs various perceptions, belief, societal pressures and cultural norms often leading towards its ignorance. The researchers of the present study being educators themselves have experienced this huge gap in open discussions with teenagers in context of the social issues related to sex, further the above subject being culturally sensitive talk shows, panel discussions or informal discussions with family have remained sleek and so is the awareness level amongst the teenagers in the educational framework. Deeping into the seriousness of the content, it was believed social media when used in educational context for creating legal awareness amongst teenagers will act as a new battlefield to express one's thoughts and expressions. As there has been prominent increase in the average time spent by teenagers on social media platforms like Instagram and Tik Tok (\* Tik Tok is now banned in India) this study using Instagram posts examines how Mumbai learners, who have always been pinned on the commercial forefront and with little whereabouts on the socio-political landscape, engage with the Romeo and Juliet law—a recent and controversial legal issue through social media, focusing on its implications for educational technology.

## **2 Research Question**

How can educational institutions leverage the use of social media to foster discussions, open dialogues and legal awareness amongst learners?

## **3 Materials and Method**

The study is an attempt to answer its research question based on single case i.e Romeo Juliet Law in India. This case study was selected as most of the teenagers have either experienced or can relate oneself to this legal content and secondly PIL was filed by Supreme Court wherein voices of teenagers the future citizens will be excluded as their civic engagement is considerably low. The methodology blends itself exploratory inquiries within the qualitative paradigm. The focus of study lies in unveiling how social media can encourage awareness on legal content and shape teenagers' perceptions or provoke discussions and actions on topics that have limited open conversations in the society. In the present research it intersects framing theory which examines how media

shapes perceptions and interpretations of events, used episodic framing in the context of social media discussions about the Romeo and Juliet law in India (Frame of the study). Instagram posts with # Romeo Juliet law, # Teenage love # Supreme Court # Love relationships were evaluated in detail. Using Content analysis it evaluated the posts between August 2023- December 2023 as PIL was filed on 19th August 2023 drawing the attention of citizens of the country. Considering the life span of the Instagram that tends to be 48 hours, the selected period suffices the requirement. The study also used Theory of planned behaviour to study the impact on the learners.

#### **4 Results and Discussions**

The content analysis of the selected media posts was carried upon to chart the legal content and its interactions. Along with coding and counting, the context and legal terms it used were studied. The average comments range from 0-23 per posts while the posts from i.e. media channel had maximum likes of 1217 followed by posts of law counsel while other had fewer than 100 likes which directs that authenticity in terms of legal content matters the most. The followers crafted narratives that either support the need for nuanced legal reforms. to protect consensual teenage relationships or emphasize the potential risks of exploitation and abuse. These posts, framed through various lenses, influence public sentiment and potentially impact the legislative process, reflecting the power of framing in shaping societal attitudes and policy directions. The two broad themes drawn were in two opposite directions where in set of commentors believe it's a cultural taboo and would normalize sex amongst teenagers while others strongly feel it should be implemented and sex education should be part of curriculum mandatorily rather an optional subject that still finds no place in Indian education ecosystem.

Further the analysis reveals that there were fewer than 100 posts in this arena, that put forth either the awareness is low, following is meagre or the appropriate hashtags # are not used to gain attention of the users. However, the verbosity of content reveals that need for factual information and posts that facilitate discussions are looked upon thereby indicating the potential to use well-crafted social media posts for legal awareness and civic engagement. Intersecting its focus on now understanding the behaviour of learners in the higher educational institute, the researcher with its group of selected participants before experimenting of using social media for legal awareness carried upon an informal discussion on their awareness and whereabouts about Romeo Juliet law. It revealed that only 5% of the teenagers had heard about it but the context was unknown and assumed it to be romantic story or betrayal. The above data reveals that knowledge with regards to legal terminologies of Romeo Juliet law is significantly low (P-value being 0.001). Thus, instead of opting for creating legal awareness in traditional teaching learning ecosystem choose to experiment with the usage of Social media as tool to leverage educational awareness. In this context the researcher asked them to look for information on Romeo Juliet Law. The first preference was using a search engine but the content being too lengthy failed to keep learners glued however when

they experimented with Instagram and Twitter it initiated a sense probing deeper. The teens being well versed with social media handling-initiated discussions and revealed their personal experiences and takes on the law. The experiment facilitated the participation of the learners by redirecting them to social media posts and carried upon focused group discussions. The narratives brought forward the various incidences that was witnessed in light sexual teenage relationships turning into statutory rapes and boy though juvenile was subject to mental harassment and torture. These sharing of experiences led them probe into the legalities of Romeo Juliet law in India, its existence across the globe. Thus, the group that initially was reluctant to even speak on this topic now dwelled into creating awareness amongst the peers. They in-fact now browsed the search engine to know more about it, creating of Instagram posts but anonymously as threat of parents and societal pressures remained dominant. Thus, learners for whom knowledge and motivation to engage on legal content was low, were now capable and motivated to engage themselves in discussions and suggestions. In other words, social media posts led them to introspect and participate in the discussions and place their view point i.e. civic discourse.

## 5 Conclusion

India being the largest democracy and highest youth population this year witnesses a registration of only 39% [Electoral Summary Report 2024] of its young population for casting vote despite campaigns running across the country. This lays an indication of low civic engagement of Generation Z especially in urban areas. The present experiment paves way for the potentialities of harnessing this social media platform for civic engagement amongst the generation Z and Alpha paving way for good democracy. The experiment significantly demonstrated a transformation in the behaviour of the teenagers from being passive in terms of legal discussions to active inhibitors. However similar engagements need to be probed into to gain deeper insights and hold it pervasive as well the scope of misinformation and selection of posts need intervention calling for improved policies on usage of platform. In the educational contexts the social media can be used as prompt on various forums to engage learners into discussions and widening one's horizon sou moto. The study envisages to now use an apt methodology to experiment with the niche area for conclusive evidence.

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# Leveraging LLMs for K-12 Assessment Design: A Comparison with Human Subject Matter Experts

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**Abstract.** This study investigates the potential of Large Language Models (LLMs) to generate high-quality multiple-choice questions for middle school subjects. The primary objective is to evaluate whether LLM-generated assessments can match or exceed the quality and alignment of those created by human subject matter experts (SMEs) with established learning objectives. A comparative analysis was conducted between assessments produced by LLMs and those developed by SMEs. Preliminary results suggest that LLMs can generate comparable assessments, offering notable advantages in terms of scalability and efficiency.

**Keywords:** K12 Education, Assessment Design, Bloom’s Taxonomy, Cognitive Alignment, LLM, Subject Matter Expert

## 1 Introduction

Developing formative assessments manually is time-consuming and often focuses on lower-order thinking skills (LOTS). There is a growing need to incorporate higher-order thinking skills (HOTS) like analyzing, evaluating, and creating to better engage students. Although educators recognize the importance of promoting critical thinking, assessments are still largely skewed towards LOTS due to constraints such as time, resources, and traditional pedagogy. [2, 4]

The emergence of Generative AI (Gen AI) presents promising solutions for integrating HOTS into test item creation. Large Language Models (LLMs) can automate this process, saving time and effort. Studies show that Gen AI can generate diverse, high-quality questions that meet or exceed traditional standards and align with contemporary educational goals. [2]. However, automating assessment generation poses risks to accuracy due to the probabilistic nature of LLMs, potentially leading to inconsistencies in question relevance. This study aims to evaluate how well LLM-generated test items align with Bloom’s taxonomy and address two key research questions:

**RQ1:** How effectively do LLMs align with Bloom’s taxonomy in generating formative assessments for K-12 education?

**RQ2:** How do learning design strategists (LDSs) rank the performance of various question generators (e.g., Claude 3 Haiku, GPT-4, Gemini 1.5 Pro, and traditional SMEs) in creating formative assessments?

## 2 Related Work

Educationists and researchers have explored the integration of LLMs in education, particularly in assessments, personalization, and enhancing efficiency. Baker extensively discusses AI's transformative potential in educational contexts[1] and Grevisse et al. [2]. On the grading and assessment, Perkins et al.[4] suggested an assessment framework AI Assessment Scale (AIAS).

This paper responds to the challenges highlighted by Huo et al. [3] and builds on the framework proposed by Perkins et al. [4] by leveraging Generative AI. The findings from this research aim to evaluate AI's capability to generate high-quality, rigorous formative assessments that incorporate higher-order thinking skills (HOTS), align with learning objectives, and improve scalability by automating the assessment generation process.

## 3 Methodology

We began the experiment by using a basic prompt to generate questions aligned with the learning objectives. The need to optimize this prompt became clear when the prompt ignored the required blooms level and generated a more advanced question. To mitigate this, we added the following key components in the final optimized prompt:

**Bloom's Taxonomy Levels:** The generated test questions are designed to challenge at different cognitive levels (LOTS/HOTS, in alignment with Bloom's taxonomy).

**Question Stimulus (Topic Content):** The generated test questions align with the relevant educational standards.

**Learning Objectives:** The generated test questions aligned with learning objectives.

**Complexity (Low, Medium, High):** The generated test questions address varying levels of complexity.

The subjects selected for this experiment include English Language and Arts 11 and 12, Biology, Chemistry, and World History. This variety allowed us to thoroughly examine how adaptable the LLMs were in generating questions in varied contexts. The assessment parameters we established for this experiment were as follows:

**Readability:** The text was required to meet an appropriate readability level for the target audience, ensuring accessibility.

**Question Complexity and Cognitive Alignment:** Each question was expected to align with specified levels of Bloom's taxonomy (LOTS/HOTS), addressing the subject matter's inherent complexity and the intended cognitive engagement.

In the initial stage of the experiment, we conducted an author-level screening process. Each question generated by the prompts from three advanced language models—Claude 3 Haiku, GPT-4, and Gemini 1.5 Pro—were carefully assessed for adherence to blooms level and regenerated to maintain consistency and fairness for the next stage.

In the second phase, the refined questions were evaluated through a survey by 18 learning design strategists (LDS), who rated the questions on alignment with learning objectives, cognitive complexity, clarity, and utility. Each question had four multiple-choice options—three from LLMs and one from a subject matter expert (SME). The responses were randomized to prevent bias, and participants ranked their preferences.

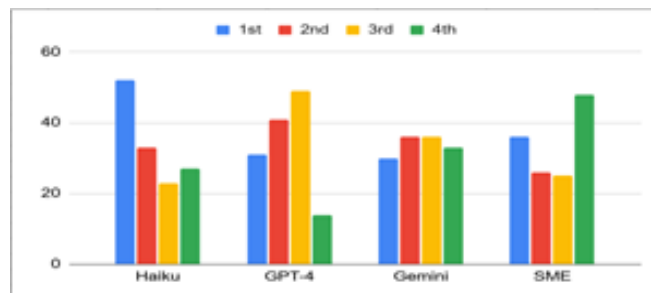
Some LDS selectively answered questions based on their subject expertise, which introduced variability in response rates. This highlighted the importance of subject-matter alignment and the challenge of cross-disciplinary evaluation.

## 4 Results

**Table 3.** Table showing Bloom’s Taxonomy categories, aligned questions, and cognitive measures.

Bloom	Aligned percentage	Cognitive Measure
Remember	91.67	LOTS
Understand	87.5	LOTS
Apply	72.22	LOTS, HOTS
Analyze	41.67	HOTS
Evaluate	55.56	HOTS
Create	66.67	HOTS

Table-1 shows the analysis of the model generated questions for Bloom’s level adherence. The data indicates that LLMs’ are able to generate lower order bloom’s level i.e. remember, understand, apply aligned questions with very high accuracy. For higher order bloom’s level i.e. create, evaluate, analyze, the alignment accuracy dips.



**Fig. 1.** Ranking of Question Generators by Learning Designer Strategists (LDSs) Across Four Categories.

Figure 1 shows a clear preference for questions generated by Claude 3 Haiku, which received the highest number of 1st preferences (52) and had the lowest average rank

(2.19). This indicates that Human LDS found Claude 3 Haiku's questions to be the most consistently high-quality.

Interestingly, questions from human SMEs received fewer 1st preferences (36) and had the highest average rank (2.63), suggesting that the LLM-generated questions are beginning to surpass those created by human experts in perceived quality.

## 5 Conclusion

This research demonstrates the potential of Large Language Models (LLMs) in improving the efficiency of formative assessment generation, particularly for lower-order thinking skills (LOTS). Claude 3 Haiku consistently produced high-quality questions, often surpassing human subject matter experts (SMEs) in simpler tasks. However, LLMs struggled with higher-order thinking skills (HOTS), showing lower alignment with Bloom's taxonomy at more complex levels. While LLMs hold promise in automating assessment creation, their limitations in generating higher-order questions must be addressed to fully realize their potential in education. Future research should focus on enhancing these capabilities to better support critical thinking and deeper learning.

**Acknowledgments.** We gratefully acknowledge the learning design strategists (LDSs) for their dedicated time, insightful feedback, and contributions, which were instrumental in enhancing the rigor and outcomes of this study.

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# An AI-Powered Interview Practice Platform to Help Job Seekers Ace Their Interviews

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**Abstract.** In today's competitive job market, traditional interview preparation methods like mock interviews and self-study often fall short, lacking the personalized guidance and comprehensive feedback needed for success. Mock interviews are costly and difficult to coordinate, while self-study fails to address the unique requirements of different job roles. This leads to inadequate preparation, causing anxiety and low confidence among job seekers, ultimately hindering their chances of securing desired positions. Our AI Interview Practice Platform tackles these issues by offering personalized interview questions based on specific job details, ensuring relevant practice sessions. It also features a resume builder to help users craft tailored, professional resumes, and a job listing tool to find openings that match their skills. Additionally, the platform provides detailed insights into target companies, including recruitment methods and previous interview questions, supporting strategic job preparation. By integrating customized interview practice, a resume builder, targeted job listings, and comprehensive company insights, our platform significantly enhances interview performance and boosts confidence. This innovative approach empowers job seekers to navigate the job market more effectively, increasing their chances of success.

**Keywords:** AI Interview Practice, Confidence, Job Market, Personalized Guidance, Interview Simulation, Strategic Preparation.

## 1 Introduction

Interview preparation is a critical step for job seekers aiming to secure their desired positions. The competitive nature of the job market makes it imperative for candidates to be well-prepared and confident in their interview skills. Traditional methods of preparation, such as mock interviews and self-study, have been the go-to strategies for many. Mock interviews often involve practicing with friends, mentors, or career coaches, providing a simulated interview experience. Self-study typically involves reviewing common interview questions, researching the company, and practicing responses.

However, these traditional methods have several limitations. Mock interviews can be time-consuming to arrange and may not always be feasible due to scheduling conflicts or the unavailability of qualified interviewers. Additionally, the feedback

received from friends or mentors, though valuable, might lack the depth and specificity needed to address all areas of improvement. Self-study, while useful for familiarizing oneself with common questions, often lacks the personalized touch that can make practice more effective. Generic questions do not cater to the specific nuances of different job roles and industries, making it challenging for candidates to fully prepare for their unique interview scenarios.

Job seekers face substantial hurdles in preparing for interviews due to the inadequacy of personalized practice and actionable feedback. Traditional methods often fall short in addressing the specific requirements of diverse job roles, leaving candidates with generic questions that fail to reflect the unique challenges of their desired positions. Additionally, the feedback provided through conventional means whether from friends, mentors, or self-assessment tends to be superficial and lacks the depth needed for meaningful improvement. This deficiency in targeted practice and constructive critique hampers candidates' ability to refine their skills effectively. Consequently, job seekers may enter interviews feeling unprepared and lacking confidence, significantly diminishing their chances of securing the positions they aspire to.

The objective of the AI Interview Practice Platform is to provide job seekers with a personalized and interactive interview preparation tool that enhances their readiness and performance. By leveraging advanced AI technology, the platform aims to fill the gaps left by traditional preparation methods. The platform generates customized interview questions based on the specific job details entered by the user, ensuring that the practice sessions are relevant and tailored to the individual's needs. Additionally, the platform offers a simulated interview environment where users can practice their responses, receiving detailed, real-time feedback that highlights their strengths and areas for improvement.

## **2 Literature Review**

Existing solutions for interview preparation encompass mock interviews with professionals, online question banks, and interview coaching services, each with its own set of strengths and limitations.

Mock interviews with professionals offer a high degree of realism and personalized feedback, closely simulating the interview experience. They can be invaluable for candidates seeking to refine their skills and gain insights into their performance. However, these interviews often present significant challenges: they are frequently expensive, require substantial time to coordinate, and are constrained by the availability and expertise of the professionals. Additionally, they may not cover the full spectrum of potential interview scenarios, limiting the depth of preparation.

Online question banks provide a broad array of common interview questions for self-study. While these resources are readily accessible and useful for general interview preparation, they fall short in several key areas. Their generic nature means they lack adaptability to specific job roles and individual needs, resulting in a less targeted practice experience. Furthermore, the absence of real-time feedback means users are deprived of immediate guidance and actionable insights to improve their responses.

Interview coaching services offer a more personalized approach, with one-on-one sessions that can be tailored to the candidate's specific needs. These services provide detailed feedback and strategic advice, making them highly effective for targeted improvement. However, the cost of coaching services can be prohibitive for many job seekers, and their accessibility is limited, particularly for those in remote or underserved regions. The time commitment required for these sessions also poses a barrier for some candidates.

Our platform seeks to bridge these gaps by utilizing advanced AI technology to deliver tailored interview practice and feedback. By inputting specific job details, users receive customized questions relevant to their target positions, ensuring a focused and effective practice experience. This personalization addresses the limitations of generic question banks by aligning practice sessions with the unique requirements of various roles.

The AI-driven approach facilitates immediate, detailed feedback, providing users with comprehensive evaluations that include ratings, correct answers, and constructive comments. This real-time feedback is essential for identifying strengths and areas for improvement, offering a clear roadmap for performance enhancement. Additionally, the platform integrates a resume-building tool and a job search feature, creating a holistic solution for job seekers. The resume builder assists users in crafting professional, tailored resumes, while the job search feature leverages LinkedIn data to connect users with relevant opportunities, streamlining the job search process and aligning with their skills and preferences.

### **3 Methodology**

The study employs a mixed-methods approach, combining quantitative analysis of user interactions with qualitative feedback to assess the effectiveness of the AI Interview Practice Platform in enhancing interview preparedness. Participants were selected from job seekers actively using the platform, focusing on individuals applying for various roles.

Users begin on the homepage, which highlights platform features like resume building and job searching. After clicking "Get Started," they access a dashboard that serves as their central hub for managing the interview practice experience. This includes tracking progress and accessing feedback.

The practice process involves several steps: users enter job details, allowing the platform to tailor questions. The AI then generates relevant interview questions, which users answer while recording their responses using a camera and microphone. Afterward, the AI provides detailed feedback on their performance.

Additionally, the job portal enables users to browse current listings with filtering options. Users can explore popular companies, provide desired roles, and receive tailored insights to improve their chances of securing positions. This structured approach aims to effectively prepare users for successful interviews.

## 4 Conclusion

The AI Interview Practice Platform stands out as an advanced tool designed to enhance job seekers' interview readiness. It provides a comprehensive solution by delivering personalized, role-specific questions tailored to the unique requirements of each job application. Users can simulate real interview scenarios by recording their responses, allowing them to practice speaking their answers aloud. Following each practice session, the platform offers detailed feedback, including ratings, correct answers, and constructive comments. This feedback highlights strengths and areas for improvement, enabling users to systematically refine their interview skills.

## 5 Impact

The platform enhances users' interview performance by addressing both technical and psychological preparation aspects. It offers customized practice questions tailored to specific job roles, helping users become familiar with expected queries and boosting confidence. The realistic simulation of interview conditions reduces anxiety and improves articulation, body language, and time management. Detailed feedback provides constructive suggestions for refining responses, making communication more effective. By supporting users through every stage of preparation—practicing questions, receiving actionable feedback, the platform ensures comprehensive readiness, significantly increasing users' chances of securing their desired positions and achieving their career goals.

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# Addressing Cognitive Loss and Enhancing Exam Preparation for Engineering Students Post-Pandemic through E-Notes Platforms

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**Abstract.** The COVID-19 pandemic reshaped learning for engineering students, causing challenges in retention and exam preparation. This study introduces Notes4U, an e-notes platform that addresses cognitive loss and enhances exam readiness by providing digital resources like e-notes, solved papers, MCQs, and video tutorials. Surveys and platform analytics show significant improvements in student performance, engagement, and understanding of complex engineering concepts.

**Keywords:** Engineering education, Digital resources, Student performance

## 1 Introduction

The COVID-19 pandemic forced a global transition to online learning, significantly impacting the study habits of engineering students [1]. With reduced access to traditional face-to-face interactions and physical resources, students have increasingly relied on digital platforms. This shift has fundamentally changed the way students prepare for exams and retain academic information [2].

## 2 Problem Statement

The sudden shift to online learning has led to cognitive loss among students, affecting their ability to retain and process information effectively. The absence of senior guidance and mentorship has further hindered their ability to efficiently use online resources, resulting in suboptimal academic performance and exam preparation.

## 3 Research Objective

This study aims to introduce an e-notes platform designed to bridge cognitive gaps and improve study practices for engineering students. By offering resources such as e-notes, practice papers, MCQs, and previous years' question papers, the platform seeks to enhance students' academic outcomes and exam readiness.

## 4 Research Questions

- RQ1. How has the shift to online learning impacted engineering students' study habits and academic performance?
- RQ2. What are the primary needs of students in terms of study resources post-pandemic?
- RQ3. How effective is the developed platform in providing necessary study materials and improving exam preparation?

## 5 Literature Review

The COVID-19 pandemic drastically changed learning habits, with students shifting from traditional classroom settings to online education, increasing their reliance on digital resources [1]. While digital learning tools have improved engagement and performance, challenges like digital fatigue and limited interaction persist [2]. Existing research highlights the benefits of online tools but lacks focus on the cognitive effects of the shift for engineering students and the effectiveness of comprehensive e-notes platforms [4]. This study aims to address these gaps by evaluating the impact of a tailored e-notes platform on student retention and exam preparation [3].

## 6 Methodology

A survey of 118 engineering students, mostly in their second year, was conducted to assess their study habits and resource preferences. Key findings revealed a need for detailed notes, MCQs, and previous years' question papers, with 71.8% favoring a customized e-notes platform. The platform was developed using WordPress with CMS, a database, and plugins for user management and content organization. Study materials were collected and uploaded for easy access. Data collection involved usage analytics and feedback through surveys, while analysis focused on user satisfaction, resource usage patterns, and performance improvements post-platform use.

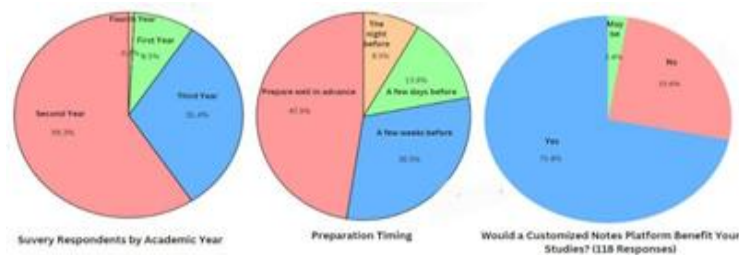
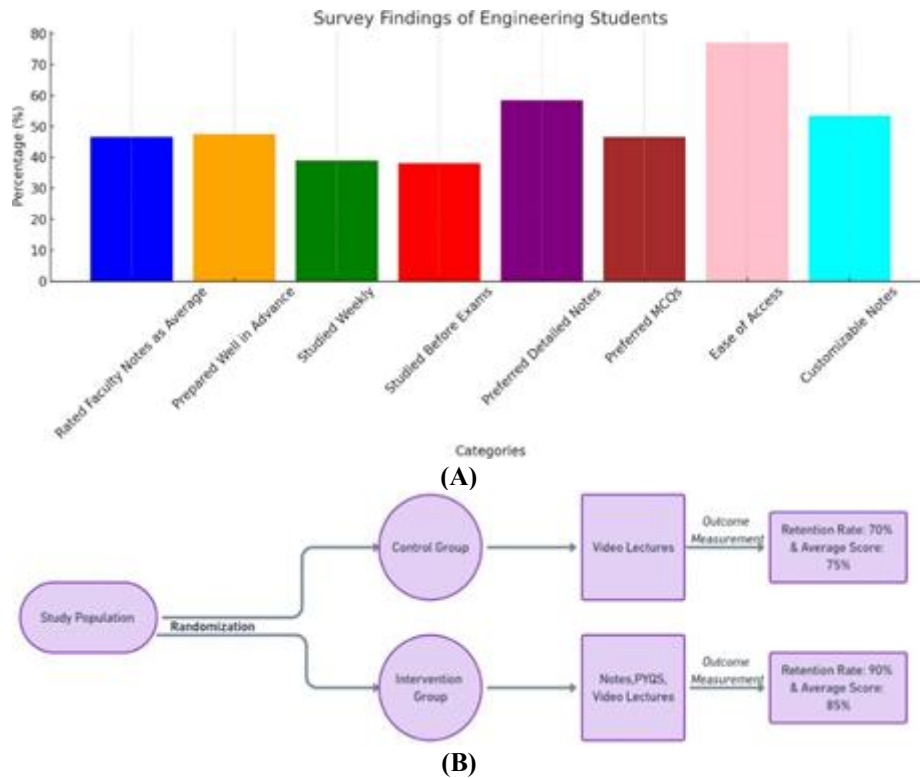


Fig. 1. Survey results on respondents.

## 7 Findings and Discussion

Survey findings showed 46.6% of students rated faculty-provided notes as average, while 47.5% prepared for exams well in advance. Most students studied weekly (39%) or only before exams (38.1%), with detailed notes (58.5%) and MCQs (46.6%) being the most preferred study materials. The Notes4U platform saw high engagement, with students praising its ease of access (77.1%) and customizable notes (53.4%). (See Fig.2A). Regular updates and interactive tools were also appreciated. The platform positively impacted exam preparation and performance, with students reporting improved study habits, better understanding of concepts, and enhanced academic outcomes (see Fig.3). A randomized study comparing a control group (video lectures only) with an intervention group (notes, previous year papers, and video lectures) showed higher retention (90% vs. 70%) and average scores (85% vs. 75%) in the intervention group. (See Fig.2B.)



**Fig. 2.** (A) Survey findings for engineering students. (B). Randomized study showing the intervention group (notes, PYQs, video lectures) had better retention (90%) and scores (85%) than the control group (70%, 75%).

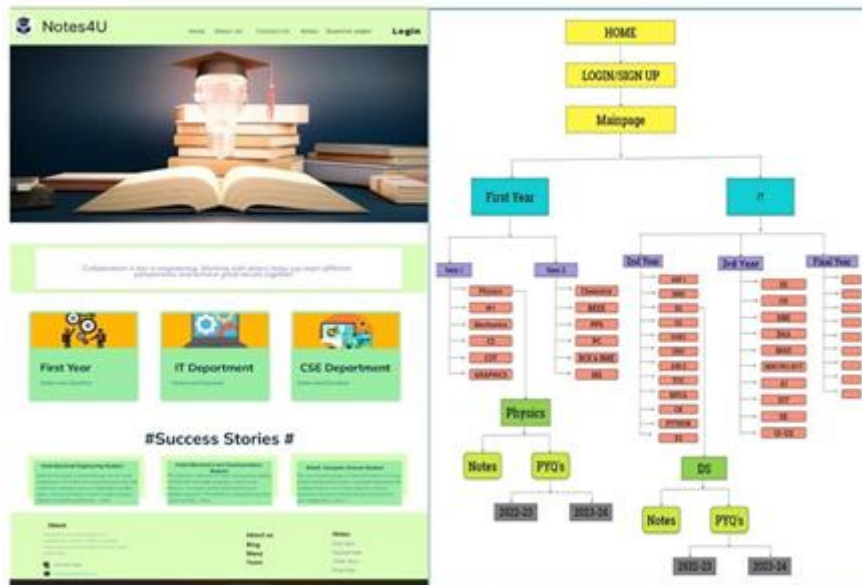


Fig. 3. Home Page and System Flow.

## 8 Conclusion

This study revealed a significant shift towards digital resources among engineering student's post-pandemic, with the developed e-notes platform effectively improving exam preparation and cognitive retention. Key recommendations include adopting digital platforms, providing comprehensive resources, and encouraging early exam preparation. Future research should focus on expanding the study across all engineering branches, analyzing long-term impacts, and optimizing user experience on digital platforms.

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# AI-Driven Teacher Professional Development: A Revolution or Risk?

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**Abstract.** The rapid advancement of artificial intelligence (AI) has increasingly influenced education, particularly in teacher professional development (TPD). Despite AI's potential benefits and drawbacks, limited research exists on its specific impact on TPD. This study fills that gap using a mixed-methods approach, incorporating surveys and interviews with different stakeholders like teachers etc. Findings show that AI enhances TPD by providing personalized learning, real-time feedback, and streamlining administrative tasks. However, concerns include over-reliance on AI, privacy and security issues, biases, and insufficient technological infrastructure. These insights help guide TPD designers in integrating AI while addressing key challenges.

**Keywords:** Artificial Intelligence, Teacher Professional Development, Teacher

## 1 Introduction

Professional development (PD) is crucial for improving teacher skills, adopting new practices, and enhancing student outcomes. While effective PD can boost teacher and student performance [1-2], traditional workshops often fail to create lasting changes [3]. Teachers struggle to implement new practices due to limited support. Research shows that ongoing, embedded PD, supported by coaching and professional learning communities (PLCs), leads to successful skill application for over 90% of teachers [4]. However, traditional PD lacks personalization and flexibility, driving interest in technology to provide more tailored professional growth opportunities.

The EdTech industry is revolutionizing education, with AI playing a key role in enhancing teaching and learning. AI technologies like machine learning and data analytics offer personalized learning, real-time feedback, and data-driven insights, helping teachers refine skills and engage in continuous learning [5]. AI supports PD by automating administrative tasks, curating content, and fostering collaboration, allowing teachers to focus on improving instruction. Research shows AI boosts educational efficiency by tailoring learning experiences and predicting student performance [6]. Platforms like Coursera, TeachLivE, and Edmodo streamline PD, instructional design, and assessment, collaboration enhancing teacher effectiveness.

Despite AI's potential in education, challenges persist, such as the risk of reinforcing biases in educational data and the need for significant investments in technology and training, especially in resource-limited institutions. Addressing these challenges requires ethical considerations and equitable access to technology and training for all educators. Additionally, there is a lack of understanding of teachers' perspectives on AI tools, which are often underrepresented in the literature. This study employs a mixed-methods approach to explore the benefits and challenges of AI in teacher professional development (TPD) by analyzing educators' perceptions and experiences, aiming to provide insights for effectively leveraging AI to enhance TPD and improve educational outcomes.

## **2 Methodology**

This study used a mixed-methods approach [7] to examine the benefits and challenges of using AI in TPD. The research aimed to answer: What are the potential benefits and drawbacks of AI as a tool for TPD? A stratified random sample of 30 participants, including K-12 teachers, higher education faculty, administrators, and policymakers, ensured diverse representation. Data collection was conducted through an online survey and follow-up phone calls, involving a 5-point Likert scale questionnaire with four sections: demographics, perceptions of AI in PD, experiences and concerns about AI, and support/training needs. Open-ended questions provided qualitative insights. Informed consent was obtained from all participants. Descriptive statistics summarized quantitative data, while content analysis identified themes from open-ended responses [8].

## **3 Findings**

The findings present both quantitative and qualitative analysis of the perceptions and experiences regarding the potential benefits and drawbacks of using AI as a tool for TPD. Most respondents are K-12 teachers, with 51.7% aged 31-40 and half having up to 5 years of experience, reflecting an early career stage. The majority come from backgrounds in Education and Educational Technology, offering informed perspectives on AI's role in PD. This demographic context helps interpret their views on AI's potential benefits and drawbacks in enhancing TPD.

### **3.1 Quantitative Findings**

The survey data reveals varying levels of familiarity with AI for PD, with 6.9% unfamiliar and 48.3% moderately familiar, yet 51.7% feel comfortable using AI for PD. Participation in PD is high, with 44.8% occasionally, 31% frequently, and 20.7% always engaging. Overall, despite moderate AI familiarity, educators show high comfort in using AI tools and actively engage in PD activities. Workshops are the preferred PD activity (66.7%), followed by peer collaboration and online courses. Most respondents (83.3%) are willing to invest time in learning AI tools, and 86.7% have used AI tools

like ChatGPT and Grammarly, with 60% reporting satisfactory experiences. Key benefits include 24/7 availability and data-driven personalization, while concerns center around over-reliance on technology and AI tool reliability. These findings suggest that while AI offers flexibility and personalization, concerns about technology dependence and tool reliability must be addressed.

The study shows a positive perception of AI in enhancing TPD. As summarized in Table 1, 91.3% of teachers believe AI can improve TPD, with 80.7% highlighting its effectiveness in personalizing learning. Additionally, 92.3% see AI as efficient and time-saving, while 77% to 84.6% support its role in providing data-driven insights and feedback. However, concerns persist, with 84.6% worried about privacy, over-reliance, and costs, and 65.4% fearing bias reinforcement. Despite this, 96.2% are willing to invest time in learning AI tools, showing strong engagement potential.

**Table 4.** Teachers' perceptions of using AI for TPD

Items	SD (%)	D (%)	N (%)	A (%)	SA (%)
1. AI has the potential to improve TPD	0	0	8.7	69.6	21.7
2. AI can personalize PD to meet teacher needs.	0	0	19.2	53.8	26.9
3 AI can make PD process efficient & time-saving.	0	0	7.7	57.7	34.6
4. AI can provide valuable data-driven insights....	3.8	0	19.2	38.5	38.5
5. AI tools offer real-time feedback & assessments.	0	0	26.9	38.5	34.6
6. AI can help in curating educational resources....	0	0	15.4	53.8	30.8
7. Concerned about privacy and security of data	0	7.7	7.7	46.2	38.5

8. AI in PD lead to over-reliance on technology.	0	0	15.4	42.3	42.3
9. AI tools inadvertently reinforce biases... data.	0	15.4	19.2	50	15.4
10. AI tools for PD costly and not accessible to all.	0	0	15.4	57.7	26.9
11. AI face technical problems affect reliability....	0	3.8	19.2	57.7	19.2
12. Resistance among teachers to adopt AI for PD.	0	3.8	15.4	57.7	23.1
13. AI effectiveness depends on the data quality..	0	0	7.7	69.2	23.1
14. Need training to use AI tools for my PD.	0	0	7.7	61.5	30.8
15. Willing to invest time in learning AI tools ...	0	0	3.8	61.5	34.6

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### 3.2 Qualitative Findings

The thematic analysis revealed key insights into participants' views on AI in TPD. Most participants expressed positive attitudes, highlighting AI's potential to enhance student learning outcomes (LO), improve teaching methods, and offer personalized learning experiences. One participant noted, 'It is needed for teaching, enhances LO.' They valued AI for saving time, automating tasks, and providing data insights. For instance, one participant remarked, 'Learning at one's own pace and time availability [.....] in AI.' However, concerns were raised about the loss of human connection, reduced creativity, and over-dependence on technology. One participant noted, 'Overreliance on AI might lead to a diminished human element,' while another added, 'It restricts creativity and makes us dependent.' Ethical issues such as data privacy and bias were also noted, with

one participant cautioning that ‘data can be misinterpreted.’ Despite these concerns, participants showed strong enthusiasm for adopting AI, emphasizing the need for accessible tools, ongoing workshops, and technical training, with one participant suggesting, Hands-on practice on AI tools are useful.

## 4 Discussion and Conclusion

This study highlights the benefits and challenges of integrating AI into TPD. Despite some unfamiliarity with AI, participants generally had a positive attitude [9] and showed a strong willingness to learn AI tools. Key benefits include accessibility, personalized learning, and data-driven insights, echoing previous research. However, concerns such as over-reliance on technology, privacy issues, and inadequate infrastructure were also noted. Addressing these challenges with balanced training and support is essential [10]. Limitations include a small sample size, and future research should focus on larger, more diverse groups to explore AI's long-term effects on TPD. Overall, this research provides valuable insights into AI's impact on TPD, helping inform future program design in education.

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# AI Meets Education: Transforming MOOC Designs with Artificial Intelligent Tools

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**Abstract.** This study explores the integration of AI, Canva, and H5P in creating multimedia for the MOOC "Mentoring for Teacher Professional Development." As education evolves to meet the needs of in-service teachers, the project leverages AI for scriptwriting, Canva for visual design, and H5P for interactive elements to enhance learner engagement, knowledge retention, and accessibility. Using a Design-Based Research (DBR) methodology and the ADDIE model, the study addresses challenges such as pedagogical alignment and technological limitations, while emphasizing inclusive design. The findings highlight AI's potential to transform online course development in education.

**Keywords:** Artificial Intelligence (AI) in Education, Multimedia Learning, MOOC Development, Inclusive Design in Education, ADDIE Model, Design-Based Research (DBR), Teacher Professional Development, Canva, H5P, Accessibility and Engagement in Online Learning.

## 1 Introduction

In recent years, technology has significantly reshaped education, especially with the rise of Massive Open Online Courses (MOOCs). These platforms provide flexible, accessible education to diverse global audiences, but maintaining learner engagement and ensuring effective knowledge retention remains a persistent challenge. Traditional instructional methods often fall short in online environments, requiring innovative approaches that can address these needs [1].

Artificial Intelligence (AI) and multimedia tools like Canva and H5P offer promising solutions to enhance the MOOC experience. AI's ability to generate personalized content, combined with Canva's visual content creation and H5P's interactive elements, can improve engagement and learning outcomes. However, these tools cannot fully address deeper, human-centric educational challenges, such as the need for social interaction, pedagogical alignment, and inclusivity [2]. While technological tools are essential, an over-reliance on them risks oversimplifying complex educational dynamics.

The integration of AI, Canva, and H5P is examined in this study through the MOOC "Mentoring for Teacher Professional Development" hosted by TISSx, focusing on in-service teachers in India. Given the diverse learner profiles in MOOCs, particularly in

India, learner engagement needs to be analyzed with a broader lens, considering social, cultural, and human factors [7][8].

## 2 Literature Review

The integration of Artificial Intelligence (AI) and multimedia tools like Canva and H5P in MOOCs has gained considerable attention for their potential to enhance learner engagement and outcomes. AI personalizes learning by tailoring content to individual needs, while Canva and H5P create interactive, visually engaging experiences. However, the effectiveness of these tools depends on thoughtful integration with pedagogical frameworks and ensuring inclusivity [3].

AI in education has shown promise in customizing learning experiences, yet risks oversimplification if human interaction and pedagogical depth are overlooked [3]. Multimedia tools, including videos and interactive elements, have been found to boost engagement and retention, particularly when aligned with instructional goals [4][6]. Inclusivity remains a critical factor, as multimedia design must cater to diverse learner needs [5].

In the Indian MOOC context, studies emphasize the importance of active learner participation and peer interactions for increasing engagement [7][8]. These findings underscore the role of human and social factors, which tools alone cannot fully address. Thus, while AI, Canva, and H5P hold promise for enhancing MOOCs, their success depends on aligning technology with broader pedagogical and social considerations.

## 3 Research Methodology

This study adopted a Design-Based Research (DBR) methodology, alongside the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation), to examine the integration of AI, Canva, and H5P in the "Mentoring for Teacher Professional Development" MOOC. This iterative process helped refine the multimedia content to meet learner needs. A purposive sample of 8 in-service teachers enrolled in the TISSx MOOC was selected, representing diverse experiences and technological proficiency. Though the sample size is small, it allowed for in-depth qualitative insights. Data were gathered via pre- and post-course surveys, focus groups, and individual interviews. Pre-course surveys established a baseline for engagement, and post-course surveys measured engagement, learning gains, and satisfaction. Focus groups provided deeper insights into the usability of AI-generated scripts, Canva visuals, and H5P interactivity. Validated surveys with both Likert-scale and open-ended questions assessed participants' engagement, learning outcomes, and satisfaction. Focus group discussions centered on key aspects of the multimedia content and its effectiveness. Quantitative survey data were analyzed using paired t-tests, with normality and variance checks. Due to the small sample size, results were interpreted cautiously. Qualitative data were analyzed thematically, identifying key themes from participant experiences to complement the quantitative findings.

## **4 Results**

The results of the study indicate a significant positive impact.

### **4.1 Learner Engagement**

Quantitative analysis revealed a statistically significant increase in learner engagement scores. The mean engagement score rose from 3.2 (pre-course) to 4.1 (post-course), with a paired t-test indicating significant improvement ( $t(7) = 4.52, p < 0.01$ ). Participants reported that the AI-generated scripts, along with the visually appealing content contributed to their enhanced involvement in course activities. One participant noted, “The interactive quizzes and visually engaging content kept me motivated throughout the course.”

### **4.2 Learning Gain**

The assessment of learning demonstrated an improvement in participants' understanding of the course content. Pre-course quiz scores averaged 62%, whereas post-course scores increased to 85%, with a t-test showing significant gains ( $t(7) = 6.78, p < 0.001$ ). Participants expressed confidence in their grasp of key concepts, attributing this success to the interactive and personalized nature of the multimedia content.

### **4.3 Accessibility and Inclusivity**

Post-course survey results indicated high satisfaction regarding accessibility and inclusivity. The average score for ease of access to course materials was 4.6 out of 5, while inclusivity of content for diverse learners scored 4.5. Overall, the findings illustrate that the integration of digital tools significantly enhanced learner engagement and facilitated substantial learning gains, supporting the potential for these tools to transform online education.

## **5 Conclusion**

This study demonstrates the effectiveness of integrating AI, Canva, and H5P in enhancing learner engagement and learning gains in MOOCs. The multimedia elements not only made the content more interactive and personalized but also improved accessibility and inclusivity, crucial factors in diverse learning environments like India. However, while these tools significantly contributed to engagement, a tools-centric approach alone cannot address broader pedagogical and social aspects. Future research should explore combining these technological innovations with human-centered design to create more holistic and inclusive learning experiences for diverse MOOC participants.

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# Finding an Optimal English Diagnostic Program for an Indian University's Writing Course

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**Abstract.** A learner's language proficiency can be assessed differently based on the purpose of assessment and its function, in addition to the target language skill, register, and speech. This paper illustrates development of an English diagnostic programs for a first-year writing course at a higher education including factors and principles. Three aspects were as follows: First, test materials were selected or created from authentic materials and reflecting task-takers' future activities in the writing course. Second, a written test is accompanied and completed by a language background survey and an interview. Third, assessed components are relevant to the learning objectives of the writing course. This paper also illustrated a sample diagnostic program with results of 383 incoming: (i) An initial screening was made with a language background survey with a reading-writing test, and (ii) half of the students were selected for a further listening-speaking assessment phrase.

**Keywords:** English Diagnostic Test, Academic Communication, First-Year Writing Course in Higher Education, Multifactor Assessment.

## 1 Introduction

A learner's language proficiency can be assessed differently based on the target language, relevant domains of, and the target speech. Diagnosing Indian learners' English skills is even trickier because of a highly diversified language backgrounds and exposure to the working language. For this reason, written or spoken tests alone often fail to capture overall language skills straightforwardly because learners' language experiences are highly diverse and multiple parameters exist; at the same time, there is a need to establish a systematic and standardized method of testing applicable to a large audience. This paper illustrates an ongoing journey to find a set of factors that should be considered for English skill assessment for academic purposes, for student allotment in an undergraduate-level writing course, with actual assessment criteria and questions introduced in an engineering college.

Higher education institutions with non-native English speakers have acknowledged the importance of adequately measuring incoming students' English proficiency to assess students' strengths and weaknesses and further identify who needs extra assistance for their academic journey. This 'post-entry' test has different foci and criteria and can hardly be outsourced from common proficiency tests such as TOEFL and IELTS,

targeting a broader pool. A number of universities overseas have developed internal screening and diagnostic systems such as the Diagnostic English Language Assessment (DELA) [1]. However, they seem sub-optimal for the Indian context because a difference in the target language, and consequently, a higher score in the tests may not directly reflect proficiency in the Indian setting. In addition, a commonly observed discrepancy between the reading and speaking skills of Indian students, coupled with their highly diverse linguistic backgrounds, makes English assessment more challenging.

## 2 Developing a Diagnostic Test: Aspects to Consider

Existing English tests developed in India have been mostly summative tests for the English subject classroom [2]. Our aim was to take an initial step for an evaluation system to estimate learners' English comprehension and speech levels relevant to oral communication. The results were planned to be used---and actually used in July 2024---for students' section assignment in our university's first-year writing course. This year, we planned to run two different sections: One set of sections with a larger number of 40 students and smaller sections with 15-18 students.

The first part considered was a survey component about learners' language background. After analyzing existing language surveys such as LEAP-Q[3] and LHQ3[4] were, a small set of questions were created asking students' proficient languages and the medium of instruction at school. English has been celebrated as a medium of instruction in many Asian country for a practical reason, even when their population has few English native speakers [5], and in India, the percentages of English-medium schools have increased in primary through secondary divisions from 1993.

The second part was about students' emotion and confidence level. Previous literature has consistently discussed learner's self-confidence as a major factor in successful language learning [7]: It reduced affective filter and students' fear [8] naturally emerging in the environment of testing their boundary, which is especially visible in the foreign language or second language learning classroom.

Thirdly, the written test was designed as a screening tool for shortlisting students for the further assessment because our purported diagnostic system aims for identifying students in need of closer care and attention, and speaking and listening skills are the most directly related to the students' adoptability in our writing course. Four language skills---reading, writing, listening, and speaking---are less correlated in multilinguals [9]. But, at the same time, the limitation in time and space at the university could not give us enough time to interview all incoming students.

Lastly, to assess student's spoken communicative skill, we used the format of group discussion for its predictability for our writing course. In English language courses, the group discussion format has been used for class activities as well as student evaluation [10]. We predicted that the incoming students' behavior at the group discussion format would best indicate their performance in the future classroom. Unlike general evaluation for the group discussion, we did not consider the pronunciation or the grammar; we majorly looked into students' speech based on the richness of vocabulary, the complexity and length of sentence formation, and the degree of interaction with classmates.

### 3 Proposed Diagnostic Program

**Screening: Language Background Survey with Written Diagnostic Test.** Our target group was 400, and out of them, 383 students participated in the summer of 2024. The first round of diagnosis was with a written test containing a survey as well as multiple choice questions for vocabulary and reading comprehension. The survey such as learner's confidence level, mediums of instruction in grades 1-12, their "mother tongue" and all proficient languages.

**Table 1.** Components in the Survey Section

Questions	Q type	Categories
1. What is your mother tongue?	Choice	Background
2. Please tell me all languages you understand relatively well.	Checkbox	
3. How confident have you been in English communication on campus for the last few days?	Likert	Confidence in English speaking
4. Do you think you need intensive assistance?	Yes/No	
5. Your school's medium of instruction in your grades 11 and 12		Medium of Instruction
6. Your school's medium of instruction in grades 9 and 10	Checkbox	
7. Your school's medium of instruction in grades 6 and 8	(all 5-8)	
8. Your school's medium of instruction in grades 1 and 5		

The accompanied test has 5 cloze questions, 4 vocabulary questions, 17 reading comprehension questions, and 1 short composition task. For example, fig. 1 is a cloze

test. The sentences were adopted from a recent news article in an Indian broadcasting system [11]. The number of options were limited to 3, instead of usual 4 or 5 to maximize the creation of ‘equally plausible-looking answers’, as argued by [12]. We found it crucial to use materials that are practically used in the Indian context. Target vocabulary, “pull the plug” in this case, was also chosen because it was known to average Indian audience and the level seemed intermediate, neither too high nor too low.

Stem: *Cloud-based services keep flights on time and our airports running smoothly. So, when these services went down, it was as if someone pulled the \_\_\_\_\_ on their operations.*

Options: (1) *plug* (2) *strings* (3) *trigger*

**Fig. 1.** A sample cloze question with the sentence taken from *The Indian Express* [4].

**Communication Evaluation: Group Discussion.** To assess student’s spoken communicative skill, we used the format of group discussion for its predictability for our writing course. In English language courses, the group discussion. Ten students were call at the same time, and one discussion topic was given to one group, out of 20 opinion or explanation-requiring topics such as “Should children do house chores?” and “What is one of the things that have changed after COVID-19?”. After 5 minutes for individual preparation, an open discussion began. Students could freely jump into the discussion and interact with others. The grading rubric followed the five criteria below. Criteria 1-3 were graded on the combined scale of 1-10; criteria 4-5 were considered only for the outlying cases: (1) Choice of word, (2) Sentence structure, (3) Interaction, (4) Speed of speech, (5) Activeness and enthusiasm. The group discussion records were used for finalizing smaller, intensive-learning sections. As a result, out of a total of 200 students, 64 students were allotted to the intensive section.

#### 4 Assessment and Reflections

For the last few years, instructors found that there did not seem to have a necessary correlation between students’ speaking and writing abilities, there was a tendency such as those who were eager to speak and communicate achieved high performance in the end. This resonates with [13]’s points about second-language speakers’ thinking process required for speaking. Our observation shaped the two-stage diagnosis program, and design each stage’s materials as close to the actual class environment as possible.

The screening test scores were on average 14 (SD 3.84) and the interview scores were on average 6.36 (SD 1.93). We focused on 200 students, who took both written

and speaking evaluation, and examined any possible correlations among their written test scores, group discussion score, and self-assessed confidence level from survey 3 (Table 1). As illustrated in Table 2, interview scores, test scores, and self-reported confidence points show little or no correlation with one another. In addition, there seems to be a positive correlation between the students' school medium of instruction and their overall performance.

**Table 2.** Regression with the interview score and the self-reported confidence

Regression	Interview score & Self-reported confidence	Test score & Self-reported confidence	Test score & Interview score
Multiple R	0.0814181	0.23746082	0.27580758
R <sup>2</sup>	0.00662788	0.05638764	0.07606982
Adjusted R <sup>2</sup>	0.00161085	0.05162192	0.07140351

There are much room for improvement for the next edition of diagnostic tests: First, the survey could have more components such as students English or native language-mediated media consumption, based on the recent trend of high exposure to language through social media and on-demand channel products. Second, the validity and accuracy of written test must be more rigorously examined, before comparing the score results. Third, the panel evaluation of the interview must be improved in a way of guarantee more consistent grading.

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# Leveraging Historical Student Course Data through RNNs for Personalized Course Recommendations

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**Abstract.** In the quest for personalized learning experiences, our research explores student learning paths using Neural Networks for course recommendation. Leveraging data-driven insights, we aim to tailor educational experiences to individual student profiles, enhancing engagement and academic success. We analyze student data through statistical methodologies to generate personalized course recommendations aligned with individual aspirations and learning styles. In this research study, we focus on analyzing data pertaining to students enrolled in the IITM BS Degree Program in Data Science and Applications with an average (CGPA) of 7 or above. Our sample comprises 5980 unique students, and we examine the courses undertaken by each student across various terms over three years. For our analysis, we narrowed our dataset to 11829 records, where each record represents a term as input and the subsequent term as the corresponding output. The trained model gives us an accuracy of about 82%. This research represents a pioneering endeavour in educational data science, merging advanced machine learning techniques with pedagogical principles. By understanding student learning paths, we aim to transcend traditional education paradigms and promote inclusive, personalized learning experiences for all learners.

**Keywords:** Personalized Learning, Academic Performance Analysis

## 1 Introduction and Literature Review

Personalized learning is a critical method for improving student engagement and success by tailoring educational experiences to individual needs. This research utilizes Recurrent Neural Networks (RNNs) to model the learning paths of students in the IITM BS program, providing customized course recommendations. Traditional methods like collaborative filtering struggle with the cold start problem and fail to account for the sequence of courses [1, 2]. RNNs, by handling sequential data, improve recommendation accuracy by understanding the order of course enrollments [3, 4]. Attention mechanisms further enhance these models by focusing on the most relevant aspects of student learning behavior [5]. Clustering and session-based approaches provide additional personalization based on student performance and optimize recommendations for

future semesters [6, 7]. This combination of techniques allows for the development of a robust, tailored learning experience for a diverse student population.

## 2 The Methodology

The main objective of this research is to explore and assess the feasibility of RNN models to capture student learning paths. The dataset originates from the Indian Institute of Technology Madras (IITM), specifically from the Bachelor of Science in Data Science & Applications program. The sample includes students with a CGPA of 7 or higher, selected to ensure course recommendations that help future students achieve or maintain a CGPA of 7 and above. The dataset comprises 5980 students, with 11829 records representing a term as input and the subsequent term as the corresponding output. The data structure represents each student’s educational journey as a sequential list of courses undertaken during each academic term and the corresponding grades. Each course  $c_i$  is represented as a one-hot encoded vector:

$$\text{One-Hot Encoding}(c_i) = \begin{cases} 1, & \text{if course } c_i \text{ is taken} \\ 0, & \text{otherwise} \end{cases}$$

The set  $S$  can be represented as a tuple of two arrays:  $S = (\text{course\_vector}, \text{grade\_vector})$ , where:

$$\text{course\_vector} = \begin{bmatrix} \text{One-Hot Encoding}(c_1) \\ \text{One-Hot Encoding}(c_2) \\ \vdots \\ \text{One-Hot Encoding}(c_n) \end{bmatrix}, \quad \text{grade\_vector} = \begin{bmatrix} g_1 \\ g_2 \\ \vdots \\ g_n \end{bmatrix}$$

The aggregated one-hot encoded course vector for student  $S$  in a term is obtained by summing the individual one-hot encoded vectors:

$$\text{Aggregated Course Vector}(S) = \sum_{i=1}^n \text{One-Hot Encoding}(c_i)$$

This preprocessing step enables the model to analyze not only which courses are taken but also the sequence in which they are taken, which is crucial for understanding dependencies between courses and for providing accurate future course predictions.

We used a seven-layer RNN to analyze student course enrollment, starting with a one-hot encoded input layer. The model features an LSTM layer (32 neurons) for long-term dependencies, a 0.2 dropout layer to prevent overfitting, and a second LSTM layer (16 neurons) for feature refinement. An attention layer weights key inputs, while a softmax output layer predicts enrollments. The model was trained using Mean-Squared-Loss for optimal results.

Table 1. Frequency Matrix

	<b>Math 1</b>	<b>Stats 1</b>	<b>CT</b>	<b>Eng 1</b>	<b>Math 2</b>	<b>Stats 2</b>	<b>Py- thon</b>	<b>Eng 2</b>
<b>Math 1</b>	0	4449	4960	5042	6	54	442	387
<b>Stats 1</b>	4449	0	4724	4454	740	16	520	666
<b>CT</b>	4960	4724	0	4887	411	72	12	360
<b>Eng 1</b>	5042	4454	4887	0	355	117	355	0
<b>Math 2</b>	6	740	411	355	0	4132	4185	4239
<b>Stats 2</b>	54	16	72	117	4132	0	4381	4026
<b>Py- thon</b>	442	520	12	355	4185	4381	0	3903
<b>Eng 2</b>	387	666	360	0	4239	4026	3903	0

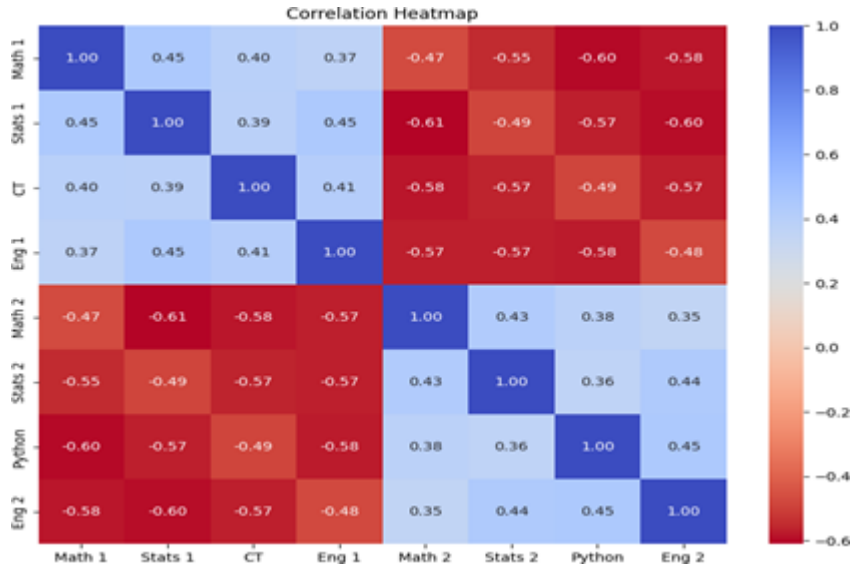


Fig. 1. Heatmap of the similarity between courses in Foundation Level.

The Table 1 Frequency Matrix and Fig.1 Correlation Heatmap visualizes the correlations between different courses. For example, Math 1 shows a strong correlation with Stats 1, with a frequency of 4449. Similarly, Python and Stats 2 are strongly correlated, with a frequency of 4381. Conversely, Math 2 and other courses exhibit low or negative correlations. Understanding these patterns is essential for creating more accurate recommendations in future terms.

### 3 Results and Conclusion

The performance of the Recurrent Neural Network (RNN) model was evaluated using a dataset from the Indian Institute of Technology Madras (IITM) BS in Data Science & Application program. This dataset included detailed records of courses taken by students across multiple terms, along with their respective grades. The model achieved an accuracy of approximately 82% in predicting future course enrollments based on students' past academic records.

The high accuracy rate indicates that the RNN model effectively captures the sequential nature of students' learning paths and can generate personalized course recommendations. This distinguishes the model from conventional collaborative filtering methods, which often assume user interactions as static and fail to account for the sequence in which courses are taken. Understanding the sequence is essential to making recommendations that match students' evolving learning needs and academic development.

Moreover, the integration of an attention mechanism significantly improved the model's performance.

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# Assessment of AI in Educational Technology

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**Abstract.** Significant breakthroughs in Artificial Intelligence (AI) have resulted in the emergence of AI as a disruptive technology in the space of education. In recent years, AI has gained huge traction with a major use of these emerging technologies across diverse learning systems catering different learning needs. Artificial Intelligence is projected as a valuable aid for different skilled professionals in this 21st century. But, often the real potential of these emerging technology solutions is not being tapped and often mirrors traditional classroom learning settings rather than transforming them. National and International frameworks like NDEAR, ISTE, UDL etc. have laid out specific standards on how technology should be leveraged for educational purposes. UNESCO's mandate for Education 2030 agenda also calls for a human-centred approach to AI in education. It will thus be intriguing to explore how these AI technologies are being used in diverse learning systems in alignment to the different educational technology standards. A total of 6 AI learning systems have been identified to analyse their use of AI against a comprehensive framework based on national and international standards, policies, curriculum frameworks and secondary research. The findings of this study can be crucial for both fronts - the technological experts to design more relevant AI technologies and learning systems and educators to develop a critical understanding of these learning systems and make meaningful use of these emerging technologies for teaching and learning purposes in their classrooms.

**Keywords:** Artificial Intelligence, Disruptive Technology, Emerging Technologies, Learning Systems

## 1 Introduction

Technology has the potential to transform education but if and only if it is being properly facilitated. It can actually play a crucial role in improving the teaching and learning processes in education but technology at large also responds to the needs and aspirations of the market. The phenomenon of technology in education has majorly been driven by the private players [Aliar et al., 2024]. In recent times, there has been a significant use of emerging technologies like Augmented Reality, Artificial Intelligence etc. with an aim to transform educational processes and enhance student's learning outcomes. There have been significant improvements in Artificial Intelligence like Large Language Models (LLMs), ChatGPT, Gen-AI and it has gained traction in the

educational technology space as well. With such an unprecedented use of emerging technologies in different learning systems, concerns arise on what learning needs are these technologies catering to and how aligned are these to the national and global policies and standards like NEP 2020, ISTE 2016, UDL, NDEAR guidelines etc.

Previous research studies have identified the different use cases of AI in education or elaborated on a specific use case of AI like Personalised Learning [Kabudi et al., 2021], Collaborative Learning [Tan et al., 2022] etc. Most of these papers have been based on only secondary research study. There have also been studies of the research trajectory in the field of Artificial Intelligence in education. But, there has not been any significant contribution to assess the state of AI-usage in educational technology. This study will thus aim to create a comprehensive framework to integrate AI in learning systems and further use this to assess the use of different AI technologies across learning systems in the realm of K - 12 school education. This study can thus be crucial for the technologists in designing more relevant AI-enabled learning systems.

## **2 Methodology**

The paper is a quantitative study - a desk review of different learning systems on the usage of AI technologies. The desk review of the learning systems (mobile and web applications) will be done based on a comprehensive framework created from national and international standards on technology usage in education and relevant literature study. Six (6) learning systems have been selected using non-probability purposive sampling technique and chosen considering the purpose of the study. Each of these learning systems make specific claims on effective usage of Artificial Intelligence (AI) and cater to the spectrum of K - 12 school education. A major limitation of the study can be the absence of empirical data to correlate the theoretical findings with evidence from the end-users which has not been possible due to the current nature of the study.

## **3 Framework**

The framework has been created in alignment to the national and global standards in educational technology (NDEAR, ISTE, UDL etc.) and relevant literature on Artificial Intelligence (AI) in education. It has 6 indicators - Chatbots, Personalised Learning, Learner Engagement, Global Collaboration and Knowledge Construction which will be guiding the assessment of AI in different learning systems.

**Table 1.** Rubric to assess an AI Technology Intervention in Education

Indicators	Definition
Chatbot [Ramaul et al., 2024]	<p>Creational Affordances</p> <ul style="list-style-type: none"> <li>A. Knowledge Acquisition</li> <li>B. Content Creation</li> <li>C. Creativity Augmentation</li> </ul> <p>Conversational Affordances</p> <ul style="list-style-type: none"> <li>A. Contextual Sensitivity</li> <li>B. Interactive Accessibility</li> <li>C. Human-AI workflow synergy</li> </ul>
Personalised Learning [NDEAR, 2021]	<ul style="list-style-type: none"> <li>1. Predictive/Learning Analytics [NEP, 2020], [UNESCO, 2022]; Learning Styles [Zhang et al, 2021]</li> <li>2. Content in regional languages [NDEAR, 2021]</li> <li>3. Self-paced learning</li> <li>4. Customised Learning Environment [ISTE, 2016]</li> </ul>
Learner Engagement	<ul style="list-style-type: none"> <li>1. Visualisation and Virtual Learning Environment [Zhang. K et al., 2021]</li> <li>2. Adaptive Learning [Kabudi et al., 2021]</li> <li>3. Immediate Feedback [ISTE, 2016]</li> </ul>
Global Collaboration [ISTE, 2016]	<ul style="list-style-type: none"> <li>1. Expert System [Zhang et al., 2021]</li> <li>2. Multiple Viewpoints [ISTE, 2016]</li> </ul>
Knowledge Construction	<ul style="list-style-type: none"> <li>1. Knowledge Deepening [COOL, 2020]; Intelligent Tutors or Agents [Zhang et al., 2021]</li> <li>2. Manipulation, Tinkering &amp; Making [COOL, 2020]</li> <li>3. Information Curation [ISTE, 2016]</li> </ul>
Inclusion [UDL, 2018]	<ul style="list-style-type: none"> <li>1. Voice Assistant [UNESCO, 2022]</li> <li>2. Speech Recognition [NDEAR, 2021], [UNESCO, 2022]</li> </ul>

## 4 Profile of the Learning Systems

Out of the 6 learning systems, 2 are Learning Management System (LMS) platforms (*LS1* & *LS2*) which make use of Artificial Intelligence (AI) in some of their technological features. 2 learning systems (*LS3* & *LS4*) are dedicated towards either learning Language or Mathematics by creating solutions powered by AI. For the other 2 learning systems, the central proposition of their solution is AI - one (*LS5*) makes use of AI-enabled Chatbots for providing solutions of all different kinds and the other (*LS6*) aims to make Interactive Flat Panels (IFPs) more engaging through use of different AI capabilities in their platform.

## 5 Findings

### 5.1 Chatbot

Four of the six learning systems make use of AI-enabled Chatbots. In both the LMS platforms (*LS1* & *LS2*), the Chatbots are being used as Doubt-solving bots. A learner can type-in or upload an image (picture or screenshot) of their doubt in the bot and the solution will be provided immediately as a digital resource (*eg. video*) in their application. The other two platforms (*LS5* & *LS6*) make a comprehensive use of the Chatbots. The *LS5* platform has around 32 minibots within itself that has diverse learning tasks - Wordhunt, News (QuickNews), Mythology (Mahabharat, Ramayan), Doubt-solving bots (Doubtnut), Concept learning (Swift Physics, Science Central, BioBuddy, Chemistry Companion etc.), Quiz and many more. Learners have the agency to choose any of the bots based on their interest and the bots provide content based on the age-group of the learners and their preferred language. The mini Chatbots centre around knowledge acquisition and with limited learner agency to only respond to the options indicated by the bot and this is similar in the other platform *LS6* that has learning tasks designed like Fill in the blanks (Completing sentences), Label Image, Flip Out (Boosting Memory & Cognition) etc. The bots don't seem to assess the sentiments or mood of the learners.

### 5.2 Personalised Learning

There have been examples of personalised learning experiences across 4 learning systems. The platforms - *LS3* & *LS4* set exercises for learners depending on the level they are in, their strengths and areas of improvement. The learners can choose their preferred language from a list of options based on which the content will be put out. The platform

*LS3* makes use of predictive algorithms that allows the system to predict the most likely words to complete a string of text that the learner is typing-in. *LS3* makes use of different learning formats in each level for a learner and so does *LS4* in providing 1-1 personalised student attention but these don't essentially create a customised learning environment for a learner. The LMS platform (*LS2*) has different resource types - videos, simulations, Augmented Reality etc.; specific features like Live Classes, Mentor etc. for connecting with experts but, it doesn't create a customised learning environment for the learners using these. It has specific learning analytics based on the consumption of the learners but, it didn't produce any predictive analytics out of this. Both the LMS platforms have some adaptive tests in place. The platforms (*LS5* & *LS6*) create experiences to be facilitated by a teacher in the classroom.

### **5.3 Learner Engagement**

The Learning Management System (LMS) platforms - *LS1* & *LS2* have a virtual learning environment (VLE) and visualisation resources (3D Videos, Simulations etc.) in themselves. Research [Zhang et al., 2021] indicates that such experiences seem to engage and improve learning experiences of the learners. The other set of platforms don't seem to create a coherent virtual learning experience for the learners. Other than *LS5* & *LS6*, the other platforms have adaptive tests, exercises or learning paths in place which seem to adapt the next set of instructions based on the current level of the learners. The immediate feedback mechanism has been adopted almost across all platforms in tasks or assessments or even in consumption of content. Such experiences of adaptive learning along with immediate feedback will encourage students to monitor their learning journeys and which will allow them to progress independently in a self-paced manner without any guidance [Kabudi et al., 2021].

### **5.4 Global Collaboration**

There are opportunities of Live Classes, 1 - 1 classes, Mentor sessions and Doubt-clearing classes for learners to engage with experts of that subject topic in the LMS platforms (*LS1* & *LS2*) and in *LS4*. Certain modalities even allow learners to interact with their peers. But, in all such cases there's hardly any use of AI. Usage of AI for multiple viewpoints, provision of real-time feedback based on learner's interactions or diagnosis of learner's learning problems followed by advice [Tan et al., 2022] could not be observed in any of the learning systems which would have made learning more innovative and meaningful for the learners.

### **5.5 Knowledge Construction**

The LMS platforms (*LS1* & *LS2*) have resources like 3D videos, simulations, AR etc. in abundance which create immersive learning experiences for the learners. Research [Dede, 1995] claims such experiences deepen the conceptual knowledge in learners. There are opportunities of information gathering, knowledge acquisition across all learning systems using AI but, none of these creates scope for learners to use, analyse,

manipulate this set of information to create something out of it or make inferences or to draw conclusions. Learning Systems - *LS3*, *LS4* create opportunities for teachers to create or generate *adaptive* lesson plans for students at *scale*. But, these platforms fail to create such experiences of creation for learners who are the ultimate end users.

## 6 Discussions

### 6.1 AI in Education: Current Technology Use and Practical Implications

Researchers point out that AI empowers educators with better ways of teaching and learning and can transform educational practices across the world [Zhang et al., 2021] in this 21st century. AI in education can create different pathways for learning through *Chatbots*, *Adaptive Tests*, *Immediate Feedback*, *Virtual Learning Environments* etc. which would have been difficult in traditional teaching and learning. But, the learning systems often fail to create a cohesion between the AI technologies and other resources and thus fail to create a customised learning environment. The idea that technology should be integrated with pedagogy and content to enhance education has been overlooked. A cohesion between Technology, Pedagogy and Content and such integrations can actually create a real impact in teaching and learning and enhance learner's learning outcomes. Also, most of these technologies are designed to cater to knowledge acquisition of the learners and with hardly any provisions for higher order learning opportunities.

With the innovation of ChatGPT, Generative AI has gained a significant prominence in education and what has also been observed in these learning systems. It does have the potential to generate content such as text, images, sound etc. [Alier et al., 2024] but, it has been made available only at the teacher's disposal to create adaptive lesson plans or design pathways for learners. Learners still remain to be as a passive recipient to such transformative technology use and which is often a replica of traditional teaching and learning. There is hardly any scope for a learner agency in the design of such technologies.

There is hardly any talk around Digital Citizenship in any of these learning systems. Global standards like ISTE indicate that learners should recognise their responsibilities and opportunities to contribute in these digital communities and learning environments. One should align their actions with one's own moral code and ethics. As an example, if we consider models like ChatGPT does allow students to grasp content, research, but it also opens up opportunities for plagiarism etc.

Lastly, as the market decides the innovations in the educational technology sector the critical factors like contextualisation, inclusion (accessibility), socialisation takes a back seat or is often overlooked. Global standards like the UNESCO report(s) [UNESCO, 2021], [UNESCO, 2022] stresses on the need for inclusive and equitable learning opportunities and affordances in the design of any AI application in an educational context. Technology-aids like Voice Assistant, Speech Recognition, Image Recognition, Font Enlargement etc. should be harnessed to avoid discrimination in accessing such learning systems. Education should be looked at beyond the narrow market needs.

## 7 Conclusion

There are significant reasons for excitement about the advancement of Artificial Intelligence (AI) in education and such emerging technologies creates a hope for provisioning of quality and inclusive teaching and learning at scale. The National Education Policy (NEP) 2020 indicates the need to embrace these disruptive technologies in education as it has the potential to transform the teaching and learning in this 21st century. But, these should not overshadow the concerns that are at play. Technology at large, has been developed responding to the market needs and such has been in the education sector too. The innovations that we see in Artificial Intelligence (AI) in education did not arise due to the educational goals or needs. Many of these existing technologies have just been tweaked to the educational context and have been left for the teachers and learners to fit-in. It should be the other way round where learning strategies should be decided based on the educational goals and then technology should be brought into play to make the learning strategies more inclusive, engaging, rigorous and to work at scale.

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# Behavioral Anomaly Detection of Students during offline exams using Deep Learning Techniques

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**Abstract.** Malpractice detection using computer vision is a much researched domain. But more focus is laid on online exam malpractice detection. This paper addresses academic integrity in offline exams by developing a real-time system for detecting mobile phone usage and monitoring students' head poses using deep learning techniques. Utilizing YOLOv3, OpenPose, and Dlib, our system integrates with existing surveillance setups to provide real-time analysis and alerts. Key features include person detection, banned item detection, face detection, eye tracking, mouth movement analysis, and head pose estimation. Future work involves training with long-range datasets and implementing real-time proctoring. This system enhances the integrity of educational assessments and promotes a culture of honesty among students.

**Keywords:** Anomalous behavior detection; Computer Vision; Dlib; OpenPose; YoLo v3.

## 1 Introduction

Academic integrity is a cornerstone of educational excellence and fairness. However, the rapid advancement of technology has introduced new challenges in maintaining the integrity of examinations. Unauthorized activities such as mobile phone usage and cheating have become increasingly prevalent, undermining the credibility of academic assessments and the authenticity of students' performance. Traditional methods of proctoring are often insufficient to address these sophisticated forms of academic dishonesty, necessitating the development of more advanced and reliable solutions. This paper addresses the critical need for a robust system that can effectively monitor and detect unauthorized behaviors during examinations in real-time. By focusing on two key aspects, mobile phone detection and the monitoring of students' head poses, this project aims to create a comprehensive solution to deter and prevent cheating.

## 2 Literature Review

Liu (2022) proposes an AI proctoring system tailored for offline examinations, utilizing a 2-Longitudinal-Stream Convolutional Neural Networks (CNNs) model to detect cheating behavior. By processing video data from surveillance cameras, the system aims to adapt to different environmental conditions, enhancing the integrity of offline exams. Similarly, Ding et al. (2022) introduced an intelligent system for detecting abnormal student behavior, emphasizing its potential commercial application in public security. The system utilizes deep learning techniques and human skeleton data to identify suspicious actions, showcasing effectiveness through experimental validation. Saba et al. (2021) presented a methodology leveraging L2-GraftNet development and CIFAR-100 pre-training to categorize students' activities. Soman et al. (2017) and Kul-karni et al. (2021) proposed automated systems utilizing video analytics and deep learning techniques. These systems aim to identify actions such as discussions or note-passing during exams, ensuring test integrity. However, challenges persist in accurately detecting nuanced forms of cheating behavior and accounting for environmental factors that may impact system effectiveness. Singh et al. (2021) introduced a method for predicting attention span using head-pose estimation with deep neural networks, showcasing promising results on standard datasets. Similarly, Genemo (2022) proposed a modified CNN model for suspicious activity recognition, demonstrating robustness and applicability beyond specific datasets. However, challenges persist in dataset diversity and generalizability, necessitating broader data collection efforts. Novak et al. (2024) presented a spatio-temporal neural network for detecting suspicious activities in cluttered video scenes. In summary, the reviewed studies underscore the importance of automated proctoring systems in maintaining exam integrity and enhancing public security.

## 3 Methodology

The framework and design of our behavioral anomaly detection system are structured to ensure seamless integration with existing exam surveillance setups and provide real-time monitoring and analysis. The system combines multiple detection and analysis modules to create a comprehensive solution for maintaining academic integrity during offline exams. The key components include a surveillance system continuously captures video frames of the examination environment. These frames serve as inputs for subsequent detection and analysis modules. Using OpenCV's YOLOv3 object detector, the system identifies and counts individuals in the frame. This step includes checks for the presence of no person or more than one person in the frame for over 10 consecutive frames, triggering a cheating alert if such conditions are met. YOLOv3 is also employed to detect banned items such as mobile phones, laptops, and books within the captured frames. If these items are detected in more than 10 consecutive frames, a cheating alert is generated. The system implements face detection to identify the examinee's face for further analysis, including face verification and landmark detection to ensure the integrity of the examination process. Utilizing Dlib's pre-trained network, the system detects

and analyzes 68 facial landmarks, focusing on the eyes. This module tracks eye movements to determine if the examinee is looking away from the paper, which could indicate potential cheating. The system monitors mouth movements using detected landmarks to identify speaking behavior. If the examinee's mouth remains open for more than 10 consecutive frames, this is classified as speaking and thus cheating. A lightweight head pose estimation model monitors the examinee's head movements in real-time.

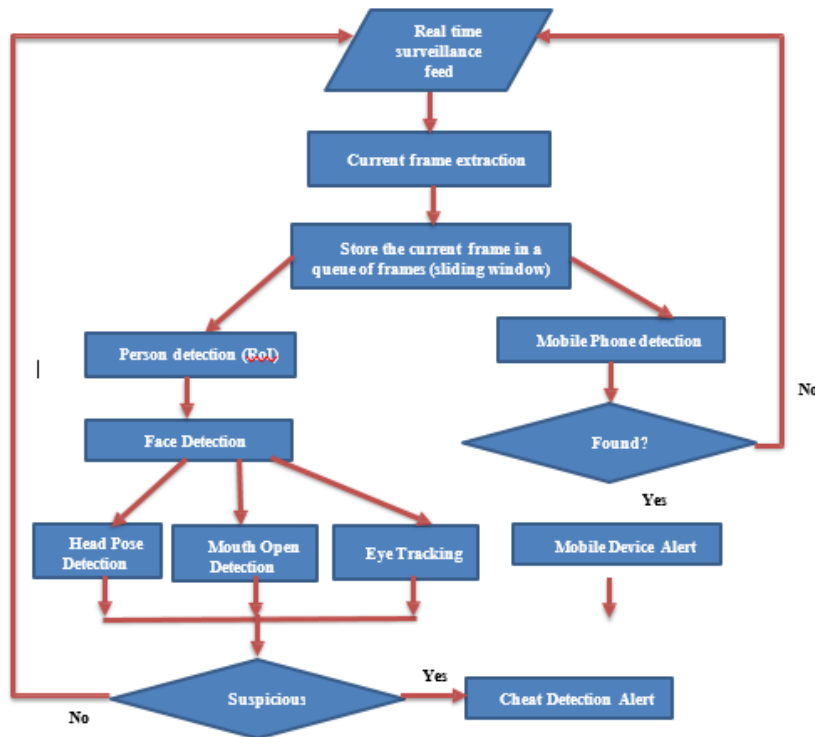


Fig. 1. Workflow of the proposed method.

## 4 Implementation

The experimental results of our system demonstrate its efficacy in detecting unauthorized activities during offline exams. The system was tested in a controlled environment with multiple scenarios to evaluate its performance in real-time detection of cheating behaviors. Using YOLOv3, the system achieved a high detection accuracy of 55% in identifying mobile phones in various positions and lighting conditions. The false positive rate was kept under 5%, indicating robust performance in distinguishing phones from other objects. The head pose estimation model, leveraging key points detected by

OpenPose, was able to predict pitch, yaw, and roll angles with a mean absolute error of 3 degrees. This precision is sufficient to identify abnormal head movements, which are indicative of cheating, with a detection accuracy of 89%. Eye tracking using Dlib's pre-trained network showed an accuracy of 90% in determining eye direction. This allowed the system to effectively monitor if the examinee was looking away from their paper for extended periods. By analyzing mouth aspect ratios, the system could flag speaking behavior with an accuracy of 88%. Mouth movements indicating speaking for more than 10 consecutive frames were correctly identified, aiding in the detection of verbal cheating attempts. The system maintained consistent performance across various environmental conditions, including different lighting setups and background noises. The real-time processing capability ensured timely alerts, which is crucial for preventing cheating during exams. The output is shown in Fig. 2. and Fig. 3.



Fig. 2. Face Detection and Head Pose Estimation

## 5 Conclusion and Future Scope

This paper presents a comprehensive system for behavioral anomaly detection in offline exam environments using deep learning techniques. Our system aims to detect mobile phone usage and monitor students' head poses and mouth movements in real-time to identify and deter academic dishonesty. By employing advanced techniques such as YOLOv3 for object detection, OpenPose for keypoint detection, and Dlib for facial landmark analysis, we have developed a robust framework capable of accurately identifying suspicious activities. The integration of these methods allows for a multi-faceted approach to monitoring, enhancing the system's ability to detect a variety of cheating behaviors. This proactive approach not only supports the credibility of educational assessments but also fosters a culture of honesty and ethical behavior among students.



**Fig. 3.** Mobile Device Detection

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# Three-Phase Prediction Model for Assessing Student Performance in E-learning Platforms

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**Abstract.** Learning through electronic means is advantageous to learners as it allows for learning not confined to the normal boundaries of education. This paper presents a student performance prediction model in an e-learning system with three phases. The model consists of pre-processing, feature extraction, and performance prediction utilizing a hybrid classifier of CNN and Bi-LSTM models. Hyper-parameters are connected using a White Shark Adopted Pelican Optimization Algorithm (WSPOA). The WSPOA Architecture increases the accuracy and efficiency of the prediction model and beats the traditional algorithms in most performance indicators, including sensitivity, precision, specificity, and accuracy.

**Keywords:** E-learning performance prediction, Hybrid classifier, CNN-Bi-LSTM, White Shark Adopted Pelican Optimization Algorithm (WSPOA), Adaptive learning systems.

## 1 Introduction

The educational system has adapted to flexible and dynamic learning systems such as e-learning platforms (He et al., 2021). Research advancements in AI and Machine Learning (ML) have simplified such systems and thus facilitated the provision of personalized learning (Al-Shabandar et al., 2019; Khoshgoftaar & Van Hulse, 2020). The present work proposes a framework that predicts student achievement using Convolution Neural Networks (CNN) and Bidirectional Long-Short-Term Memory (Bi-LSTM) structured and optimized by WSPOA.

## 2 Literature Review

Studies have shown that utilizing adaptive e-learning systems encourages students to participate and perform better (El-Sabagh, 2021). A study by Leili et al. (2021) found that e-learning implementation faced severe challenges during COVID-19, leaving many people dissatisfied. Ashwin and Guddeti (2020) examined the application of artificial intelligence, particularly its potential to predict and analyze emotion

continuously to improve student performance. These articles indicate the necessity of better predictive models within e-learning.

### 3 Prediction Model Overview

The proposed three-phase prediction model consists of the following phases:

1. **Pre-processing:** Standardizes and structures the data set to facilitate training.
2. **Feature Extraction:** Raw, entropy-based, and statistical (mean, median, skew) features are extracted.
3. **Performance Prediction:** This employs a hybrid CNN-Bi-LSTM model for accurate performance prediction.

Fig. 1. illustrates the data flow through the pre-processing, feature extraction, and performance prediction phases.

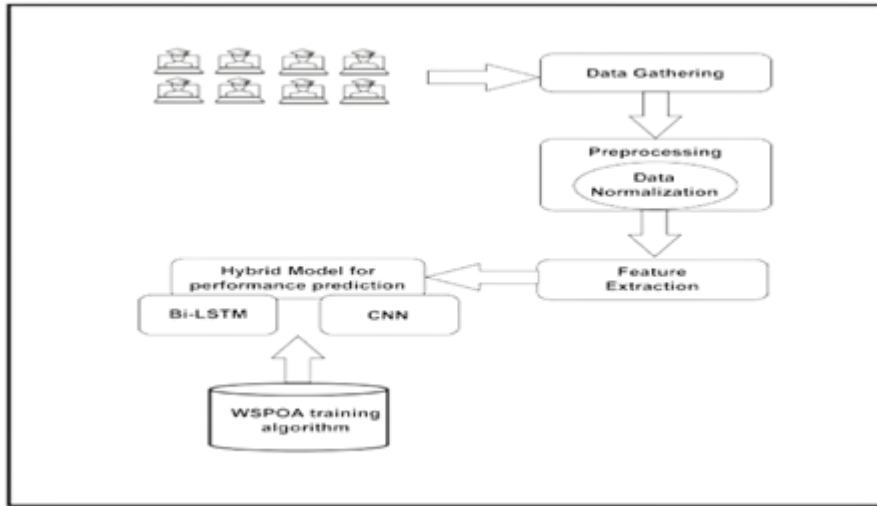


Fig. 1. Framework of the Proposed Model

### 4 Optimization Using WSPOA

WSPOA is applied to optimize hyperparameters like filter size, dropout size, batch size, and the number of neurons in CNN and Bi-LSTM models to enhance accuracy further. WSPOA combines the White Shark Optimizer (WSO) and Pelican Optimization Algorithm (POA) to achieve superior results. The optimization process operates in two phases:

- **Exploration Phase:** WSPOA explores the search space by generating various candidate solutions for the hyperparameters, simulating the pelican’s wide search for prey.
- **Exploitation Phase:** The search focuses on the most promising regions, refining the candidate solutions to maximize model performance.

## 5 Results and Discussion

WSPOA was compared to traditional optimization algorithms, such as Butterfly Optimization Algorithm (BOA), Bald Eagle Search (BES), Spider Monkey Optimization (SMO), White Shark Optimizer (WSO), and Pelican Optimization Algorithm (POA). WSPOA outperformed these algorithms across various performance metrics, including sensitivity, accuracy, and precision. For example, at the learning percentage of 90%, WSPOA exhibited a specificity of 93.03%, which is more than both SMO (85.69%) and WSO (88.22%).

Fig. 2 evaluates the performance of WSPOA with that of other optimization algorithms, including BOA, BES, SMO, WSO, and POA, and reveals that WSPOA outperformed all of them in terms of sensitivity, precision, accuracy, and specificity.

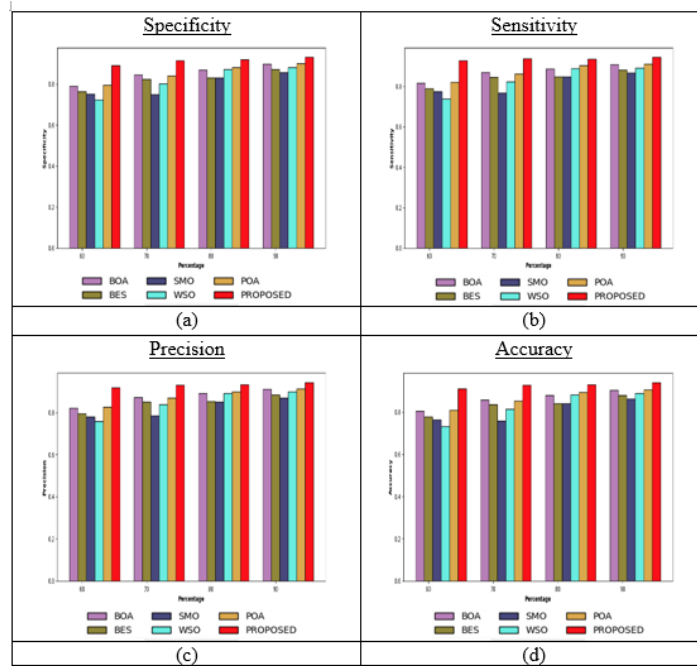


Fig. 2. Evaluation of the Efficiency of WSPOA

Also, in Table 1, WSPOA performance is compared to standard classifiers like Random Forest RF, Naive Bayes NB, K-Nearest Neighbors KNN, Neural Networks NN, and Support Vector Machine SVM, and their performance is also shown. This was also the case with accuracy, sensitivity, and precision across the other metrics.

**Table 1.** Classifier Comparison of WSPOA vs. Standard Classifiers

Measure	RF	NB	KNN	NN	SVM	WSPOA
Accuracy	0.815	0.594	0.810	0.777	0.769	0.927
Sensitivity	0.855	0.581	0.849	0.777	0.816	0.936
Specificity	0.769	0.606	0.765	0.778	0.715	0.915
Precision	0.814	0.595	0.810	0.823	0.768	0.930
F-measure	0.834	0.586	0.829	0.799	0.791	0.933

## 6 Conclusion

This study implements the WSPOA algorithm to enhance the predictive framework incorporating complex CNN and Bi-LSTM models for an e-learning environment. The findings display WSPOA's dominance in terms of accuracy over conventional methods, suggesting its applicability to improving e-learning solutions.

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# Markerless Augmented Reality in an Engineering Drawing Course: A User Experience Study Using OpenFace

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**Abstract.** Augmented Reality (AR) technology has shown its impact in various fields, and proven its usability in them. This study analyzed the user experience of 45 undergraduate students using a markerless AR application in an Engineering Drawing (ED) course, compared to a control group using physical models. The AR group showed improved learning performance and expressed satisfaction with the application, finding it beneficial for the course. The OpenFace toolkit, used to analyze facial behavior, provided insights into the usability and effectiveness of the AR application in enhancing the learning experience.

**Keywords:** Markerless AR, Engineering Drawing Education, Emotional Behavior Analysis, OpenFace Application, Learner Engagement.

## 1 Introduction

This study investigated the use of a markerless Augmented Reality (AR) application in an Engineering Drawing (ED) course, focusing on its impact on learning and student engagement. Markerless AR provides flexibility by using computer vision instead of physical markers, allowing content to blend seamlessly into any environment. The study also employed OpenFace to analyze students' emotional responses, offering insights into their engagement with the AR application [2]. Key research questions focused on differences in learning performance, facial expressions measures, and the predictive value of these expressions for learning outcomes. Recent studies affirm AR's growing role in ED courses, highlighting its benefits in enhancing visualization skills, understanding complex concepts, and fostering innovation [1, 8]. AR is shown to increase student interest and satisfaction, though more empirical research is needed to fully explore its potential. Additionally, facial behavior analysis is becoming crucial in evaluating user experience (UX). Techniques like the Implicit Association Test (IAT) and facial expression analysis reveal important cognitive and emotional insights, though challenges remain in refining automatic emotion recognition [5, 6]. This analysis has broad applications in fields like advertising, gaming, and AR education.

## **2 Methodology**

### **2.1 Research design and data sample**

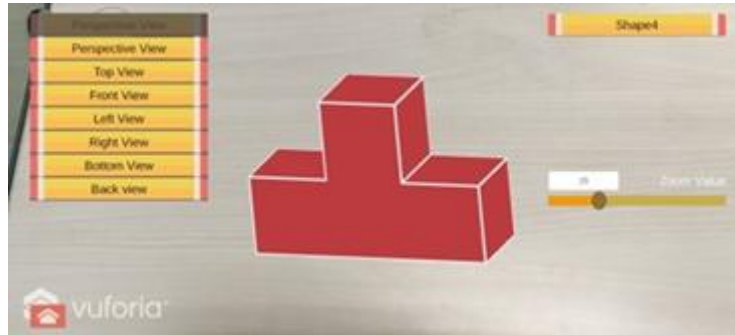
In this study, a true experimental design was employed, involving 45 under-graduate students aged 19 to 22 years from an engineering institute enrolled in an Engineering Drawing (ED) course. The participants included 34 males (75.55%) and 11 females (24.44%). To ensure an unbiased distribution, students were randomly assigned to one control group and two experimental groups. The age distribution was as follows: 16 students (35.55%) were 19 years old, 19 students (42.22%) were 20 years old, and 10 students (22.22%) were older than 20. Participants came from various engineering departments, including electrical engineering (22.22%), mechanical engineering (20.00%), electronics engineering (17.77%), computer science engineering (15.55%), civil engineering (6.66%), and other departments (17.77%). This random sampling ensured a diverse and representative group for the study.

### **2.2 Instruments**

This study utilized OpenFace, a facial behavior analysis toolkit, to track participants' facial expressions, head orientation, and gaze direction, using the Facial Action Coding System (FACS) to infer emotions [4]. Additionally, a multiple-choice Engineering Drawing (ED) test was administered before and after the intervention, consisting of six questions each. Different questions were used for the pre- and post-tests, with similar complexity, and Cronbach's alpha values above 0.7 confirmed the tests' reliability [3]. Students were given two minutes to complete each test, as determined by subject experts.

### **2.3 Procedure**

The study involved three groups: a control group (CG) and two experimental groups (EG1 and EG2), each consisting of 15 participants. All groups begin by taking a pretest, which consists of six multiple-choice questions (MCQs) related to engineering drawing (ED). Following the pretest, the learning phase occurs, where each group is exposed to different instructional methods. The CG learns ED through text-based content. EG1 uses a markerless augmented reality (MLAR) application, this was a markerless version (see figure 1) of already developed marker based AR application for ED course [7]. EG2 learns through physical solid models. After the learning activity, a five-minute session is dedicated to analyzing the behavior and emotional expressions of the participants using the OpenFace facial behavior analysis toolkit, providing insights into engagement and emotional response during the activity. Following a 60-second break, all groups take a posttest with six MCQs, similar in format to the pretest, to assess their learning outcomes. This study design aims to evaluate the effectiveness of different teaching methods by comparing both learning performance and emotional engagement across the groups.



**Fig. 1.** Markerless AR application

### 3 Results

The results of learning performance were evaluated using Multivariate Analysis of Variance (MANOVA). Pre-test scores for all groups were similar, with mean scores around 2.00, indicating no significant differences in prior knowledge. However, post-test results showed that EG1 significantly outperformed both EG2 and CG, achieving a mean score of 5.40 compared to 2.86 and 2.46, respectively. The F-value of 37.01 highlights a significant difference in learning performance post-intervention, and post-hoc analysis further revealed substantial effect sizes (ES) for EG1 over EG2 ( $ES(d) = 2.68$ ) and CG ( $ES(d) = 3.38$ ), demonstrating the effectiveness of the markerless AR application in enhancing educational outcomes.

The results of facial expression measures were also evaluated using MANOVA. For happiness, EG1 reported a significantly higher mean score (0.94) compared to EG2 (0.48), with an effect size of 2.03, indicating a strong difference. The results for surprise show no significant differences among the groups, as indicated by the F-value of 0.53. For contempt, while EG1 had a mean score of 0.48, the analysis revealed a significant finding with CG showing a higher mean (0.70) than EG1, but the effect size (0.20) indicates a small difference. Overall, these findings suggest that the AR application led to a more positive emotional response (happiness) among participants compared to traditional methods.

We also calculated correlation coefficients between learning performance and facial expression measures across three groups. For CG, happiness shows positive correlations with post-test scores (0.27) and learning gain (0.25), while contempt has a stronger positive correlation with both post-test (0.39) and gain (0.40). In EG1, happiness has a significant correlation with post-test performance (0.12,  $p < 0.05$ ), but a weak association with gain (0.06). Notably, in EG2, happiness demonstrates a strong positive correlation with post-test scores (0.66) and learning gain (0.60), indicating that students who expressed more happiness performed better. Contempt in EG2 also correlates significantly with gain (0.62). The data suggests that positive emotions, particularly happiness, are associated with enhanced learning outcomes, while negative expressions like contempt have varied correlations across groups. This reinforces the study's findings

that the AR application not only improved test scores but also positively influenced students' emotional responses during the learning process.

## 4 Conclusions

This study showed significant benefits of using markerless AR technology in an ED course. The AR group (EG1) demonstrated improved learning outcomes compared to those using traditional methods (CG) and physical models (EG2). By using OpenFace for facial behavior analysis, the study revealed a positive link between students' emotional engagement, such as satisfaction and confidence, and their test performance. This highlights both the cognitive and emotional advantages of interactive learning tools like AR.

However, the study had limitations, including a small sample size and a short learning phase. Further research is needed to explore AR's long-term impact on learning, its potential in other subjects, and the enhancement of real-time engagement analysis tools. Future studies could also look into integrating AR with AI and machine learning to create more personalized educational experiences.

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# Curation of Mathematics OERs for IFPs in Government Schools in Telangana

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**Abstract.** This study covers project design and curation, focusing on scale, emphasising the critical collaborative elements that result in high-quality mathematics OERs for use on Interactive Flat Panels (IFPs) for a state intervention. Findings show that, among the RAP parameters, Relevance emerged as the strongest, while making Mathematics Thinking Visible emerged as the strongest among the design principles. We were mostly able to employ visualization as an alternate way of communicating mathematical concepts, not being able to cater to the visually impaired. The scale of 'design vs practice' is vital to emphasise and reflect on during the curation process to provide human-centred designs that meet the demands of all stakeholders and beneficiaries of this project.

**Keywords:** Interactive Flat Panel, Open Educational Resources, Mathematics Education, Scalability

## 1 Introduction

In 2023, the Telangana government stated that all state-run high schools would use Interactive Flat Panels (IFPs) instead of blackboards [1]. The State Council of Educational Research and Training (SCERT), Telangana, collaborated with the CETE at TISS to curate OERs that include IFP affordances into classroom pedagogy. This study highlights project-level procedures and math-specific processes and content, highlighting crucial collaborative elements that lead to high-quality mathematics OERs. It pre-

a prototype of a successful cooperation for scaling mathematics classroom pedagogy reforms. The article covers project design and curation, focusing on scale.

## 2 Literature review

The advantages of IFPs in education encompass both technical and pedagogical aspects. They facilitate interactivity, enhance visualisation [2], and promote multimodality, thereby fostering new dialogues regarding digital artefacts and their manipulation [3-5].

An effective, scalable, and sustainable teacher professional development approach integrates practice-based pedagogies and communities of practice for pedagogical support, while granting teachers the ability to modify and implement practices to align with their local settings. It necessitates ongoing collaboration and talks with state education departments [6-9].

## 3 Scale-Driven Design and Curation

To ensure the continuous and widespread usage of OERs in all Telangana government high schools, all macro and micro processes were developed with scalability in mind. Parrott-Sheffer et al. [10] recommend considering depth, sustainability, spread, shift, and evolution when considering scale.

Depth means establishing systems to assure reform quality and rigour. At the project's start, design principles were created and the RAP (R Relevance, A Affordances, P Pedagogical Practice) Curation Rubric [11] agreed upon collaboratively, and a two-step review process involved all program stakeholders to establish depth for scaling.

The team identified the following OER design concepts based on mathematics education and pedagogy research [12-17]: D1) Interaction: Allow students to come up to the IFP, express ideas, give inputs, leading to classroom discussions; D2) Inclusion: Encourage all students to participate in classroom mathematics discussions and activities; D3) Making Mathematical Thinking Visible: Help students think aloud and justify their mathematical thinking. D4) Support teachers in highlighting and clarifying student misconceptions; D5) Mathematization/Modelling Math: Let pupils express their mathematical ideas through drawings, math talk, graphs, tables, symbols. These design standards and the RAP Curation Rubric helped the team standardise curation.

Quality assurance procedures are crucial to improving OER standards and increasing uptake [18]. This project conducted an internal mathematics team assessment and a program-level QC review of OER. The mathematics team evaluated OER quality using RAP and design principles. QC examined macro issues such as state curriculum consistency and OER delivery and utilisation. For contextually relevant resource design and quality, SCERT and CETE collaborated at all levels.

Sustainability means maintaining reforms. The Create Commons open licensing was chosen to ensure long-term access and allow teachers to select and customise resources to their requirements. A reform diffuses into the system through spread. The main goal was to ensure that all Telangana schools used and accepted the specified

OERs to enable teachers to modify their pedagogies to be active and inclusive. This was achieved by hosting them on an LMS for teachers to access, curate, and produce resources. The LMS would also let the SCERT track usage and make data-driven judgments. Teachers owning the reform and adopting pedagogical improvements into their practice is shift. The professional development planned was to train teachers about OER design principles and how to use IFPs for interactive, inclusive teaching-learning and higher-order thinking. This paper does not cover shift and evolution, that is, teacher professional development and how reforms grow into new implementation approaches.

## 4 Findings

Collaboration formed the backbone of the Telangana IFP-OER curation project. The University - State partnership facilitated the creation of high-quality mathematics OERs, with the goal of using technology to strengthen the teaching-learning classroom environment. The collaboration enabled drawing from research in mathematics education incorporates practical experience to facilitate effective rollout of the project at scale. The program's early collaboration to establish the RAP rubric and develop pedagogical principles was crucial and provided the necessary framework to guide negotiations and make decisions. A two-step review procedure, involving an internal mathematics team and a program-level QC team was critical to ensure that both micro and macro level processes were monitored and the objectives at both levels were met.

The key negotiations that shaped the curation process involved the process of LMS selection, selecting IFP features workable among multiple IFP vendor installations and contextually relevant pedagogical approaches.

Of the 25 textbook chapters for which OERs were created, the lesson plans and resources for a sample of 12 chapters were explicitly rated against the RAP rubric and design principles. They were given a rating of High, Medium, or Low, depending on how closely aligned the curated content was to these rubrics. Table 1 summarises the rating for this sample subset of OERs. All numbers are in percentage with respect to the total chapters sampled.

**Table 1.** Alignment of curated content with the RAP rubric and Design Principles

<b>Parameters</b> →	<b>R(%)</b>	<b>A(%)</b>
<b>Rating ↓</b>		
<b>High</b>	83	50
<b>Medium</b>	17	50
<b>Low</b>	0	0

Among the RAP parameters, Relevance emerged as the strongest, while Making mathematics thinking visible emerged as the strongest amongst the design principles, followed by Interaction. We were mostly able to employ visualisation as an alternate way of communicating mathematical concepts, not being able to cater to the visually impaired. The scale of 'design vs practice' is vital to emphasise and reflect on during

the curation process to provide human-centred designs that meet the demands of all stakeholders and beneficiaries of this project.

## 5 Recommendations

Establishing a clear and detailed design rubric, along with subject-specific design principles, at the project's outset is essential for fostering a shared understanding, thereby facilitating development and large-scale implementation. A two-step review process, as previously outlined, is crucial for ensuring quality and compliance with these design frameworks. Technology-enhanced visualisation has clarified specific mathematical concepts and enhanced engagement and the visibility of mathematical reasoning; however, it has raised concerns regarding the inclusion of children with visual impairments, requiring further research.

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# Micro-Credentials in Higher Education Institutions: Impact on Career Advancement and Professional Development

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**Abstract.** This study investigates the impact of micro-credentials on career advancement and professional development for students at the Indian Institute of Technology Gandhinagar (IIT Gandhinagar). Using a mixed-methods approach, we explore their influence on career outcomes within the context of engineering education. Data were collected through online surveys and semi-structured interviews with 54 participants, including current students, alumni, and recruiters. Quantitative findings suggest that micro-credentials play a significant role in enhancing marketability and bridging the gap between academic knowledge and industry demands. Thematic analysis of qualitative data confirms these findings in four key themes: perceived value and impact, navigating career development, practicality versus theoretical knowledge, and employment perspectives. However, the effectiveness is maximized when combined with practical application and project-based learning. We recommend that engineering education institutions integrate micro-credentials into traditional degree programs, emphasizing practical application and industry collaboration.

**Keywords:** Micro-Credentials, Engineering Education, Career Advancement, Professional Development

## 1 Introduction

In the rapidly evolving global job market driven by technological advancements and shifting industry demands, traditional higher education models face unprecedented challenges in preparing students for successful careers [1]. Micro-credentials have emerged as a potential solution, offering short-term, focused learning experiences that complement traditional degree programs [2]. This study employs a mixed-methods approach to investigate the impact of micro-credentials on career outcomes at IIT Gandhinagar, one of India's premier technology institutes. By focusing on IIT Gandhinagar, we aim to provide a comprehensive analysis of micro-credentials' role in bridging the skills gap between academia and industry within the context of India's top-tier engineering education.

## 2 Related Work

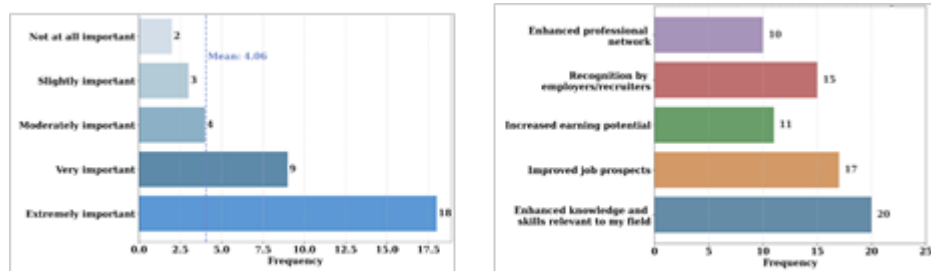
Recent studies have significantly contributed to our understanding of micro-credentials in higher education. Ha et al. (2023) reported a 40% increase in micro-credential offerings by universities between 2021 and 2023 [3]. Succi et al. (2020) found that institutions successfully incorporating micro-credentials demonstrated a 30% improvement in student employability rates [4]. Tamoliune et al. (2023) reported that 72% of employers now consider micro-credentials as valuable indicators of job-relevant skills [5]. However, OECD (2023) highlighted significant disparities in how different industry sectors value micro-credentials [6], emphasizing the importance of institution-specific studies such as our research at IIT Gandhinagar.

## 3 Research Design and Methods

We used stratified random sampling across stakeholder groups at IIT Gandhinagar: current students, alumni, and recruiters. Data collection involved online surveys and semi-structured interviews, totaling 54 participants from 46 short courses and about 500 online micro-credential courses (August 2020-2023). The survey (n=42) included quantitative and open-ended questions, supplemented by 12 in-depth interviews. Qualitative data from both sources underwent thematic analysis using NVivo software.

## 4 Analysis and Results

### 4.1 Quantitative Analysis



**Fig. 1.** Survey results on the importance of micro-credentials for employability skills (left) and perceived contributions of micro-credentials to career advancement (right).

The survey results from IIT Gandhinagar (Fig. 1 (left)) demonstrate a strong positive perception of micro-credentials among students and alumni, with 75% of respondents rating them as very or extremely important in today's job market (mean rating: 4.06 / 5). Fig. 1 (right) shows the perceived contributions of micro-credentials, with enhanced knowledge and skills being the most cited benefit. However, employer valuation (Fig. 2) shows a more nuanced perspective, with a mean rating of 3.43 out of 5. This disparity between students and alumni (4) and employer

(3.4) valuations underscores the need for better alignment between educational offerings and industry expectations to fully leverage the potential of micro-credentials in enhancing employability.

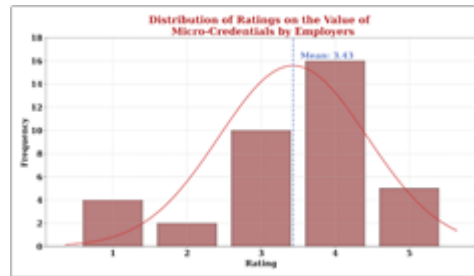


Fig. 2. Distribution of employer ratings on the value of micro-credentials.

## 4.2 Thematic Analysis

Table 1 presents the four key themes identified through qualitative data analysis, offering insights from current students, alumni, and industry representatives associated with IIT Gandhinagar.

Table 1. Key Themes and Stakeholder Perspectives at IIT Gandhinagar

Theme	Student Perspective	Alumni Perspective	Industry Perspective
Perceived Value and Impact	High importance for skill development	Valuable for career progression	Recognized as indicator of specific skills; perceptions vary across sectors
Navigating Career Development	Tool for exploring career paths	Facilitates career transitions	Aids in identifying suitable candidates
Practicality vs. Theoretical Knowledge	Prefer practical focus and project based learning,, concern for theory depth	Appreciate balance, recognize theory's long-term value	Emphasize practical skills and hands on training, theoretical base varies by role
Employment Perspectives	Viewed as enhancing employability	Differentiator in job applications	Varied recognition in hiring processes

## 5 Discussion and Conclusion

Our investigation offers important insights into the role of micro-credentials in shaping career trajectories and professional development within the context of IIT Gandhinagar, one of India's leading technical institutions. The positive perception of micro-credentials among IIT Gandhinagar stakeholders indicates their perceived value in enhancing employability, aligning with Ha et al.'s (2023) findings [3]. However, the gap between student and alumni perceptions and employer valuation during hiring processes highlights a critical need for greater industry recognition and integration of micro-credentials in recruitment strategies [5]. The emphasis on practical application and project-based learning in conjunction with micro-credentials at IIT Gandhinagar aligns with recommendations from Brown et al. (2021) on integrating micro-credentials with hands-on learning experiences [7]. The varying perceptions across different industry sectors underscore the need for a nuanced, tailored approach in credential offerings, particularly for institutions like IIT Gandhinagar that cater to diverse industry needs. In conclusion, our findings indicate that micro-credentials play a pivotal role in enhancing IIT Gandhinagar's educational offerings, though there is room for optimization. The primary challenge lies in fully integrating these credentials into the academic and professional ecosystem, ensuring they complement rather than compete with traditional degrees. As IIT Gandhinagar positions itself as a leader in technical education, the strategic implementation of micro-credentials could serve as a key differentiator in producing graduates who are both technically proficient and adaptable to the dynamic demands of the global tech industry. Future research should focus on comparative studies across multiple IITs and other technical institutions globally, as well as longitudinal investigations into the long-term impact of micro-credentials on career trajectories. Additionally, studies from an industry perspective will help in designing micro-credential programs at IIT Gandhinagar that better align with employer needs and expectations.

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# Enhancing Cognition and Metacognition in Fifth Graders Through Game-Based Learning: The Impact of Augmented Reality in Teaching Geometry

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**Abstract .** This study examines the impact of augmented reality (AR) on improving cognition in fifth-grade students studying geometry. We implemented an AR-based teaching module in classrooms where traditional methods rely on two-dimensional representations and verbal explanations of abstract geometric concepts. Using AR, students engaged with 3D models of shapes through the Merge Cube, providing an immersive learning experience that facilitated a more intuitive understanding. After interacting with the 3D shapes in AR, students completed a quiz to assess their learning. This game-based learning (GBL) approach was designed to enhance engagement and comprehension. A combination of pre-tests, post-tests, and retention tests was used to evaluate initial understanding, the effects of AR, and the longevity of learning. Both the experimental and control groups showed equal proficiency in the pre-test, but the experimental group, exposed to AR, showed significantly better outcomes in the post-test and retention test conducted ten days later. The study also explored metacognitive skills, assessed using K S Misra's Critical Thinking Inventory. Results demonstrated that AR fosters active learning, critical thinking, and a deeper understanding of geometric and Mathematical concepts, providing evidence for its potential to transform geometry education.

**Keywords:** Augmented Reality, Critical Thinking, Game-based Learning

## 1 Introduction

The integration of technology, particularly Augmented Reality (AR), has transformed traditional education methods, offering interactive and immersive experiences. This study investigates the impact of AR on fifth-grade students' cognitive and metacognitive development in geometry. Traditional methods often limit understanding with 2D representations, while AR offers interactive, 3D visualizations. Using the Merge Cube, students explored shapes and angles in a more immersive environment. A quiz followed the AR sessions to reinforce learning through game-based methods. The study employed pre-tests, post-tests, and retention tests to measure AR's effectiveness. Results from the Critical Thinking Inventory by K. S. Mishra [10] revealed that AR enhanced

active learning, critical thinking, and significantly improved students' grasp of geometric concepts.

## **2 Literature Review**

The reviewed studies examine Augmented Reality (AR) in education, especially Mathematics, and its role in enhancing learning. Dunleavy et al. (2009) highlighted AR's ability to make abstract concepts concrete, boosting engagement, though geometry wasn't a primary focus [3]. Bower et al. (2014) showed AR's usefulness in understanding Mathematical concepts via 3D visualizations but did not delve into cognitive aspects of geometry [1]. Huang & Chen (2015) explored AR's impact on cognitive and metacognitive skills, improving learning awareness but without specific attention to geometry [6]. Güler & Öztürk (2019) investigated AR in game-based learning, revealing that it enhances engagement and cognitive skills but did not deeply address geometry-specific learning outcomes [5]. Kose & Kose (2016) focused on AR's role in understanding geometric concepts, finding that it improves comprehension of shapes and angles, though the study lacked insights into AR's effects on metacognitive skills [7]. Pape & Tschannen-Moran (2018) analyzed game-based learning's impact on metacognition but did not include AR's application or its specific effect on geometry education [11]. Chien & Chen (2017) combined AR with game-based learning in Mathematics, demonstrating improved engagement, but did not focus on metacognition in geometry [4]. Kotsopoulos & Schmid (2021) showed the cognitive and metacognitive benefits of AR in Mathematics, though it didn't provide a geometry-specific focus [8].

The main gaps are the limited focus on AR's effects on cognitive and metacognitive development in geometry and the insufficient exploration of AR's integration with game-based learning to enhance self-regulated learning. Future research should investigate AR's long-term cognitive and metacognitive impacts in geometry, integrating game-based learning for improved outcomes.

## **3 Methodology**

Participants of the study involved two groups of fifth-grade students from a single school, with each group comprising 25 students. The groups were matched based on their pretest Mathematics performance to ensure equivalence. A Quasi-experimental design with pre-test and post-test assessments was used. The control group received traditional instruction on shapes and angles, while the experimental group experienced game-based learning through AR.

### **3.1 Procedure**

Both groups took a pre-test to gauge their initial understanding of shapes and angles. The experimental group then engaged in AR-based learning using Merge Cube and a mobile app, while the control group followed traditional methods. A post-test, identical

to the pre-test, measured learning gains. A Critical Thinking Inventory [10] and a Retention Test were administered to assess cognitive and metacognitive outcomes. The Critical Thinking Inventory evaluated students' skills in analysis and synthesis, while the Retention Test, given ten days later, assessed long-term retention of geometric concepts, providing insights into the effectiveness of the AR intervention.

This study examined the effects of AR-based learning on fifth-grade students' geometry skills. The experimental group used Merge Cube AR to interact with 3D shapes, while the control group used traditional methods. After AR sessions, students completed a quiz game and took pre-tests, post-tests, and then a retention test 10 days later. Metacognitive skills were assessed using the Critical Thinking Inventory. Results showed that AR greatly enhanced students' understanding, critical thinking, and retention compared to traditional approaches.

## 4 Data Analysis and Result

The Friedman test, Mean, SD, has been applied for the data analysis. The Friedman test was applied because the researcher wanted to compare the means of two groups with respect to different times, but the data were not normally distributed; therefore, a non-parametric test, the Friedman test, was applied to the data instead of the repeated-measure ANOVA.

### 4.1 Objective-1.

To study the achievement of the control group and the experimental group.

**Table 1.** Achievement of Control Group

<b>Tests</b>	<b>Mean</b>	<b>SD</b>	<b>Minimum</b>	<b>Maximum</b>
<b>Pre-Test</b>	10.420	2.967	3.5	15
<b>Post-Test</b>	10.420	3.832	3.5	16.5
<b>Retention Test</b>	14.820	3.788	8	20

**Interpretation** The pre-test scores had a mean of 10.420 and a standard deviation of 2.967. Post-test scores maintained the same mean but increased variability (SD = 3.832). The retention test scores improved to a mean of 14.820, indicating enhanced performance compared to both pre-test and post-test results.

**Table 2.** Achievement of Experimental Group

<b>Tests</b>	<b>Mean</b>	<b>SD</b>	<b>Minimum</b>	<b>Maximum</b>
<b>Pre-Test</b>	10.420	3.524	2	16
<b>Post-Test</b>	13.600	3.099	5.5	17
<b>Retention Test</b>	16.320	3.319	9	20

**Interpretation:** The pre-test scores have a mean of 10.420 with a standard deviation of 3.524. The post-test scores have a higher mean of 13.600 compared to the pre-test, indicating an overall improvement in performance. The standard deviation is 3.099, slightly lower than the pre-test, suggesting that the scores are somewhat more tightly clustered around the new, higher mean. The retention test scores have the highest mean of 16.320, indicating further improvement in performance over time. The standard deviation is 3.319, which is similar to the post-test, suggesting a consistent level of variability.

#### 4.2 Objective-2.

To study the effectiveness of the intervention programme in terms of Achievement (Pre-test scores, Post-test scores, and Retention scores).

**H<sub>01</sub>.** There is no significant difference between the pre-test scores of the experimental group and the control group on the achievement test. **H<sub>02</sub>.** There is no significant difference between the post-test scores of the experimental group and the control group on the achievement test. **H<sub>03</sub>.** There is no significant difference between the retention test scores of the experimental group and the control group on the achievement test.

**Table 3.** Comparison of Achievement Score between Control Group and Experimental Group

Tests	N	Groups	Mean Rank	z- value	p-value
<b>Pre-test</b>	50	Experimental	24.76	.360	.719
		Control	26.24		
<b>Post-test</b>	50	Experimental	31.82	-3.71	.002
		Control	19.18		
<b>Retention test</b>	50	Experimental	28.68	-1.552	.121
		Control	22.32		

**Interpretation:** The Mann-Whitney U test results indicate that rejecting the null hypothesis relies on the U value; however, if NNN exceeds 20, it depends on the Z value. A Z value between  $\pm 1.96$  and  $\pm 2.58$  signifies U is significant at the 0.05 alpha level, while values greater than  $\pm 2.58$  indicate significance at the 0.01 level. If Z is less than  $\pm 1.96$ , the null hypothesis is accepted. Pre-test results show no significant difference between the experimental and control groups, with a p-value of 0.719 ( $Z = 0.360$ ), suggesting similar baseline scores. Post-test results indicate a significant difference, with the experimental group having a mean rank of 31.82 versus 19.18 for the control group. A p-value of 0.002 ( $Z = 3.71$ ) is statistically significant, indicating positive effects from the intervention. However, the retention test results show no significant difference (p-value = 0.121,  $Z = 1.552$ ), suggesting the initial gains from the post-test were not maintained over time.

**Table 4.** Repeated Measures Friedman Test for Experimental Group

Chi-Squared	df	p-value	Kendall's W
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<b>Repeated Measures</b>	30.960	2	<.001	0.619
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**Interpretation:** The Friedman test indicates that there is a statistically significant difference in the scores across the three-time points (pre-test, post-test, retention) for the experimental group. The p-value is less than 0.001, indicating strong evidence against the null hypothesis. Kendall's W (0.619) suggests a moderate to strong effect size.

### Post-hock Analysis

**Table 5.** Bonferroni Value for Experimental Group

		Mean Dif-	SE	t	p bonf
		ference			
<b>Experimental Pre-Test</b>	Experimental	-3.60	.755	-4.767	< .001
	Post-Test				
<b>Experimental Post-Test</b>	Experimental	-6.320	.755	-8.369	< .001
	Retention				
<b>Experimental Post-Test</b>	Experimental	-2.720	.755	-3.602	< .002
	Retention				

### Interpretation:

**Pre-Test vs. Post-Test:** There is a significant difference between the pre-test and post-test scores for the experimental group. The Bonferroni-corrected p-value is less than 0.001, indicating a significant improvement in scores from the pre-test to the post-test.

**Pre-Test vs. Retention:** There is a significant difference between the pre-test and retention scores for the experimental group. The Bonferroni-corrected p-value is less than 0.001, indicating a significant improvement in scores from pre-test to retention.

**Post-Test vs. Retention:** There is a significant difference between post-test and retention scores for the experimental group. The Bonferroni-corrected p-value is 0.002, indicating a significant improvement in scores from post-test to retention.

The Friedman test results, and post hoc analyses indicate significant improvements in scores from pre-test to post-test and from pre-test to retention for the experimental group. There are also significant improvements from the post-test to retention, demonstrating that the experimental group continued to improve or retain their performance after the post-test phase.

### 4.3 Objective-3.

To study the difference between the mean scores of the control group concerning their pre-test, post-test, and retention test.

**Table 5.** Repeated Measures Friedman Test for Control Group

Chi-Squared	df	p-value	Kendall's W
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<b>Repeated Measures</b>	27.856	2	<.001	0.557
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**Interpretation:** The repeated measures analysis indicates that there is a statistically significant difference in the scores across the three time points (pre-test, post-test, retention) for the control group. The p-value is less than 0.001, suggesting strong evidence against the null hypothesis. Kendall's W (0.557) suggests a moderate to strong effect size.

#### Post-hock Analysis

**Table 6.** Bonferroni Value for Control Group

			Mean	Differ-	SE	t	pbonf
			ence				
<b>Control Pre-Test</b>	Control Test	Post-	$6.661 \times 10^{-16}$		0.672	$9.918 \times 10^{-16}$	1.000
	Control	Reten-	-4.400		0.672	-6.551	< .001
	tion						
<b>Control Post-Test</b>	Control	Reten-	-4.400		0.672	-6.551	< .001
	tion						

**Interpretation: Pre-Test vs. Post-Test:** The mean difference is extremely small ( $6.661 \times 10^{-16}$ ), which is effectively zero. The Bonferroni-corrected p-value is 1.000, indicating no significant difference between pre-test and post-test scores for the control group. **Pre-Test vs. Retention Test:** There is a significant difference between pre-test and retention scores for the control group. The mean difference is -4.400, and the Bonferroni-corrected p-value is less than 0.001, indicating a significant decrease in scores from pre-test to retention. **Post-Test vs. Retention test:** There is a significant difference between post-test and retention scores for the control group. The mean difference is -4.400, and the Bonferroni-corrected p-value is less than 0.001, indicating a significant increase in scores from post-test to retention. The repeated measures analysis and post hoc comparisons for the control group indicate that:

- There is no significant change in scores between the pre-test and post-test.
- There is a significant increase in scores from the pre-test to retention and from the post-test to retention.

This suggests that, unlike the experimental group, the control group did not show improvement from the pre-test to the post-test and exhibited a decline in performance over time, but after some time, scores increased in the retention test.

#### 4.4 Objective-4.

To study the critical thinking of the experimental group of students. The intensity analysis reveals strong overall positive responses, with a total average intensity score of 4.37, indicating high agreement across all items. Key areas include:

**Connecting Information (intensity 4.8):** 80% strongly agreed, showing a strong tendency to integrate information for better understanding. **Picking Relevant Information (intensity 4.44):** 44% strongly agreed, indicating an ability to analyze important data effectively. **Learning from Mistakes (intensity 4.8):** 80% strongly agreed, demonstrating a strong willingness to learn from errors in mathematics. **Questioning Decisions (intensity 4.2):** 88% agreed or strongly agreed, and 8% disagreed, reflecting some hesitation in questioning decisions. **Considering Others' Ideas (intensity 4.24):** Most agreed, but 8% disagreed, indicating some reservations in valuing others' perspectives. **Fact-Based Decision Making (intensity 4.2):** 88% favoured making decisions based on facts, though 8% showed disagreement. **Asking for Reasons (intensity 3.8):** Lower agreement, with 20% expressing disagreement, indicating some resistance to seeking explanations. **Considering Practical Applications (intensity 4.44):** 88% agreed, showing a strong preference for applying solutions practically. **Real-Life Knowledge Application (intensity 4.56):** 96% agreed, emphasizing a strong belief in applying knowledge to real-world situations. **Thinking about Facts (intensity 4.24):** 92% agreed, reflecting a preference for fact-based thinking, though 8% disagreed.

Overall, responses are highly positive, but areas such as questioning decisions and asking for reasons show slightly more hesitation or division, suggesting these as potential areas for further development.

## 5 Discussion

The data analysis shows that the AR-based intervention significantly improved the experimental group's achievement and critical thinking skills compared to the control group. While immediate gains were evident, long-term retention requires further exploration. Critical thinking inventory results demonstrated strong cognitive skills, with high scores for connecting information and learning from mistakes (4.8). However, variability in questioning and integrating diverse viewpoints suggests areas for growth. An overall intensity score of 4.37 reflects strong critical thinking abilities. A longitudinal study is recommended to better understand the long-term development of metacognitive skills through game-based learning.

## 6 Conclusion

This study demonstrates that integrating augmented reality (AR) with game-based learning significantly enhances fifth-grade students' geometry outcomes, improving cognitive and metacognitive skills. Future research should explore AR's long-term effects and its applicability in diverse educational settings.

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# Best Practices and Teaching Demos

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# Exploring Middle School Students' Challenges and Alternate Conceptions in Machine Learning: A Classroom Study

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**Abstract.** Artificial intelligence powered applications are becoming ubiquitous, and a basic understanding of machine learning can help K-12 students become informed consumers and creators. As technology becomes increasingly pervasive, understanding its underlying principles, including machine learning, is essential for digital citizenship. Jobs of the future will increasingly require skills related to data science, artificial intelligence, machine learning making all of them foundational skills. While a variety of standardized machine learning curricula and platforms have been developed, their adoption in schools remains inconsistent, with many institutions providing minimal or no dedicated education. Most of these solutions focus on implementation, there is a gap in understanding the challenges, and alternate conceptions of the students. This study investigates the challenges and alternate conceptions encountered by middle school students (grade 6-8, n=30) while learning data modeling concepts of machine learning in computer science (CS) lessons. We implemented the code.org course of artificial intelligence and machine learning (AI & ML) for grades 6-8. This paper focuses on student conceptions in concepts of data quality, prediction, feature selection, and model accuracy. We utilize classroom observations in the machine learning classes to uncover the alternate conceptions. Our findings indicate that while students were engaged and learning, the classroom discourse and activities revealed certain alternate conceptions. Some of the alternate conceptions uncovered are about data quantity, relevancy of features and feature selection. Based on this study we propose specific research questions and themes that can be explored further. This study also offers insights to curriculum development aimed at improving data modeling education and fostering student engagement within artificial intelligence and machine learning concepts.

**Keywords:** artificial intelligence, machine learning, computer science, alternate conceptions.

## 1 Introduction

The pervasiveness of AI necessitates a fundamental understanding of ML for K-12 students. ML empowers them as informed technology consumers and creators. Despite its importance, standardized ML education is lacking, with many schools focusing on

implementation rather than student understanding. This study addresses this gap by investigating student challenges and conceptions in data modeling, a crucial ML concept. Research suggests that acquiring basic ML skills fosters digital citizenship and prepares students for future careers increasingly reliant on data science and AI (Vuorikari et al., 2018).

The curriculum was based on the Code.org course on artificial intelligence and machine learning for grades 6-8, with specific adaptations to focus on data quality, prediction, feature selection, and model accuracy. The learning outcomes were carefully coined for the curriculum

### 1.1 Learning Objectives

The program was designed with the following learning objectives:

- Identify the basic principles of data modeling in machine learning
- Recognize the importance of data quality and its impact on model performance
- Identify model accuracy and its limitations
- Gain hands-on experience with simple machine learning tasks

The curriculum was structured in a progressive manner following a spiral approach. Each unit included a mix of theoretical lessons, hands-on activities, and group discussions to encourage active learning and engagement. The table below shows the structure of the curriculum implemented for this study.

**Table 1.** Structure & Duration of curriculum

Course Topics	Duration
Introduction to Data and Machine Learning	2 weeks
Data Quality and Preparation	2 weeks
Feature Selection and Model Building	3 weeks
Model Evaluation and Interpretation	2 weeks

## 2 Implementation

The machine learning education program was implemented over a 9-week period during the regular computer science classes for grades 6 and 8. All the students had access to a computer and Code.org AI & ML curriculum materials (adapted for this study) were used for this study. Instructional methods that were employed to engage with the content were:

- Interactive lectures: To introduce new concepts and facilitate class discussions
- Hands-on activities: To allow students to apply learned concepts in practical scenarios
- Group projects: To encourage collaborative learning and problem-solving

- Guided inquiry: To help students discover key concepts through structured exploration
- Simplified Python-based machine learning tools (e.g., a modified version of scikit-learn)
- Custom-designed datasets for various prediction tasks
- Visual aids and interactive demonstrations for complex concepts

The student learning was assessed through set of assessments like-

- In-class observations and discussions
- Short quizzes to gauge understanding of key concepts
- Practical assignments involving data analysis and simple model building

### **3 Methodology**

#### **3.1 Research Design**

This study employed a qualitative approach utilizing classroom discourse analysis. This method allows researchers to examine how students engage with concepts and uncover their underlying understandings (Bogdan & Biklen, 2007). The participants were a convenience sample of middle school students in grades 6 and 8 (n=30).

#### **3.2 Data Collection**

Data was collected through independent classroom observations during computer science lessons utilizing the Code.org AI & ML curriculum for grades 6-8. Observations focused on student discussions and interactions related to data quality, prediction, feature selection, and model accuracy.

#### **3.3 Data Analysis**

Thematic analysis was employed to identify recurring themes and patterns in the classroom discourse related to student conceptions of data modeling.

### **4 Findings**

Our observations revealed that students were generally engaged and actively participating in the ML lessons. However, several challenges and alternate conceptions emerged:

- Data Quantity: Some students held the misconception that more data always leads to better model performance, without considering data quality or relevance.
- Feature Selection: Students often struggled to identify relevant features for their models, sometimes focusing on superficial or irrelevant attributes.

- **Model Accuracy:** There was a tendency to overemphasize raw accuracy without considering other important metrics or the context of the problem.
- **Prediction Understanding:** Some students had difficulty grasping the probabilistic nature of ML predictions, expecting deterministic outcomes.

These findings highlight the complex nature of teaching ML concepts to middle school students. The alternate conceptions identified, particularly those related to data quantity and feature selection, suggest a need for more targeted instruction in these areas. The challenges students faced in understanding model accuracy and predictions indicate that more hands-on, practical examples may be beneficial in illustrating these concepts.

Our results align with previous research suggesting that students often struggle with abstract concepts in computer science education (citation needed). However, this study provides specific insights into the challenges faced in ML education, an area that has been less explored at the middle school level.

## **5 Conclusion**

This study contributes to the field by exploring middle school students' challenges and alternate conceptions in data modeling within ML education. The findings highlight the need for further research on specific questions and themes, such as effective strategies for teaching feature selection and conveying the nuances of model accuracy.

## **6 Recommendations**

Based on our findings, we propose the following areas:

### **6.1 For further research, we recommend:**

- Developing effective visualizations to illustrate the relationship between data quantity, quality, and model performance.
- Exploring pedagogical approaches to teach feature selection in age-appropriate ways.
- Investigating methods to convey the probabilistic nature of ML predictions to young learners.

### **6.2 For curriculum developers, we recommend:**

- Incorporating more hands-on activities that allow students to experiment with different datasets and feature sets.
- Developing lessons that explicitly address common misconceptions identified in this study.
- Creating resources that help teachers explain complex ML concepts using age-appropriate analogies and examples.

## **7 Limitations**

This study is limited by its use of a convenience sample and the potential influence of the observer on classroom discourse. Future research should aim for a larger, more diverse sample and consider employing multiple data collection methods to triangulate findings.

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# Improving Readiness to Engage and Build with AI

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**Abstract.** Given the recent democratization of artificial intelligence (AI), it is imperative to equip educators with the essential conceptual knowledge and competencies required for success as professionals. I describe the design and evaluation of a two-day synchronous pilot workshop for in-service teachers, which offered a non-technical introduction to AI and its cutting-edge applications in education. Teachers' readiness to engage and build with AI using pre-post validated surveys showed improvements of up to Cohen's  $d$  1.46, reflecting the significant potential of brief well-designed AI literacy programs in upskilling educators.

**Keywords:** AI literacy, Teacher training, Constructivist education

## 1 Objectives

Empowering all citizens to understand the impact of artificial intelligence (AI) on human lives has become increasingly more important. Educators, in particular need AI education to (i) navigate the complex space of teaching and learning with AI (e.g., evaluating how AI tools work, and if and whether they might be useful, effective and ethical in particular learning contexts), and (ii) support their students in developing AI literacy. However, structured opportunities for educators to learn the foundations of AI, its applications in education and engage in hands-on experiences of building with AI are scarce. To address this gap, a two-day (thirteen hours) pilot workshop was developed for in-service teachers from Singapore schools. The learning objectives comprised – (i) developing conceptual knowledge about what is AI and how it's used in the real-world, (ii) understanding various components of machine learning that powers AI systems, including data, algorithm, model and prediction, (iii) critiquing the benefits and risks of AI usage, with particular relevance to educational contexts, and (iv) gaining experience with developing and deploying an AI application for education (AIED).

## 2 Pedagogical Strategies

A suite of constructivist pedagogies balancing telling and self-directed exploration was employed. The workshop began with interactive lessons on foundational knowledge every teacher needs to know to embed AI into their everyday teaching practice (part I

– three hours) – (i) knowledge (what is AI, history of AI, applications of AI), (ii) skills (e.g., design thinking, data fluency), and (iii) values (ethical decision making, bias and fairness awareness). Participants came up with their own metaphors in groups to understand how machine learning works by drawing analogies to humans learning a new skill. Neural networks were introduced with unplugged activities mimicking how the brain works. Contrasting case study descriptions were used to progressively nudge awareness of privacy. Subsequently, the workshop transitioned to how AI systems can support teachers and how can they can navigate the fascinating space of human-AI collaboration in education by co-creating with generative AI via effective prompting (part II – six hours). Big ideas from the learning sciences like collaboration, personalization, assessment and building on students’ cultural assets were used to anchor the class discussion. Several worked examples of effective starter prompts for teaching and administrative tasks scaffolded participants’ learning. This workshop section concluded by using jigsaw to nudge reflection on the ideal collaboration setup between students and an intelligent tutoring system by considering four interdependent components – nature of collaboration, nature of situation, AI system characteristics, and human characteristics. Finally, participants worked in groups to build an AI-powered recommendation system for a locally relevant educational problem and stakeholder (e.g., student, teacher, parent) of their choosing (part III – four hours). By engaging in individual work as preparation for collaboration, participants went through iterative phases of problem-statement creation and pitching their solutions, devising a data collection and anti-bias plan, collecting data (via Google forms), training a pre-built supervised machine learning model (via Hugging Face), and conducting qualitative error analysis on the model’s output. In summary, participants exercised agency in solving a meaningful problem.

### 3 Empirical Evaluation

Pre-post surveys ( $N = 33$ , 5-pt. Likert scale) adapted from validated AI literacy frameworks (e.g., [1]) showed participants were significantly more prepared to (i) critically describe how AI works (9 items,  $= 0.82$ , e.g., "I understand the strengths and limitations of AI technologies", "I can analyze why and how data is collected for AI applications", Cohen’s  $d$  1.46), (ii) integrate AI in their teaching and learning (20 items,  $= 0.89$ , e.g., "I can effectively integrate AI technologies into my classroom routines", "I understand the ethical obligations and responsibilities teachers need to assume in the process of using AI technologies", Cohen’s  $d$  1.04), and (iii) build new applications with AI tools (5 items,  $= 0.80$ , e.g., "I can identify and break down a problem that can be solved with AI", "I am proud of an AI application that I helped build", Cohen’s  $d$  0.83).

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# Use of Virtual Learning Labs in Teaching at Program Level in the College

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**Abstract.** Virtual labs are innovative online platforms that allow students, researchers, and professionals to conduct experiments and simulations in a digital environment. These labs offer remote access to sophisticated tools and resources, bypassing the need for physical labs and expensive equipment. Virtual labs enhance learning and experimentation across various scientific disciplines by mimicking real-world laboratory conditions through interactive simulations and real-time feedback. The primary benefits of virtual labs include increased accessibility, cost-effectiveness, flexibility, and scalability, making them valuable in educational, research, and professional training contexts. Virtual labs allow users to experiment in a safe and controlled setting, thus fostering a deeper understanding of theoretical concepts. They complement traditional teaching methods in educational settings by providing hands-on experience at a fraction of the cost, making practical learning more widely available. Despite their advantages, virtual labs face challenges like the lack of tactile experience, the digital divide, and technical limitations. Recommendations to address these challenges include adopting a blended learning approach, improving digital infrastructure, and advancing virtual lab technologies. As technology progresses, virtual labs are expected to become vital to modern education and research, providing innovative hands-on learning and experimentation solutions.

**Keywords:** Virtual labs, Online experiments, Remote learning, Simulations, Interactive learning

## 1 Introduction

Virtual labs are online platforms that allow students, researchers, and professionals to conduct experiments and simulations in a controlled, digital environment. Unlike traditional laboratories, virtual labs allow users to access sophisticated tools and resources remotely, eliminating the need for physical presence and expensive equipment [1]. They offer a wide range of experiments across various scientific disciplines, enabling users to explore, learn, and experiment at their own pace.

These labs are designed to mimic real-world laboratory conditions, providing interactive interfaces, detailed simulations, and real-time feedback. Users can perform

complex experiments, manipulate variables, and observe outcomes, all within a safe, virtual setting [2]. This enhances the learning experience and makes it more accessible to individuals who might not have access to physical labs [3].

Virtual labs are particularly beneficial in educational settings, where they can complement traditional teaching methods by offering hands-on experience in a cost-effective and scalable manner. They are also valuable in research, allowing for experimentation without the constraints of physical resources, and in professional training, where they can be used to simulate real-world scenarios and procedures [4]. As technology advances, virtual labs are becoming an integral part of modern education and research, paving the way for innovative approaches to learning and experimentation [5].

## **2 Objectives**

1. **Enhanced Accessibility:** To provide learners and researchers with access to advanced experimental tools and resources, regardless of their geographical location or access to physical labs.

2. **Cost-Effective Learning:** To offer a more affordable alternative to traditional laboratories by reducing the need for expensive equipment, materials, and physical space.

3. **Flexible Learning Environment:** Allowing users to conduct experiments at their own pace and convenience facilitates self-directed learning and exploration.

4. **Safe Experimentation:** To provide a risk-free environment where users can experiment with various scenarios without the dangers of real-world labs, such as chemical spills, electrical hazards, or equipment malfunctions.

5. **Interactive Learning:** To enhance the learning experience through interactive simulations, real-time feedback, and the ability to manipulate variables and observe outcomes directly.

6. **Scalable Education:** To support large-scale educational initiatives by enabling institutions to offer practical lab experiences to a broader audience without physical space or resource constraints.

7. **Bridging Theory and Practice:** To help students and professionals apply theoretical knowledge to practical situations, reinforcing learning through hands-on experience in a virtual setting.

8. **Innovation in Research and Training:** To facilitate innovative research and professional training approaches by allowing for the simulation of complex and varied scenarios that might be difficult or impossible to replicate in physical labs.

## **3 Description of Virtual Labs**

This lab helps users understand the concept of NLP Morphology, Earned Value Analysis, N-Queen Problem, and Array implementation of Stack Data Structure and Control

Structures in Python Programming. At the same time, it also helps the user to know the theory and consolidate it using the pretest and posttest for each experiment.

In this virtual lab, the students can perform experiments based on concepts like NLP – Morphology, Earned Value Analysis, N-Queen Problem, Array implementation of Stack Data Structure, Control Structures in Python Programming etc.

Each experiment consists of the following seven sections.

1. Aim – This describes the goal of the experiment.

2. Theory – This section contains the details of the theoretical concepts related to the experiment. The users should read and understand the theory underlying the experiment before using the Simulation. This helps reinforce theoretical concepts and relates theory with practical aspects. These are the important learning outcomes of any laboratory experiment.

3. Pre-Test – After reading and understanding the theoretical concepts, the students/users can test their understanding by answering the questions in the Pre-Test section. This helps them while experimenting with the Simulator.

4. Procedure – The students/users must follow a step-by-step process while experimenting with the Simulator. This section provides an explanation of the complete procedure to be followed.

5. Simulation – The Simulator has interactivity through which the users perform Experiments. Once they start the simulation and while it is running, the users get an indication of the outputs. These interactivity features help the users understand the workings of the experiment.

6. Post-Test – After the students/users have experimented, they can complete self-assessments by answering the post-test questions.

7. The experiments are based on concepts of NLP – Morphology, Earned Value Analysis, N-Queen Problem, Array implementation of Stack Data Structure and Control Structures in Python Programming, and hence all the students or users who have these concepts as part of their curriculum or undergoing a related online course or anyone wishes to understand the basic concepts can perform these experiments.

Link to the Entry or Web portion of the Entry: <https://vsit.edu.in/vlab.html>

## **4 Discussion of Benefits**

Virtual labs offer numerous benefits, transforming education, research, and professional training. Their accessibility is a major advantage, breaking down geographical and financial barriers so learners can access advanced setups without physical labs. This democratizes education, enabling more students and researchers to engage in hands-on learning, regardless of institutional resources.

Cost-effectiveness is another benefit, as virtual labs significantly reduce the expenses of equipment, maintenance, and materials, making education more affordable. The flexibility of virtual labs allows students to work at their own pace, revisiting concepts as needed to support personalized learning.

Finally, virtual labs are scalable, supporting large user numbers and fostering global collaboration among students, educators, and researchers in a shared virtual space.

## 5 Challenges

Despite their benefits, virtual labs face several challenges. A major issue is the lack of tactile experience, as they cannot replicate the physical handling of materials and equipment, which is crucial in fields requiring manual dexterity.

The digital divide also presents a challenge; not all students have access to high-speed internet or suitable devices, widening educational inequalities. Technical limitations mean some complex experiments may not be accurately represented, risking gaps in understanding.

Additionally, creating high-quality virtual labs demands significant resources and expertise, which some institutions may lack. Finally, virtual labs may reduce opportunities for collaborative, hands-on learning, impacting the development of soft skills like communication and teamwork.

## 6 Recommendations

To maximize the benefits of virtual labs while addressing their challenges, several recommendations can be made:

1. **Blended Learning Approaches:** Institutions should consider integrating virtual labs with traditional, physical labs to provide a more comprehensive learning experience. This blended approach can help students gain both digital and tactile skills.

2. **Invest in Infrastructure:** Governments and educational institutions should improve digital infrastructure to ensure all students can access the necessary tools and internet connectivity to participate in virtual labs.

3. **Enhance Virtual Lab Technologies:** Continued investment in developing virtual lab technologies is essential. This includes improving the realism of simulations, incorporating more advanced artificial intelligence, and exploring ways to simulate tactile feedback.

4. **Collaboration and Sharing:** Institutions and developers should collaborate to create shared virtual lab platforms that can be accessed by multiple institutions. This can reduce costs and ensure a higher standard of quality.

## 7 Conclusion

Virtual labs represent a powerful tool in the evolution of education and research, offering unparalleled accessibility, cost-effectiveness, and flexibility. However, their successful implementation requires careful consideration of their challenges, such as the lack of tactile experience and the digital divide. By adopting a blended learning approach, investing in digital infrastructure, and enhancing the realism of virtual simulations, institutions can overcome these challenges and fully leverage the potential of virtual labs. As technology advances, virtual labs are poised to become integral to

modern education, providing students and professionals with the skills and knowledge they need to succeed in a rapidly changing world.

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# Implementing EdTech Internship Program on Analytics, Data Science, and Emerging Technologies

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**Abstract.** The EdTech Internship Program on Analytics, Data Science, and Emerging Technologies was designed to bridge the gap between academic theory and practical application through experiential learning. Hosted at D.Y. Patil College of Engineering and Technology, Kolhapur, and guided by IIT Bombay's Centre for Educational Technology, the 60-day internship involved over 230 engineering students. The program integrated GitHub-based collaboration, deep learning projects, and real-life data analysis in the education domain, supported by structured mentorship and a rigorous evaluation framework. Findings highlight the program's effectiveness in fostering technical proficiency, problem-solving, and collaborative learning—key competencies for the emerging data-driven workforce.

**Keywords:** EdTech Internship, Analytics and Data Science Training, Experiential Learning.

## 1 Introduction

The EdTech Internship on Analytics, Data Science, and Emerging Technologies is a comprehensive, learning-focused initiative designed to integrate theoretical concepts with real-world applications. Led by Prof. Sridhar Iyer, IDP in Educational Technology, IIT Bombay, and facilitated by the EdTech Society, Mumbai, the program was hosted at D. Y. Patil College of Engineering and Technology (DYPCET), Kolhapur. The internship was coordinated by Dr. Ashwin T S, Internship Chair at EdTech Society, and Dr. Kapil B. Kadam, Internship Coordinator, CSE, DYPCET, Kolhapur. Spanning 60 days, from April to August 2024, the program saw the participation of 231 undergraduate engineering students from the CSE, Data Science, and AIML departments, with 177 successfully completing all tasks. This internship emphasizes hands-on learning and equips participants with key skills in analytics, data science, and emerging technologies through real-life problem-solving in the education sector.

## 2 Internship Structure and Timeline

The internship followed a modular structure, guiding participants through the process of learning core concepts before applying them in real-world contexts. The phases were:

1. GitHub Learning (2 weeks):

Over 80 hours, students learned critical GitHub functionalities, including repository creation, branch management, commits, pull requests, and merges. GitHub became the platform for collaborative work and version control.

2. Deep Learning (4 weeks):

Participants spent 160 hours mastering deep learning techniques focused on classification tasks using various data modalities. Working in groups, they leveraged available datasets to build and evaluate models.

3. Real-life Data Analysis (2-3 weeks):

Students then moved on to analyzing predefined or self-generated datasets within the education domain. This phase, spanning 80-120 hours, allowed them to apply deep learning techniques to solve real-life challenges.

4. Report Writing and Submission (1 week):

In the final 40-hour phase, participants drafted detailed reports documenting their project methodologies, results, and insights, culminating in the final evaluation.

## 3 Best Practices for Teaching and Mentorship

Several best practices were integral to the success of this internship:

1. Collaborative Learning for Deep Learning Projects:

Group-based tasks for deep learning projects promoted peer learning, collaboration, and shared problem-solving.

2. Real-World Application:

Students engaged in education-domain projects, ensuring practical exposure to deep learning in impactful areas.

3. Flexibility and Parallel Learning:

The modular structure allowed for flexibility, enabling participants to manage parallel tasks, reflecting the multitasking demands of professional environments.

4. Structured Mentorship:

Fifteen local faculty mentors were nominated by the host institute to guide and monitor student progress, ensuring alignment with learning goals. These mentors played a pivotal role in providing feedback and direction.

## 4 Evaluation Framework

The evaluation was multi-dimensional, assessing both technical skills and communication abilities. The key components of the evaluation included:

1. Report Submission:

Students submitted reports drafted using an Overleaf template, adhering to specific guidelines for formatting and content.

Evaluation Criteria: Clarity, adherence to the template, and depth of content.

2. Video Demonstration:

Participants created a 3-5 minute video demonstrating their project, focusing on objectives, methodologies, and results.

Evaluation Criteria: Conciseness, clarity, and effectiveness in presenting key project aspects.

3. Poster Design:

Students were tasked with designing a poster that visually communicated their project outcomes. Creative tools such as Canva, PowerPoint, Figma, or Photoshop were used.

Evaluation Criteria: Creativity, clarity, and effectiveness in communicating project details.

4. Code Submission:

Participants were required to update their GitHub repositories with the final code and include relevant links in the report and project tracker.

Evaluation Criteria: Code functionality, GitHub contributions, and effective use of version control. Participants were encouraged to engage closely with their mentors for regular feedback and alignment with the program's objectives.

## 5 Conclusion

In conclusion, the EdTech Internship on Analytics, Data Science, and Emerging Technologies at D.Y. Patil College of Engineering and Technology has been a highly effective learning initiative. By integrating theoretical knowledge with practical applications in educational data, collaborative group work, and structured mentorship, the program has significantly enhanced participants' understanding and equipped them with the essential skills required in today's data-centric landscape. This commitment to experiential learning and innovative teaching methodologies lays a solid groundwork for students' future endeavors in data science and related fields, particularly in the realm of educational analytics.

**Author Contributions.** All authors contributed equally to this work, sharing an even workload and responsibilities throughout.

**Acknowledgments.** We would like to express our gratitude to all those who contributed to the successful implementation of the EdTech Internship Program. We are thankful to the Centre for Educational Technology, IIT Bombay, and the EdTech Society for supporting this initiative, as well as D. Y. Patil College of Engineering and Technology for participating and hosting the internship. We are also thankful to the participating students and faculty mentors for their dedication and collaborative efforts, which were instrumental in making this initiative a success.

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# Bringing Quadratic Equations to Life with Art and Technology

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**Abstract .** By integrating mathematics, art, and technology, the project aims to make learning quadratics engaging and meaningful. Students will gain a deeper understanding of quadratic functions and their transformations while appreciating the creative potential of mathematics. The stained-glass window project provides a creative and visual approach to understanding quadratic equations and their solutions. By asking learners to design stained-glass windows on graph paper and later on DESMOS, they are not only exploring the aesthetic aspect of art but also applying mathematical principles in a practical context. Designing different quadratic curves and equations challenges them to think critically about how equations translate into graphical representations. Moreover, the process of drawing lines through the curves to create patterns introduces the concept of solving simultaneous equations and the intersection of lines and curves representing solutions. This hands-on approach allows learners to see the mathematical concepts come to life, fostering a deeper understanding of quadratic equations and their solutions. The project also encourages learners to exercise their imagination and creativity as they strive to build symmetric patterns. Through this creative endeavor, they gain insight into the transformation of functions and develop spatial reasoning skills.

**Keywords:** quadratics, transformations, DESMOS, stained glass window, simultaneous equations

## 1 Objective

An innovative teaching methodology developed that integrates visual elements and artistic representations to simplify the understanding of solving simultaneous equations using elimination or substitution methods. Additionally, it will illustrate the concept of roots in quadratic equations, explaining the connection between the number of roots and intersection of curves. By incorporating art into quadratic equations, aim to enhance students' comprehension and engagement with abstract mathematical concepts, fostering a deeper appreciation for the relevance of algebraic problem-solving in everyday scenarios.

## 2 Descriptions of the principles behind the design and development

Integrating art into the teaching of quadratics for higher grade is a brilliant way to make abstract mathematical concepts more tangible and engaging. This methodology uses visual and artistic representations to make solving simultaneous equations and understanding quadratic roots more engaging and accessible.

Visuals will offer a tangible and intuitive understanding of abstract mathematical concepts, making it easier for learners to grasp the meaning behind finding solutions and the significance of roots.

Artistic representations will not only enhance engagement but also provide alternative perspectives, aiding in the visualization of mathematical concepts and their real-world applications.

Interactive elements will allow learners to explore and manipulate equations, gaining a deeper understanding of the relationships between variables and the outcomes of algebraic operations.

By providing multiple modes of presentation, the methodology ensures that learners with varying preferences and strengths can engage with the material effectively.

Start with simple examples and progressively introduce more challenging problems, allowing learners to build upon their understanding incrementally and develop problem-solving skills at their own pace.

Encourage learners to reflect on their learning process, receive feedback on their performance, and apply insights to refine their understanding of mathematical concepts.

## 3 Details of implementation

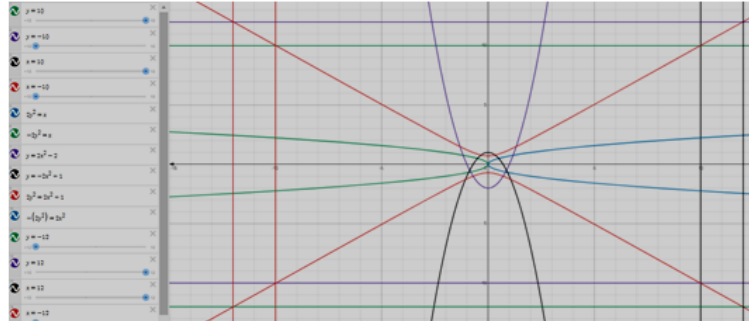
Following steps can be followed to learn quadratics and can be integrated with art and technology to make it engaging and meaningful.

- Begin with a brief overview of quadratic functions and their real-life applications. Understand the standard form of a quadratic equation  $y=ax^2+bx+c$  and the vertex form  $y=a(x-h)^2+k$ .
- Introduce Desmos and demonstrate how to input quadratic equations.
- Show how to create sliders for a, b, and c to dynamically change the graph.
- Highlight the effects of each coefficient on the graph:
  - a affects the direction and width.
  - b shifts the vertex horizontally.
  - c moves the graph vertically.
- Show how changing h and k in  $y=a(x-h)^2+k$  translates the graph horizontally and vertically.
  - Demonstrate the effect of a on the width and direction of the parabola.
- Introduce and demonstrate reflections and stretching:
  - Reflections over the x-axis:  $y=-a(x-h)^2+k$
  - Horizontal stretches/compressions:  $y=a(bx-h)^2+k$

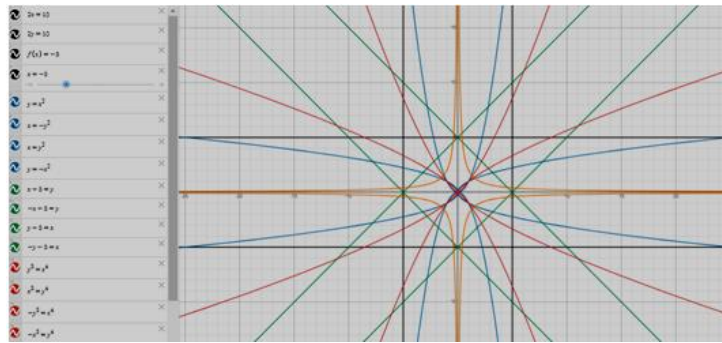
- Vertical stretches/compressions:  $y=a(x-h)^2+k$
- Show examples and allow students to explore these transformations on Desmos.
- Explore transformations of quadratic functions including translations, reflections, and stretching by an interactive transformation activity.
  - Distribute a worksheet with a set of quadratic equations in vertex form.
  - Students can work in pairs to input the equations into Desmos, adjust  $a$ ,  $h$ , and  $k$ , and observe the transformations/changes.
- Graphing quadratic functions
  - Students can sketch the quadratic curve on the graph paper by using tabular method where they can take different values of  $x$  and can find different values of  $y$  and label key features (vertex, axis of symmetry).
- Introduction to Quadratic art stained-glass window Project
  - Introduce the concept of creating art using quadratic transformations
  - Show examples of artistic designs created with quadratic functions and straight line
  - Explain the project guidelines: Students will create a piece of art by combining various quadratic functions, transformations and straight lines.
  - Provide a rubric for the project, outlining expectations for creativity, accuracy, and complexity.
- Creating and Presenting Quadratic Art
  - Students use Desmos to start creating their quadratic art based on their plans.
  - Encourage experimentation with different transformations to achieve desired artistic effects.
  - Circulate the room to provide guidance and support, ensuring students are using transformations correctly.
  - Students present their quadratic art to the class, explaining the equations and transformations used.
  - Class discussion on the challenges and discoveries made during the project.
  - Reflect on how integrating transformations, art, and technology helped in understanding quadratic functions.



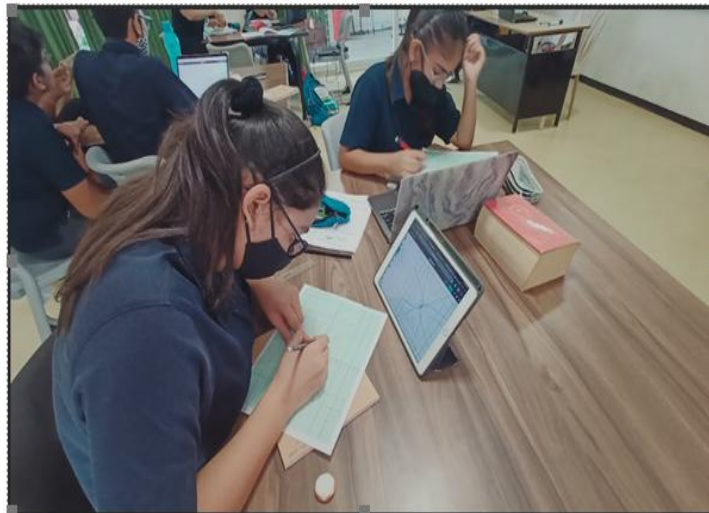
**Fig. 1.** Example of stained glass window project



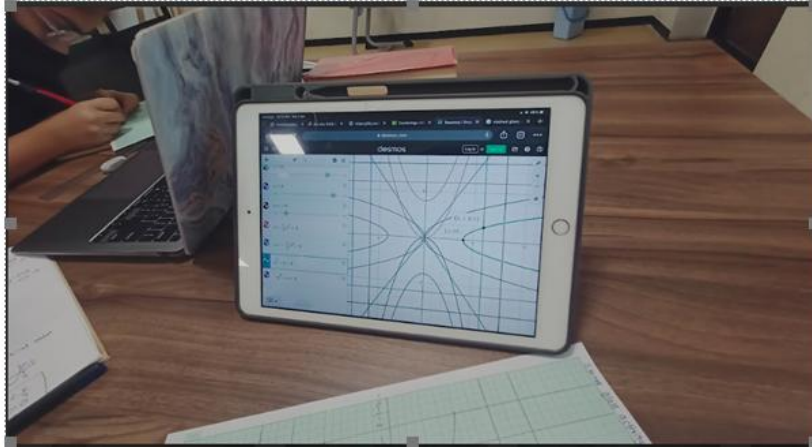
**Fig. 2.** Example of stained glass window project



**Fig. 3.** Example of stained glass window project



**Fig. 4.** Learner sketching graph on graph paper



**Fig. 5.** Example of stained glass window project

#### **4 An evaluation of the implementation**

An evaluation of the implementation can be judged by monitoring student engagement during the activities. Note if students appear interested and enthusiastic about using Desmos and creating quadratic art.

Assess students' ability to correctly apply transformations using Desmos during class activities. Pay attention to how well they understand the effects of changing  $a$ ,  $h$ , and  $k$  in the vertex form of a quadratic equation.

Note the creativity and originality of students' quadratic art projects. Encourage diverse and imaginative designs.

Assess the quality and creativity of the quadratic art project and the ability to explain the mathematical concepts and transformations behind their art.

Domain: Mathematics	Unit Title: Quadratics and Functions				Grade: 11
Student Name:					Date:
	Exceeding (9-10)	Meeting (6-8)	Approaching (3-5)	Needs Improvement (0-2)	Marks
Use of Functions and Transformations	Quadratic functions are present and properly graphed. Transformation of functions like translation, reflection and stretching are appropriately used.	Quadratic functions are present and properly graphed. Transformation of functions like translation and reflection are used fairly well.	Some quadratic functions are present and properly graphed. Basic use of transformation of functions evident.	Quadratic functions are present and graphed but transformation of functions are not used.	
Use of Equations	At least 10 equations are used correctly. The graph makes clear and logical use of both Linear and Quadratic Equations or Inequalities.	At least 8 equations are used correctly. The graph makes good use of both quadratic and linear equations or inequalities.	Less than 5 equations are used. The graph makes adequate use of quadratic and/or linear equations.	There are no equations present.	
Desmos Features	Graphing features are used at an accomplished level. The correct scale/window is chosen for the graph, equations are edited using correct formatting, and a variety of colors/line types are used.	Graphing features are used at a developing level. Two of the following are likely used to some extent: correct scale/window is chosen for the graph, equations are edited using correct formatting, and a variety of colors/line types are used.	Graphing features are used at a beginners level. One of the following features is used: correct scale/window is chosen for the graph, equations are edited using correct formatting, and a variety of colors/line types are used.	Graphing features are not used effectively or not used at all. The graph is not visually appealing.	
Creativity	The equations are used creatively. The learner demonstrated efforts and showed relevant details. The subject choice was highly challenging.	The learner's work demonstrates some creativity. The subject choice was acceptable, but could have been more challenging.	The learner's work demonstrates little creativity. The subject choice was acceptable enough for the level of the course.	There is evidence of minimal personal creativity and engagement. The subject choice was below grade level expectations.	
Perseverance	The learner exhibits exemplary efforts and produces work with excellence.	The learner exhibits consistent efforts to produce above average work.	The learner exhibits just enough effort to meet the academic requirements. Work could be improved with little effort.	The learner exhibits minimal efforts and work is not completed in a satisfactory manner.	
<b>TOTAL MARKS</b>					

Fig. 6. Rubrics to assess learning

## 5 What was learned from the experience

This innovative methodology fosters a more engaging and enriching learning experience for students, allowing them to grasp mathematical concepts through an artistic lens.

While technology can enhance learning, it's important to provide adequate instruction and resources to ensure all students can use it effectively.

A variety of teaching methods can cater to different learning styles and improve overall student comprehension and engagement.

Ongoing assessment and feedback are essential for responsive teaching that meets students' needs effectively.

Providing clear guidelines and examples can help students maintain mathematical accuracy while being creative. Additional support and checkpoints can ensure they stay on track.

## 6 Recommendations for others

Integrating art into the learning-teaching process offers numerous benefits, including enhanced motivation, positive emotional responses, and heightened curiosity among learners. By incorporating art into mathematics education, abstract mathematical concepts become more tangible and accessible to learners. The fundamental objective of this integration is to render education both effective and engaging. As educators, it is incumbent upon us to demonstrate to our learners the inherent beauty of mathematics. This requires adopting a growth mindset and embracing innovative approaches to teaching. Art serves as a powerful medium of communication and a dynamic tool for facilitating the teaching-learning process.

The quote by Ignacio Estrada, "If a child can't learn the way we teach, maybe we should teach the way they learn," encapsulates the essence of student-centered education. By recognizing and accommodating diverse learning styles and preferences, educators can create inclusive and enriching learning environments that cater to the needs of all learners. Embracing art as a pedagogical tool empowers educators to foster creativity, critical thinking, and deeper engagement among learners, ultimately facilitating their academic growth and success.

**Acknowledgment.** The author thankfully acknowledge the support provided by DESMOS and the authorities of The Northstar School, Gujarat, India.

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# Innovative Techniques in Chemical Engineering with ASPEN HYSYS

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**Abstract.** The student-centred learning framework known as *Outcome-Based Education* (OBE) is oriented on evaluating student performance using predetermined outcomes. With this strategy, all educational endeavors are guaranteed to be in line with the ultimate objective of turning out graduates who are capable and prepared for the workforce. Aspen HYSYS courses have been incorporated into a Skill Lab framework that adheres to the concepts of *Outcome-Based Education* (OBE), which is a major development in chemical engineering education. Leading process simulation software; Aspen HYSYS, is necessary for the design, simulation and optimization of chemical processes in modern chemical engineering. The emphasis on practical, hands-on experience in the Skill Lab approach guarantees that students acquire the technical skills needed for industry application in addition to understanding theoretical principles. The Aspen HYSYS Skill Lab courses were prepared for chemical engineering students including curriculum structure, teaching learning process and assessment. With an emphasis on how they connect with OBE to meet predetermined learning objectives.

**Keywords:** Aspen HYSYS, Skill Lab, Outcome Based Education, Chemical Engineering, Process Simulation, Practical Skills, Industry Application

## 1 Introduction

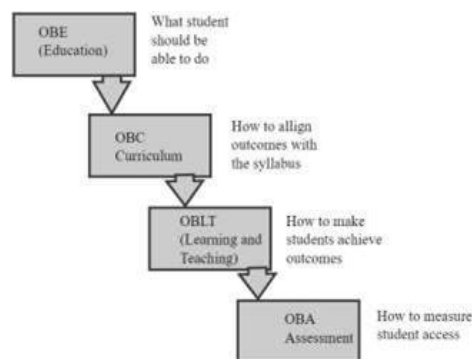
Chemical engineering is a dynamic field nowadays, and efficient chemical process design, simulation, and optimization are essential. Aspen HYSYS is a powerful process simulation program that provides necessary features for modelling complex chemical reactions. It is a vital component of modern chemical engineering curriculums. By providing students with the skills they need to thrive in the workforce, Aspen HYSYS courses are integrated into an Outcome-Based Education (OBE) framework with the aim of closing the knowledge gap between theory and practice [1]. The student-centered learning framework known as "Outcome-Based Education" (OBE) places a strong emphasis on achieving certain, quantifiable goals. OBE makes ensuring that all teaching, learning, and assessment activities are in line with these specified outcomes by concentrating on what students should be able to accomplish by the end of their educational journey [2]. This method works especially well in technical domains like chemical engineering, where it's essential to apply theoretical understanding to practical is-

sues. Aspen HYSYS courses can be integrated into an OBE framework by creating a curriculum that gives students a great deal of practical experience in addition to theoretical instruction [3]. The curriculum is divided into modular sections that gradually increase students' confidence and skills while focusing on distinct learning objectives. Students receive a thorough grasp of process simulation and the expertise required to use Aspen HYSYS through a combination of lectures, tutorials, interactive simulations, and project-based learning [4].

Within this paradigm, evaluating students' overall competence, giving ongoing feedback, and conducting summative and continuous assessments are all part of the assessment process. Quizzes, assignments and lab exercises are examples of formative assessments that are used to track progress and pinpoint areas that require work [5]. Summative evaluations such as final exams and capstone projects, gauge how well students can use their knowledge and abilities in real-world situations [6]. Strong support mechanisms such as online resources, technological help centres, and frequent teacher feedback are integrated to guarantee that students get the direction and help they need during their educational journey [7]. This all-encompassing method not only improves the educational process but also gets students ready for lucrative employment in chemical engineering [8].

Educational institutions can develop graduates who are not only knowledgeable but also able to use their talents in real-world contexts by coordinating the teaching and learning of Aspen HYSYS with OBE principles. By preparing students for the demands of contemporary chemical engineering professions and fostering the field's progress this approach guarantees that students are industry-ready [9].

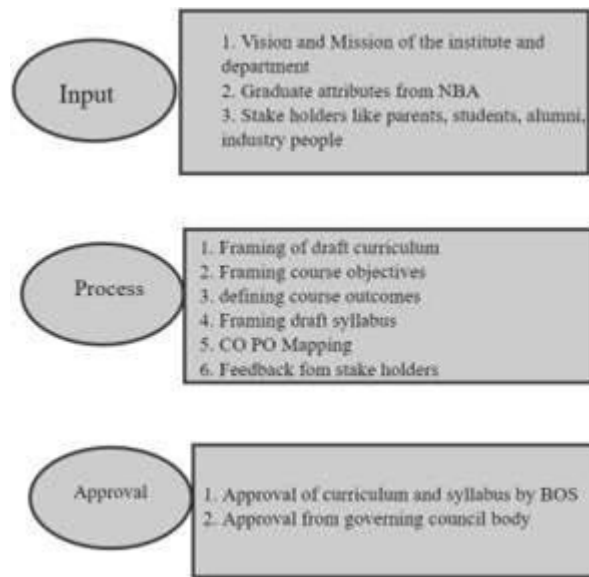
The primary focus of OBE is "What the students are capable of doing". The task at hand is well-defined, and the intended outcome has been determined beforehand [10]. OBE is superior to traditional "structured tasks." Students must actively engage in the learning process and demonstrate their proficiency through progressively challenging assignments and higher order thinking. OBE highlights assessments and outlines the advantages of the program for companies [11]. The research paper focus on detailed information about ASPEN HYSYS course according to meet OBE. The detailed discussion on curriculum structure, learning objectives, learning and teaching processes, exam and assessment, CO attainment and student feedback are also included in study [12].



**Fig. 1.** Outcome based Education

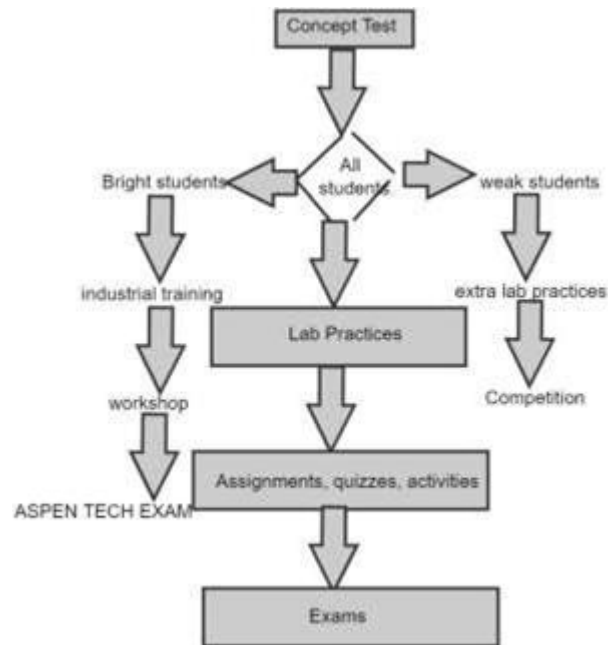
## 2 Methodology

The OBE involves three important elements like curriculum development, teaching learning and assessment. Fig. 2 explains outcome based curriculum development process. It focuses on four major parameters such as curriculum planning, designing, implementation and evaluation.



**Fig. 2.** Outcome based curriculum development

A student-centered educational strategy known as "outcome-based teaching and learning" (OBTL) focuses clear emphasis on the goals of the curriculum for students to meet. Then, instructional strategies and learning exercises are created to help students reach these goals. The evidence for OBTL's success comes from student learning experiences and evaluation results. Regular evaluations of these data will result in ongoing enhancements to the quality of the program. Fig 3 explains teaching learning applied in skill lab course.



**Fig. 3.** Teaching learning process for ASPEN HYSYS

The method of obtaining evidence of learning based on the quantity of learning outcomes attained rather than the total of marks on various assessment tasks is known as outcomes-based assessment. Fig 4 explains course outcomes related documents used for skill lab course. Faculty have taken many assignments based on lab practices, quizzes and project based on industry need.

### **3 Results and Discussions**

#### **3.1 Discussion on Curriculum Development**

Mission and vision of institute and department was prepared and finalised. Based on that the course description, course objectives and course outcomes decided for course and according to that draft syllabus copy is prepared. The draft syllabus was sent to researchers, academicians and industry person for their inputs. The detailed results were shown in the figure 5.

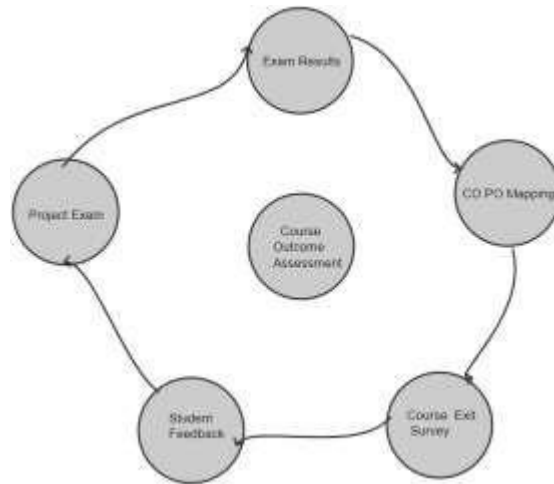


Fig. 7. Course outcome assessment

**Course Description:**  
 This course provides students comprehensive knowledge and practical skills in process simulation and optimization using ASPEN HYSYS. Students will learn to model, simulate, and analyze various chemical processes, enhancing their research capabilities and preparing them for industry or advanced studies.

**Course Objectives:**

- To understand the fundamentals of process simulation and optimization.
- To develop proficiency in using ASPEN HYSYS for process modeling and simulation.
- To apply simulation techniques to solve real-world chemical engineering problems.
- To conduct research and development projects using ASPEN HYSYS.
- To enhance critical thinking and problem-solving skills in the context of process engineering.

**Course Outcomes:**  
 By the end of the course, students will be able to:

- Demonstrate understanding of the principles and concepts of process simulation and optimization.
- Utilize ASPEN HYSYS to create and analyze process models.
- Conduct process optimization using ASPEN HYSYS tools.
- Interpret simulation results to make informed engineering decisions.
- Apply simulation techniques in research projects.
- Collaborate effectively in teams to solve complex engineering problems.

Fig. 8. Course description, course objectives and course outcomes

PRACTICAL:		
Practical No. 1	Title: Introduction	2 Hours
Introduction to ASPEN HYSYS(Fluid Package & Component Addition)		
Practical No. 2	Title: Software Tools & Basic Component Drawing	2 Hours
Interface of Software: Different tools available, Basic Component & commands		
Practical No. 3	Title: Refrigeration Cycle	6 Hours
Propene Refrigeration Cycle Industrial Application		
Practical No. 4	Title: Refrigerated Gas Plant	6 Hours
Refrigerated Gas Plant, Logical operation in Hysys, Interconnection of different equipments		
Practical No. 5	Title: Optimization by Simulation	4 Hours
Simulation & optimization of process parameters in given process flowsheet		

TEXT BOOKS:		
1. Aspentech Getting Started Aspen Hysys V8 Manual		
2. Process Simulation using Hysys V8 by Ahmed Deyab fares		

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3. A. K. Jana "Process Simulation And Control Using Aspen", PHI Publications, (ISBN: 9788120336599.)		

Fig. 9. Course syllabus for ASPEN HYSYS



Fig. 10. Stakeholder feedback copy from industry person

### 3.2 Discussion on Teaching-Learning Process

At the start of term faculty has conducted concept test for all students. With the help of the test weak and bright students were identified. Teacher has to plan various activities for weak and bright students such as practice assignments, model making competition, workshops, training and ASPEN TECH User certified exam. Figure 8 explains weak and bright student data. Fig 9 and 10 explains sample copy of assignments as well as activity conducted for students.



MIT   Academy of Engineering <small>(An Autonomous Institute Affiliated to Savitribai Phule Pune University)</small>		ASSIGNMENT		
Alandi (D), Pune – 412105		ACADEMIC YEAR	2023-24	
SCHOOL OF CHEMICAL ENGG.		SEMESTER	VI	
		CLASS & DIVISION	TY	
COURSE CODE	CH364	ASSIGNMENT NO.	01	
COURSE	Skill lab	DATE	9/01/2024	
Que. No.	Question Description	Marks	CO No.	RBT Level
1	<p><b>Learning Objectives:</b></p> <ul style="list-style-type: none"> <li>• Define a fluid package (property package, components, hypotheticals).</li> <li>• Add streams.</li> <li>• Understand flash calculations.</li> <li>• Attach stream utilities.</li> <li>• Customize the Workbook</li> </ul>			
	<p><b>Problem statement:</b></p> <p>We have a stream containing 15% ethane, 20% propane, 60% i-butane and 5% n-butane at 50°F and atmospheric pressure, and a flow rate of 100lbmole/hr. This stream is to be compressed to 50 psia and then cooled to 32°F. The resulting vapor and liquid are to be separated as the two product streams. Neglect the pressure drop inside the condenser.</p> <p><input type="checkbox"/> Fluid pkg: Peng Robinson</p> <p>What are the flow rates and molar compositions of two product streams?</p> <p>Component Vapor Liquid</p> <p>Ethane</p> <p>Propane</p>	10	1	L3

Fig. 9. Sample copy of assignment

### 3.3 Discussion on Course Outcome Assessment

Course outcome assessment involves exams, continuous assessment, projects, course exit survey, student feedback. The detailed analysis for ASPEN HYSYS course was done by faculty. The results are discussed.

<b>MIT</b>   Academy of Engineering <small>(An Autonomous Institute Affiliated to Savitribai Phule Pune University)</small>	<b>ACTIVITY</b>	
	<b>ACADEMIC YEAR</b>	2023-24
<b>Alandi (D), Pune – 412105</b>	<b>SEMESTER</b>	VI
<b>SCHOOL OF CHEMICAL ENGG.</b>	<b>CLASS &amp; DIVISION</b>	TY

<b>COURSE CODE</b>	CH 364	<b>ACTIVITY NO.</b>	01
<b>COURSE</b>	SKILL LAB	<b>DATE</b>	16/04/2024

ACTIVITY DETAILS	
<b>Name of Activity</b>	Prepare a simulation of any Chemical Process Plant
<b>Activity Details</b>	Take a real flowsheet from Chemical Engineering Process Technology Dryden book. Complete the simulation with ASPEN HYSYS and prepare a model and presentation. Also prepare a detailed report.

<b>Type of Activity</b>	Collaborative	<b>Mode of Assessment</b>	Inclass+OutClass
<b>Course Topic Covered</b>	Simulation	<b>Marks</b>	10
<b>Course Outcome</b>	Learning and apply knowledge of skill lab	<b>Revised Blooms Taxonomy Level</b>	L4

*(Remark: Course Instructor to add assessment rubrics for each activity)*

Criteria	Exceptional Quality (30 Points)	Best Quality (22 Points)	Average Quality (15 Points)	Lowest Quality (10 Point)
<b>Criteria 1 (10M)</b>	New case study	New case study	Repeated case study	Class case study
<b>Criteria 2 (10M)</b>	Complete simulation with result	Only simulation without result	Partially simulation	Without simulation and result
<b>Criteria 3 (5M)</b>	Presentation with new technology with presentation skill	Presentation with new technology without presentation skill	Typical Presentation technology with no presentation skill	Not prepared
<b>Criteria 4 (5M)</b>	Answers given for all 5 questions	Answers given for all 3 questions	Answers given for all 2 questions	Answers given for all 1 questions

Fig. 10. Sample copy of activity

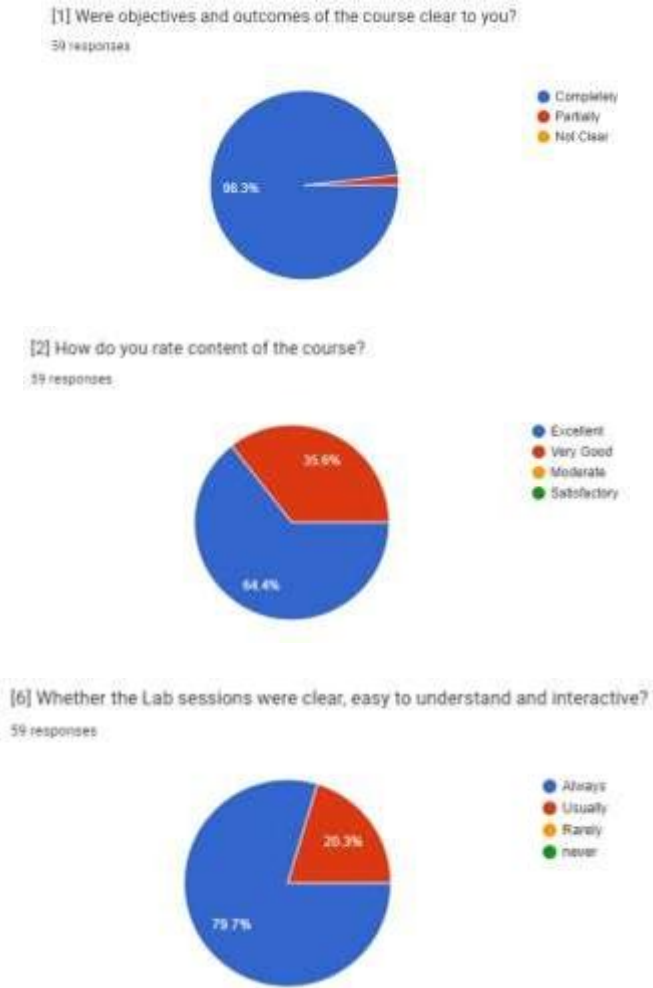


**Fig. 11.** Project demonstration

Has the Teacher covered the entire Syllabus as prescribed by the Institute?	0.9
Has the Teacher covered relevant topics beyond syllabus?	0.8
Effective of Teacher in terms: - Technical content/course contents - Communication Skills - Use of teaching aids	1
Pace on which content was covered.	1
Motivation and inspiration for students to learn.	1
Support for the development of students skill - Practical Demonstration - Hands on training	0.9
Clarity of expectations of students' progress.	0.8
Feedback provided on Students progress	0.9
Willingness to offer help and advice to students	1
Overall, how do you rate your experience in this course?	1
<b>Total Score:</b>	<b>9.7</b>

**Calculation:**  
 Excellent >= 100%  
 Good >= 75% and <= 99%  
 Satisfactory >= 50% and <= 74%  
 Average >= 25% and <= 49%

**Fig. 12.** Student feedback of faculty for ASPEN HYSYS course



**Fig. 13.** Samples of course exit survey

The CO PO mapping for ASPEN HYSYS course was prepared by considering factors like performance indicator, identification of PO and PSO, CO attainment, PO and PSO attainment, MSE, ESE, continuous assessment, Internal assessment marks. The detailed analysis is shown in Fig 14.

MIT   Academy of Engineering		CO Attainment						
Alandi (D), Pune - 412105		CLASS:	TY BTech	ATTAINMENT LEVEL				
UG - Chemical Engineering		COURSE:	Skill Lab ASPEN HYSYS	1	2			
ACADEMIC YEAR:	2023-2024	COURSE CODE:	CH064	60	70			
TERM:	VI	COURSE TEACHER:	Mr. S. S. Shinde	80				
Sr. NO.	CO	COURSE OUTCOMES	REVISED BLOOM'S LEVEL	TARGET FOR COs %	GA TARGETS ACHIEVED (%)	ESE TARGETS ACHIEVED (%)	Average of Assignments (%)	ATTAINMENT LEVEL
1	CO1	Build a python program for handling syntax and semantics.	Level 3	60		48.00	48.00	0.00
2	CO2	Demonstrate proficiency in handling data structures useful in Data Science	Level 3	60		64.00	64.00	140
3	CO3	Apply the different methods of data computations on real time data	Level 3	60	91.00	79.00	83.80	3.00
4	CO4	Interpret the different methods of data manipulation on real time data	Level 3	60	91.00	48.00	65.20	152
5	CO5	Apply data visualization for real time data	Level 3	60	83.00	64.00	71.60	2.16
6	CO6	Apply basic techniques of data science.	Level 3	60	83.00	79.00	80.60	3.00
<b>Average</b>				60	87.00	63.67	68.87	185

Program Outcome Attainment																
Course Outcomes	PO's												PSO's			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	
CO1	1.97	1.57	1.04	1.04	0.52	1.04	0.52	0.92	0.52	0.52	0.52	0.92	1.04	0.52	0.5	
CO2	2.00	1.33	2.00	1.33	1.33	1.33	0.67		0.67	0.67	0.67	0.67	1.33	1.33	0.7	
CO3	1.34	1.56	1.56	1.56	1.56		0.78		0.78	0.03	0.78	0.78	0.78	0.78	1.8	
CO4	1.35	1.35	1.35	0.68	1.35	1.35	1.35		1.35	0.68	0.68	0.68	0.68	0.68	1.35	0.7
CO5	1.04	1.04	1.38	0.68	1.04		0.68	0.68	1.38	1.38	0.68	0.68	0.68	0.68	1.38	0.7
CO6	1.42	1.13	1.42	1.13	1.13	1.42	1.13	1.42	1.13	1.13	1.42	0.71	1.42		0.7	
AVERAGE	1.79	1.66	1.45	1.24	1.49	1.19	1.02	0.87	1.13	0.89	0.79	0.67	0.99	1.07	0.80	

Fig. 112. Sample copy of CO PO mapping

## 4 Conclusion

The student-centred learning framework known as "Outcome-Based Education" (OBE) is oriented on evaluating student performance using predetermined outcomes. The course should follow OBE then consider following like bloom's taxonomy, course description. Course objectives and course outcomes should be aligning with blooms taxonomy. The rough draft copy of syllabus was prepared and then it was approved by stakeholders like alumni, parents, students and industry. The concept test help faculty to understand each and every student as slow and fast learner student. It will help faculty to plan lecture and practical accordingly. For this course faculty have planned some extra lab sessions for weak student and ASPEN TECH user certified exam for bright student. Various assignments, quizzes and activities were also conducted. Course outcome assessment involves student feedback, course exit survey, CO PO mapping of subject. By considering all parameters there is improvement of each and every students result.

**Disclosure of Interests.** The authors have no competing interests to declare that are relevant to the content of this article.

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# Long-Term Impacts of Educational Technology: Professional Development, and Innovative Pedagogical Approaches

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**Abstract.** The integration of educational technology (EdTech) into academic settings has led to significant advancements in teaching and learning methodologies. This study explores the long-term impacts of EdTech on critical thinking, creativity, and lifelong learning skills. Additionally, it examines the role of professional development (PD) for educators, equity in access to technology, and the complexities of digital assessment implementation. Employing a mixed-methods approach, this research provides comprehensive insights into the sustained effects of EdTech, effective PD strategies, and challenges in achieving equitable access and reliable digital assessment.

**Keywords:** Educational Technology, Long-Term Impact, Professional Development, Digital Assessment, Critical Thinking, Creativity.

## 1 Introduction

The rapid adoption and substantial investment in educational technology (EdTech) have promised enhanced learning experiences and improved educational outcomes. However, there is a notable gap in understanding EdTech's long-term impact on student outcomes, specifically regarding critical thinking, creativity, and lifelong learning skills. This research addresses this gap by examining the sustained effects of EdTech beyond short-term gains, providing valuable insights into its role in fostering essential skills for the future.

This research also highlights the importance of exploring strategies to bridge these gaps and ensure equitable access to technology-enhanced learning environments. It focuses on a few of the assessment tools and strategies that leverage technology to provide timely and constructive feedback to students.

This research investigates adaptive technologies that cater to local educational needs.

## 2 Literature Review

Research on the long-term impacts of EdTech highlights its potential to transform educational experiences beyond immediate engagement. For instance, [1] Siemens (2005) discusses connectivism as a learning theory emphasizing the importance of digital technologies in knowledge construction. [2] Dede (2016) underscores the need for strategic

and thoughtful integration of technology to foster critical thinking and creativity, which are essential for lifelong learning. [3] Constructivism, as posited by Vygotsky (1978), asserts that learners construct knowledge through active engagement with their environment. According to theory proposed by Deci and Ryan (2000), the use of personalized and self-paced learning modules in EdTech, providing students with more control over their learning processes [4]. Adaptive learning technologies, highlighted by Johnson et al. (2016), use data analytics to tailor educational content to the individual learner's pace and needs, thus optimizing the learning experience [5]. Collaborative learning, facilitated by digital platforms, allows for the development of critical thinking and communication skills through group work and peer-to-peer interaction [6]. The SAMR model (Puentedura, 2006) outlines four levels of technology integration: Substitution, Augmentation, Modification, and Redefinition. This framework helps educators progress from using technology as a direct substitute for traditional methods to leveraging it for transformative teaching practices [7]. Effective PD programs are those that are ongoing, collaborative, and closely aligned with teachers' day-to-day practices [8] (Dertling et al. (2011)).

### **3 Methodology**

This study employs a mixed-methods approach, combining quantitative surveys and qualitative discussions and observations to provide a comprehensive analysis of the issues at hand. The quantitative component includes real time assessment data analysis of engineering first year students of last academic year 2023-2024. The teacher feedback and session feedback regarding the effective implementation of teaching pedagogy was taken from students' time to time. These included questions designed to measure the professional development of a teacher as well as critical thinking and creativity among students over time.

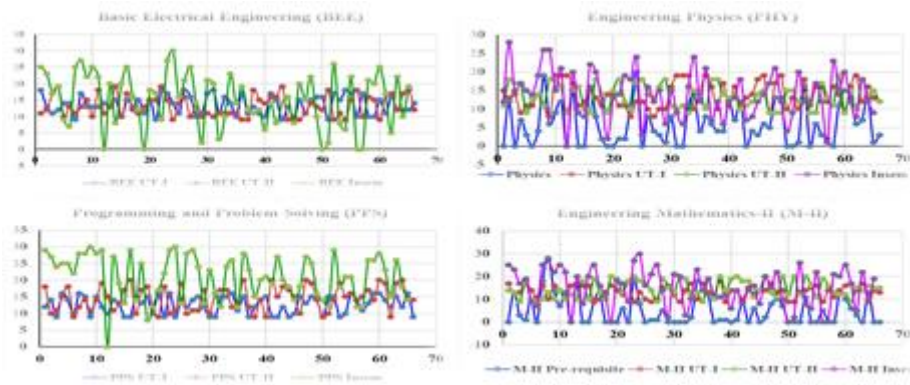
The qualitative component involves continuous assessment of student by using project-based learning, one of the effective pedagogies.

### **4 Results Analysis**

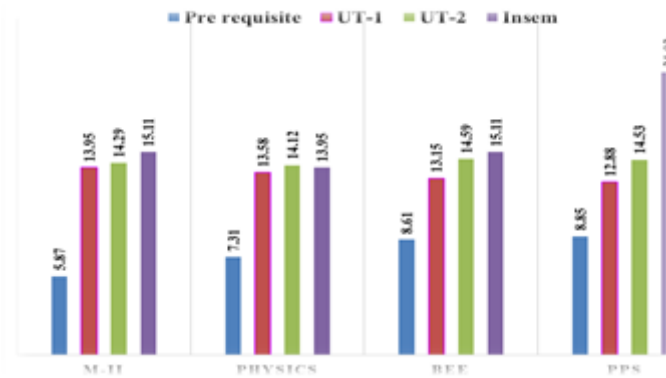
The quantitative data reveals that EdTech significantly improves immediate student engagement and academic performance. However, its impact on the development of critical thinking and creativity varies across different educational contexts. The study finds that students exposed to EdTech consistently over time show better development in critical thinking and problem-solving skills compared to those with intermittent exposure.

The prerequisite test has been conducted at the entry of students in first year engineering, based on this prerequisite test slow and advanced learner students were identified. Special lectures for the slow learners were arranged which included a variety of teaching tools like nptel videos, Matlab, Octave, Geogebra etc. It is observed that students found the course more interesting, so the class engagement of students increased. This can be observed in the test conducted during the teaching term. Figure 1 depicts

progress in the outcome in terms of result for the individual subject. In Table 1 the overall performance of the students in a class has been shown. Blue color bar represents the average marks scored by the students in a class for individual subject, likely red color shows unit test one, green color shows unit test 2 whereas violet color indicates the average marks scored by the students in the in semester (Insem) exam conducted by university. From the graph, gradual improve-ment in the result can be clearly observed.



**Fig. 1.** Subject wise analysis of student’s performance



**Fig. 2.** Overall average analysis of student’s performance.

The implementation of innovative pedagogical approaches, such as project-based learning (PBL) was found to be very practical approach of pedagogy to train the students to face real world problems. As part of curriculum PBL has been conducted during the last year. Batches of 20 students were formed in which 5 to 6 students were present in each group. One project was assigned to each group. Teacher was assigned as facilitator to every batch. Students were having choice for choosing the topic of the project. Students could also take suggestions from the facilitator to finalize the topic of project.

Initially students were wondering about the basic concepts involved in project and its execution. But at the end of the teaching term students found to very confident about the concepts and overall understanding of the projects. This can be witnessed by observing the continuous evaluation reports of the students. It can be observed that the marks of the students are low. Whereas the second evaluation of projects of the same class has been improved. Improvement in the performance of the students can easily be witnessed by comparing the marks obtained by students in first and second evaluations.

This adaptive learning pedagogy found to be effective in personalizing the learning experience, catering to individual student needs and pacing. Also help to enhance the ability of critical thinking, creativity, and lifelong learning skills.

## 5 Conclusion

This research provides insights into the long-term impacts of EdTech, emphasizing the importance of continuous PD. The study highlights the need for a new approach to EdTech integration, considering the diverse needs and contexts of learners and educators. By addressing these areas, the research contributes to an understanding of how to leverage EdTech effectively in educational settings.

**Acknowledgments.** I am grateful to the institute for providing support and facilities for this research.

**Disclosure of Interests.** The authors have no competing interests to declare that are relevant to the content of this article.

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# Workshops

International Conference on  
Technology 4 Education,  
T4E 2024 Gandhinagar, India,

December 6–8, 2024

ETSy Proceedings



# Navigating the Ethical Landscape of AI in Education: Challenges and Solution

Daevesh Singh, Navneet Kaur, & Shitanshu Mishra

UNESCO, India

**Abstract.** The integration of Artificial Intelligence (AI) into education has transformed education by offering Personalized Adaptive Learning Systems that provide personalized learning experiences to learners, tools to automate grading to enhance efficiency of teachers, and assist administrators with predictive analytics for admissions and course scheduling. However, it also presents significant ethical challenges that must be navigated to ensure equitable and effective use. This workshop delves into the purpose of AI in education, emphasizing a humanistic and flourishing-centric approach aimed at making AI in education more learner-centric. Additionally, we will examine the critical role of data in AIED, including the types of learner data and the challenges surrounding data including ownership, interpretation, privacy, and legal compliance, etc. We will also explore the concept of Data Commons (DC) as a potential framework to address these challenges, discussing its purpose, governing structure, and the principles that inform it. Through this we aim to guide educators, policymakers, and developers in the responsible deployment of AI technologies in educational settings. By fostering a dialogue on ethical considerations, we seek to empower stakeholders to harness AI's benefits while safeguarding the rights and equity of all learners.

# Crafting Engaging eLearning Experiences — from Concept to Completion

Varsha Kumar, Manish Dhawan, & Siddhant Salve

FLAME University, Pune, India

**Abstract.** In today's digital learning landscape, creating effective and engaging eLearning experiences is critical for educators. This hands-on workshop, "Crafting Engaging eLearning Experiences: From Concept to Completion," aims to provide participants with a comprehensive understanding of the instructional design process, including course development strategies, content creation techniques, and best practices for using eLearning authoring tools. By the end of the workshop, participants will have the skills and confidence to create compelling and interactive eLearning modules that improve learner engagement and knowledge retention.

# Facilitating Failure-driven Sensemaking in Classrooms

Tanmay Sinha

National Institute of Education, Nanyang Technological University, Singapore

**Abstract.** Can learning be enriched by embracing failure? Many educational systems shy away from failure-driven learning, emphasizing instruction-first methods. Yet, learning from failure cultivates resilience and adaptability. Drawing on empirical evidence, this workshop will (i) introduce participants to a suite of sensemaking-focused pedagogies for intentionally introducing failure moments into students' learning, (ii) offer guidelines on how to implement these pedagogies with high fidelity in classrooms, (iii) provide hands-on opportunities for codesigning lesson plans following these guidelines, and finally (iv) provoke reflection on why and when such pedagogies work and fail.

## Student Question-Driven Learning - an Active Learning Strategy Workshop

Sumitra Sadhukhan, Spruha Satavlekar

Indian Institute of Technology Bombay, Mumbai, India.

**Abstract.** Student-Question Driven Learning (SQDL) is a teaching-learning strategy designed to motivate students to engage in question-posing activities while learning a new concept. This workshop is a hands-on practice of SQDL strategy, designed for educators, to experience the orchestration of SQDL. As the content of this workshop, we will be training participants on “Everyday Computational Thinking (Everyday CT)”, the concept of empowering individuals living in the ubiquitous computing world to optimise their day-to-day lives with the help of computational thinking situated in their everyday lives. The training will be orchestrated with the help of the SQDL learning strategy on a question-posing platform developed by the researcher (workshop proposer) at IIT Bombay. The experience of interaction with the SQDL learning strategy as a teacher will enhance the teaching-learning skills that will motivate the teachers to explore and apply this strategy in their classrooms. The experience of gaining knowledge on Everyday Computational Thinking as a learner will enhance their understanding of the concept.

# DIY Smartphone-Based Experiments in Physics and Engineering

Aakash Dewangan, Abhilash Patel, Deepak Ghavari, Parth Joshi, Subodh Bhosale, Sumanta Kumar Dutta, and V. Kartik

**Abstract.** Traditional classroom teaching typically relies on aural and visual methods to convey theoretical concepts, while laboratory experiments focus on using standard equipment and tools. However, a real-time blend of theory and experimentation is often missing from these conventional methods. This workshop aims to demonstrate the use of smartphone sensors for teaching and learning physics concepts through hands-on experiences. By introducing instructors and students to smartphone-based sensing and analysis tools, this approach bridges the gap between classroom teaching and laboratory experimentation. It also provides a platform to the students for kinesthetic learning. Additionally, these tools support project-based learning, making them valuable for students from higher secondary to postgraduate levels.

# Exploring Generative AI in Education: Potentials and Challenges in Design, Enactment, and Reflection Phases

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**Abstract.** The integration of Generative AI (GAI) into education is an emerging trend, offering numerous opportunities and challenges across various phases of the teaching and learning process. This hands-on workshop is designed for educators, researchers, students, and professionals working at the intersection of technology and education. Participants will explore the potential of GAI in three critical phases of formal learning sessions—design, enactment, and reflection—through collaborative discussions and activities. The workshop will follow a structured, interactive format, allowing participants to engage in group-based brainstorming, SWOT analysis, and idea sharing to better understand how GAI can enhance learning outcomes, teaching practices, and reflection processes.

# Computational Thinking Pedagogy using Tangible Notional Machines

Uday Nath Gunda, Swaroop Joshi, Arun Raman

BITS Pilani, Goa Campus

**Abstract.** The development of lowtech-edtech is crucial for enhancing the access, scale and sustainability of computing education initiatives in India. The proposed workshop intends to give a hands-on experience to participants on developing, critically examining and using tangible lowtech pedagogical tools for teaching computational thinking at-scale. Specifically, the workshop will focus on a notional machine that abstracts a computer as an agent reading from and writing to a memory. We will start by brainstorming the requirements/specifications for such a tangible NM to be an effective pedagogical tool, then use and critique a physical prototype and finally develop lesson plans that incorporate the prototype.

## Applying Epistemic Network Analysis and Ordered Network Analysis in TEL Research

Debarshi Nath, Amit Paikrao, Ramkumar Rajendran, Jyoti Shaha, Kabyashree Khanikar  
Indian Institute of Technology Bombay, India

**Abstract.** Epistemic Network Analysis (ENA) is a new approach for identifying and quantifying relationships among elements in coded data, such as chat interactions among learners in digital learning systems. It visualises these relationships through dynamic network models, which can depict the structure of relationships, the strength of associations, and track changes in them over time. ENA allows for visual and statistical comparisons of these networks. This method has proven to be valuable for investigating a variety of qualitative and quantitative research questions where meaningful patterns of association are suspected, such as discourse analysis, collaborative problem-solving, programming tasks and in eye-tracking studies. This workshop aims to provide a comprehensive tutorial on ENA, covering its conceptual foundations, how to visually and statistically assess them and offering hands-on exercises with actual educational data. We also introduce Ordered Network Analysis (ONA), an advanced approach derived from ENA which is particularly useful for modelling temporal dynamics in the data.

# Tools and Product Demos

International Conference on  
Technology 4 Education,  
T4E 2024 Gandhinagar, India,

December 6–8, 2024

ETSy Proceedings

# Design and Development of a Pocket Glossary App on Select Literary Terms for English Language Learners at Graduate Level

Greeshma Raveendran, Divya. C. Senan and Geetha Janet Vitus

Department of Education, University of Kerala, Karyavattom, Kerala, India

**Abstract.** This paper presents the design and development of a mobile application that aims at enhancing graduate-level English language learners' understanding and appreciation of literary terms. Drawing inspiration from M.H. Abrams' "Glossary of Literary Terms," the app integrates the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) and a human-centered design thinking approach. It features explainer videos, a glossary with definitions and pronunciations, related readings, teacher connectivity, outcome-based tasks, progress tracking, learning evaluations, and a unique "teach-back" function named "flipping the teacher." The app is designed to create an immersive learning environment and to support the specific needs of English language learners, aiming to foster literary comprehension and self-directed learning.

**Keywords:** Instructional Design, Empathy-Driven Insights, Learning Outcome Evaluation, Dynamic Learning Environment, Self-Directed Learning, Literary Appreciation

## 1 Introduction

Mastering the subtleties of the English language is essential for graduate students, particularly for effective literary appreciation and interpretation. Literary terms play a vital role in this process; yet many students struggle with these concepts, undermining their confidence in engaging with literature. The proposed "Pocket Glossary App on Select Literary Terms" (PGASLT) seeks to enrich the understanding and appreciation of literature for graduate-level learners. The paper details the app's design and development, emphasizing its capacity to meet the educational demands of this demographic.

## 2 Design and Development

The PGASLT was developed through the ADDIE model, providing a comprehensive framework for instructional design. The integration of design thinking principles ensures that user needs are prioritized throughout the development process. The app's key features include collection of explainer videos (engaging visuals that succinctly explain

each literary term), glossary with meanings and pronunciations (an authoritative glossary offering clear definitions and audio pronunciations), related reading materials (curated passages from literature that exemplify each term), teacher connect (a networking feature allowing users to communicate with educators for guidance), outcome-based tasks (interactive assessments to evaluate users' understanding of literary concepts), progress tracking (tools that allow users to monitor their learning journey and receive feedback), learning evaluation tests to assess comprehension of literary terms), flipping the teacher (a unique option for users to record themselves defining literary terms, enhancing comprehension through self-teaching).

### **3 Methodology**

The initial design stage used focus group discussions, interviews, and document analyses of related literature. Data collected from these methods were used to generate word clouds and conduct a thematic analysis with the Speak.ai tool, organizing codes into themes that informed the initial paper prototype. Cluster sampling was employed to select and gather data from the study sample during implementation. The following steps guided the app's development, incorporating the principles of Design Thinking and the ADDIE Model (Analysis, Design, Development, Implementation, and Evaluation):

1. Identifying literary terms: A literature review was conducted to determine the most relevant literary concepts for inclusion in the app.
2. User profiling: Surveys collected data on English language learners' needs and preferences.
3. Design prototyping: Prototypes were created based on user feedback and insights.
4. Testing and evaluation: The app prototype was tested with a small group of users to pinpoint potential improvements.

### **4 Expected Outcomes**

This educational app is anticipated to significantly enhance English language learners' comprehension and retention of literary concepts, while also improving their analytical and interpretative skills. The immersive features of the app promote self-directed learning, encouraging learners to engage critically with literary texts.

### **5 Conclusion**

The design and functionality of the app provide a dynamic and engaging learning environment that supports self-directed learning. The ongoing research will be critical in evaluating the app's effectiveness and understanding its potential impact on English language learners' literary appreciation skills.

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# GaMINLab – Using content gamification to cognitively engage learners in science inquiry practices through simulation-based labs

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**Abstract.** Practical labs, an integral part of the science curriculum, are expected to help learners to do science. Ideally the learners should involve in various science inquiry practices to ‘do science’ as a scientist would during the practical lab activities. In recent years, the use of simulation-based labs which facilitate doing practical labs online, has extensively emerged. The relative advantage of such labs is facilitating learners do virtual experiments anytime, anywhere and any number of times with affordances that illustrate concepts beyond the boundaries of traditional labs. Depending on support and potential for doing inquiry labs, wide range of simulation-based labs are available, ranging from low potential labs to high potential inquiry-based simulation labs. Though sophisticated simulation-based inquiry labs are available, literature and empirical studies report issues such low motivation and cognitive engagement in such labs and related tasks. This happens as learners may find complex situations, difficult problems and intangible concepts difficult to comprehend, face steep learning curve while using online lab, etc [1]. This leads to dropout from activity or not engaging as intended in the lab activities.

Our system, GaMINLab (Gamification (Meaningful) in Inquiry Lab) aims to cognitively engage learners in science inquiry tasks through simulation-based labs. Gamification is one of established approach to nurture student engagement and makes use of game attributes to drive game-like player behavior in a non-game context. GaMINLab incorporates content gamification approach, which involves application of game elements and mechanics to alter content and to make it game like. Content gamification design features in GaMINLab include a) Open ended problem with a storyline posed as challenge along with mystery questions – this aims to kindle curiosity and engage learner in playful exploration b) Avatars to encourage learner to assume role of scientist in inquiry tasks c) Meaningful badges and Progression indicators like stars, points, flags during inquiry tasks to help learners get tangible indicators of accomplishments, progression, behaviors d) Mascot providing prompts/scaffolds to conduct inquiry tasks and produce related artifacts. Currently inquiry tasks supported are a) planning and carrying out investigations b) analyzing and interpreting data c) engaging in argument from evidence d) obtaining, evaluating and communication data.

GaMINLab system is ready with two labs, two problems of different scenario in an integrated learning environment. More labs and problems are being added. Studies are being conducted with CBSE class VIII/IX students for design validation. GaMINlab is built around OLabs simulations with support for inquiry tasks. Online Labs (OLabs) [2] for school lab experiments is a significant initiative by Indian government to supplement physical labs and is aligned to CBSE curriculum. Currently it is being used widely by thousands of CBSE schools all over India with over 4 Lakh users.

Currently GaMINLab is built with h5P interactive activities in Moodle and OLabs simulations are integrated in it (See Fig. 1). The GaMINLab intervention can potentially be used by students and teachers of CBSE schools who have been currently using OLabs. It can be used in use-cases such as a post-lab activity, home-work activity, pre- lab activity, etc. It can also be used in instruction delivered using active learning strategy.



**Fig. 1.** GaMINLab - Plan Investigation Task

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# Building Blocks - The Mathematics Learning App Gamified Mathematics Pedagogy

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**Abstract.** Building Blocks (BB) is a set of 400+ interactive Math learning games developed by Akshara Foundation for all children in grades 1 to 8 (age group 5 to 14). It is a FREE product aimed at providing a supplemental self-exploratory tool for all children, but specially focused on children from low-income families to learn joyfully at home at the child's pace in her space. BB is a key edtech constituent of our holistic Math program, Ganitha Kalika Andolana (GKA, translating to "Math Learning Movement").

## 1 Introduction

BB is available as a Math learning App on Google Play Store as well as individual games uploaded on DIKSHA and linked to several Indian states' "Energized Textbooks (ETBs)". ETBs are textbooks with QR Codes in each chapter, which when scanned leads the child to free curated content on DIKSHA. The games are mapped to the syllabus as per the National Curriculum Framework. Currently, it is available to all children in English and 8 Indian languages. BB runs both offline and online and on low-cost smartphones, the fastest growing segment of devices. BB is also deployed as .apk fully packages via Akshara's website <https://akshara.org.in/en/learning-app/>

ETBs/DIKSHA is the primary mode of deployment for Building Blocks games. Currently, BB games are linked to 10 state ETBs which have distributed over 33 million ETBs to children in government schools in their respective states.

## 2 Problems being addressed

<sup>¾</sup> Children in government schools and low budget schools in India get less than 3 hours of Mathematics instruction in the classroom per week.

<sup>¾</sup> Teachers by and large use the "blackboard and chalk" approach to teach Mathematics. The National Education Policy 2020 also talks about the need to "gamify" learning in order to spark curiosity in the child and invite her to explore and learn.

<sup>¾</sup> Children in these schools have no exposure to any edtech product that kindles the child's natural curiosity and urge to learn and explore Math.

¾ At home, there is no learning environment nor support from parents or other adults who are either uneducated themselves or unavailable to lend support.

¾ Edtech worldwide has been limited to tools and content for those with choice and access. Edtech has found little relevance in remote, rural villages with often no access to power, internet and where families have no fee-paying capacity.

¾ BB seeks to provide the “bottom of the pyramid child” exposure to Math learning at her pace in her space, her home.

### **3 Who does BB serve?**

BB serves to deliver quality math games especially to children in government schools in remote village communities so that they can claim digital awareness and literacy and harvest it to learn and progress. BB serves all children in the age bracket 5 to 13 (grades 1 to 8) estimated to be over 180 million children in India. However, our focus is on all children in government schools and low budget schools (estimated number 120 million as per UDISE 2021-22) who have ready access to ETBs through the State.

### **4 BB’s Key features**

BB was conceived as a supplemental tool to provide the children (typically from government schools) access to joyful Math learning at home. Some of BB’s key features are:

- As a FREE gamified Math learning app of games for grades 1 to 8, BB is a unique social edtech innovation. Its features include:
  - Fun, interactive and intuitive to use.
  - Relevant to the child's context - with daily life examples, concepts explained through stories/games.
  - Has progress tracker, visual gamification, animation to explain concepts.
  - Works on basic entry-level Android smartphones making it affordable on the fastest growing segment in smartphones.
  - Works on-line and offline.
  - Mapped to grade-wise syllabus
  - Large selection of games in PRACTICE mode (to reinforce concepts taught in class) and also games in CHALLENGE mode (to assess levels of learning, only in grades 1 to 5)
  - Available in 9 Languages – English, Hindi, Kannada, Odia, Gujarati, Marathi, Tamil, Telugu, Urdu - covering four-fifths of India’s children studying in vernacular medium schools
  - Designed using Open-Source tools and made available using a Creative Commons licensing format.

Set out below is a YouTube link to short videos on Building Blocks games:

[https://www.youtube.com/playlist?list=PLxWIHsIoCtrmJzaH\\_VM-FeJFYyw5VjXaO](https://www.youtube.com/playlist?list=PLxWIHsIoCtrmJzaH_VM-FeJFYyw5VjXaO)

## **5 Demonstrated Reach and Impact**

While learning cannot be traced back specifically to the impact of BB usage, as in any edtech solution, we find BB certainly enriches the enablement and joy of math learning in children. Over 5.5 million+ games have been played so far, 78% of these in various vernacular languages (implying usage by children in vernacular medium government schools or low-cost schools). As we continue to link BB game content to more state ETBs and as more states print and distribute ETBs, we expect BB usage to ramp up manifold.

### **5.1 Certifications and Accolades:**

- 2019 - EdTechXGlobal Impact Award Finalists
- 2021- mEducation Alliance Awards - Numeracy and STEM Top 3 Nominee
- 2024 & 2025 - HundreED Global Collection
- 2024 - ICEIE (International Certification of Evidence of Impact in Education) - Bronze for Effectiveness and Equity

### **5.2 External Studies on efficacy of BB**

1. Edtech Tulna Report by IIT Mumbai / CSF (Jan 2023)
  - [Final Building Blocks Evaluation Report \(Grades 1-2\) \(akshara.org.in\)](https://akshara.org.in)
  - [Final Building Blocks Evaluation Report \(Grades 3-5\) \(akshara.org.in\)](https://akshara.org.in)
2. Sattva Consulting Impact Evaluation Study (Jan 2021)
  - [Akshara-IA\\_Designed-report\\_19th-June-compressed-1-1.pdf](#)

# **Inclusion of Gamification Elements in Virtual Lab to see its Effect on Users' Engagement**

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## **1 Introduction**

The increasing reliance on digital platforms for remote education has highlighted a critical challenge: maintaining student engagement in virtual learning environments. Virtual labs (VL), although effective for practical learning, often struggle to capture users' attention and sustain motivation. This Gamified Virtual Lab (GVL) developed for Simple Pendulum topic taught in class 9 of the CBSE board in India addresses this challenge by integrating gamification elements (GE), such as Levels, Visual cues, Storytelling, and Rewards, within a fully interactive virtual lab environment. This can be used as a standalone system or as an additional learning tool.

This demo will showcase how a physical lab topic is converted into a GVL and has embedded the GE to improve engagement. In the demo, attendees will experience the interface firsthand, and interact with various GE.

## **2 Gamified Virtual Lab**

The product is developed using Figma and is fully functional. The lab starts by introducing a ped-agent who would guide the user throughout the process. To make the user comfortable within the learning environment, four mind-pondering questions on the topic of motions is introduced. The lab is divided into four sections, Theory section, Procedure section, Simulation section, and Assessment section. In the theory section, the theory of the Simple Pendulum is explained in the form of text and graphical representations with visual cues. To make the user concentrate and not overwhelm them with lengthy content, it is divided into pages with appropriate natural pauses. In the next section, two ped-agents explain the lab procedure with appropriate graphical representations and visual cues pointing appropriate portion of the lab and masking the rest. In the Simulator section, the procedure is explained again by another ped-agent. The user needs to calculate the value of gravitational force on each Environment (Earth, Moon, and Mars) by varying variables like String length, Bob mass, and Swing Angle. They

are transported to the Moon and Mars along with another set of ped-agents in a spaceship. Coins are used to buy the required fuel. The users are assessed at the end of each section and a badge was provided on passing it. Hints are available against spending of coins. This would help users to clear the assessment. The fourth section assesses their understanding of the topic learned, here the hints are free. A certificate of completion was generated after the completion of the activity. By choice, the progression is kept in a sequence and can be accessed once. The color schemes, design of ped-agents, badges, and a certificate, and the interaction text were kept as per the users' age range.

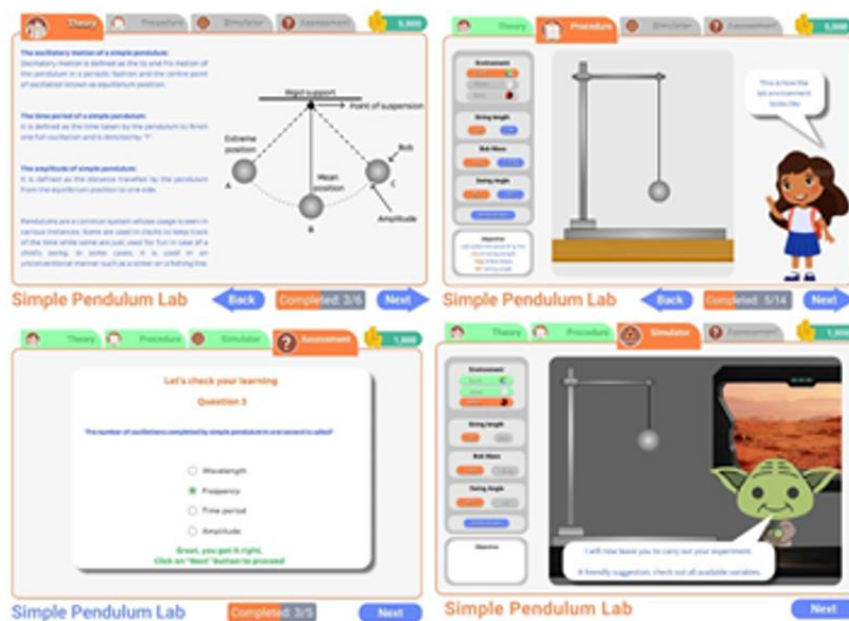


Fig. 1. Screenshots of sections (Clockwise): Theory, Procedure, Simulation and Assessment

### 3 Stakeholders

This product can be used by School teachers and EdTech researchers working in the domains of Gamification, Engagement, and Virtual Labs. Teachers can implement it as a part of their curriculum or treat it as additional learning material. Researchers can design studies to further understand the engagement level due to gamification. One can use this to generate awareness about Virtual Labs and its applications. In light of such requirements, there is a need to motivate users (teachers and students) to the usefulness of Virtual Labs in their day-to-day laboratory activities. When doing this, proper care should be taken that the users (students in particular) are motivated to use all facilities

and features a laboratory can provide by keeping them engaged till the learning objective is achieved.

# LA-ReflecT Dashboard: Scaffolding Reflection on Learning with Teacher Prompts & LLM Interactions

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**Abstract.** This demonstration highlights the dashboard of an e-learning platform, LA-ReflecT. Teachers can author micro-learning activities in LA-ReflecT. The data collected while the students attempt the activity is presented in a dashboard, which they can see just after completing the task. To reflect on learning based on that data, the teacher can also author activity-specific reflection prompts. This specific demonstration integrated an LLM module, which calls an interactive chatbot for the students to support making the dashboard data.

**Keywords:** Learning Dashboard, Reflection on learning, Self-Regulated Learning, LA-reflecT, Reflection prompts, LLM

## 1 Reflection on Learning with Learning Analytics

Learning Dashboards are often used in the e-learning context to support learner's regulation in learning and teacher noticing while orchestrating educational activities. However, the design of a dashboard mostly focuses on the presentation of the learning traces, the processed log which is captured in the platform and does not prioritize sense-making of that information by the users. While researchers have studied sense-making process of the end-users of some of dashboards, gap still remains to incorporate scaffolds to support dashboard sense-making. One of the challenges is how to align the particular learning context and identify the reflection points corresponding to the information the dashboard provides to the end users. With varying learning tasks, the aspect to reflect on might vary. One way to incorporate that knowledge for the user is to be able to author the learning activity explicitly and having a provision to include scaffolding in the dashboard. However, we have not come across any reflection scaffold that is designed in the existing dashboards.

In this work we present the LA-ReflecT [1-4], a microlearning environment with analytics enabled infrastructure which enables teachers and learners engage in data-informed reflection on their practices.

## 2 Reflection prompt and LLM integration in LA-ReflecT

Teachers can use LA-ReflecT as an external tool integrating it with their own LMS through the LTI protocol. They can author multimedia micro learning activities and publish it in their course (examples [5,6]). The learner can attempt the tasks in the activity and the learning design navigates them to a learning analytics dashboard immediately after attempting a task for reflecting on the learning episode. To support the reflection there are two affordances that is designed at this stage. First, the teacher can directly add reflection prompts during the authoring phase of the learning task itself. The learners can see those prompts along with the information presented in the dashboard to reflect on their learning process during the task. Secondly, teachers can add an explainability function that connects to a large language model (LLM), and open up an interactive chatbot that the learner can interact with corresponding to a particular learning task. This tool demo provides a hands-on experience of the LA-ReflecT system and demonstrates the authoring function of the learning activity and reflection prompt. Then switching to a learner role, the participants can explore the explainability chatbot in the learning dashboard. The demo opens up discussions related to the affordances for learning dashboard explainability that focuses on learner reflection, design of reflection prompts and prompting strategies to incorporate LLMs.

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# ‘Engineering’ Quality Assignments – Seven Principles to Frame Assignments which lead to Holistic Learning

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**Abstract.** Engineering education requires a balance of theoretical knowledge and practical application, but traditional assignments often lack the necessary focus to fully engage students. Continuous assessments, however, offer several advantages, such as reinforcing learned concepts, reducing the emphasis on final exams, and fostering skills like problem-solving and critical thinking. In this paper, we proposed a model of a seven-step approach to the assignment, inspired by well-established taxonomies of Revised Bloom’s approach and Dee Fink’s approach, which has emerged from the desire to make every assignment meaningful and outcome-oriented.

**Keywords:** Quality Assignment, Revised Bloom's Taxonomy , Dee Fink’s Taxonomy.

## 1 Introduction

Engineering studies often require various skills, from theoretical knowledge to practical application. The traditional approach to writing and submitting assignments was found to have certain shortcomings, with a focused approach missing. In professional engineering, tasks often require iterative work and self-assessment. Some advantages of continuous and frequent assessments are that they help reinforce the concepts learned in class, ensuring that students retain the material over time rather than making the evaluation end semester heavy. Exploration of technical concepts, problem-solving and critical thinking abilities, skill development leading to ideation and inculcating an attitude towards learning are some observations related to students completing assignments. Continuous assessment also helps identify areas where students may be struggling, enabling timely interventions and support to address these issues. Regular assessments provide ongoing feedback to students on their performance, helping them understand their strengths and areas for improvement. It also allows instructors to adjust their teaching methods based on student performance and understanding. Overall, continuous evaluation provides a more comprehensive and effective means of assessing student learning and development, making it a significant component of engineering education.

This study explores the impact of learning, which happens through assignments given, and the process of continuous assessment of Engineering students at Vidyalkar Institute of Technology. The Institute has created a combination of class assignments and home study assignments (individual and collaborative) for all courses to reinforce technical concepts through assignments. Meticulous follow-up ensures a continuous flow of assigning work, receiving submitted work, assessment, and evaluation, and a closed loop of sharing feedback with the learners to discuss their performance. In this paper, we proposed a model of a seven-step framework to the assignment, inspired by well-established taxonomies of Revised Bloom's approach and Dee Fink's approach, which has emerged from the desire to make every assignment meaningful and outcome-oriented.

### **1.1 Research Gaps Identified**

Some gaps identified in this learning process are that not all assignments may be application-based, considering time constraints, and not using the latest tools could be another issue. They may not go beyond the boundaries of the prescribed syllabus. During team formation students may tend to form teams based on their comfort level with other team members, rather than selecting team members on the basis of their respective individual competencies. When it comes to assignments, students may tend to take shortcuts to replicate other students' work, but this could be an opportunity to instill ethics and professionalism among students and help them see the bigger picture so that they understand that, eventually, their learning work will benefit them and others in the long run.

Revised Bloom's Taxonomy is an updated version of the original Bloom's Taxonomy, which was introduced by Benjamin Bloom and colleagues in 1956 [1]. The revised version [2], developed in 2001 by Anderson and Krathwohl, reorganizes and redefines the cognitive processes involved in learning. Educators can use revised Bloom's Taxonomy to design assignments and create learning objectives targeting different cognitive complexity levels. It also helps develop assessments that test the learners' recall application, analysis, and creativity. The revised version uses verbs, making it more action-oriented. Some of the limitations of Revised Bloom's Taxonomy are that, as the structure is pyramidal, hierarchical learning may take place. It isn't easy to adapt it to diverse learning styles as it is a static model with more focus on the Cognitive Domain and relatively less emphasis on developing the Psychomotor Domain (Hands-on learning) and the Affective Domain (Emotional Quotient and attitude). Some assessments may be subjective.

Dee Fink's Taxonomy of Significant Learning is a model developed by Dr. L. Dee Fink in 2003 to enhance the quality of learning experiences [3]. Unlike Bloom's Taxonomy, which focuses primarily on cognitive domains, Fink's taxonomy has a more holistic approach, considers a broader spectrum of learning outcomes and is especially useful in designing assignments that promote holistic and meaningful learning experiences.

Fink's taxonomy identifies six interrelated categories of significant learning. Dee Fink's taxonomy focuses on making connections between ideas, people, and realms of

life. This approach encourages interdisciplinary learning and the ability to see relationships among different topics and fields. It includes personal and social awareness, interpersonal skills, and the capacity for self-reflection and empathy, meaning significant learning occurs when multiple categories are engaged simultaneously. Dee Fink's taxonomy encourages students to become autonomous and independent learners. Implementing this taxonomy can lead to designing assignments by determining significant learning in a particular context and then planning activities and assessments to achieve the desired outcomes. However, on the flip side, some of Dee Fink's taxonomy's limitations include the challenge of designing technical assignments, as there is an overemphasis on holistic development. The assessment is also complex, and it is challenging to integrate it within the existing framework.

The proposed Research Question is: Can the quality of an assignment be verified using a proposed framework, which includes specific criteria based on expected learning outcomes, and will this help in effectively enhancing the learning experience?

## **2 Proposed Framework**

Taking insights from Revised Bloom's Taxonomy and Dee Fink's taxonomy of significant learning, we are proposing a seven-point framework to check if every assignment is meaningfully given so that it contributes to the overall learning process. This framework is intended to be a practical tool for teachers to design quality assignments. Each item on the framework represents an actionable criterion for the assignment design so that the expected learning outcomes are achieved. The proposed framework evaluates whether the assignments give learners the following abilities:

1. Does it allow a learner to find applications in another field or cross-field?
2. Does it allow a learner to find advanced, alternative software tools and hardware/technologies?
3. Does it allow a learner to encourage contributions to open source or respective societies/professional bodies?
4. Does it allow a learner to compare existing work and identify the gaps?
5. Does it allow a learner to find the difference between Theoretical and Practical Solution(s)?
6. Does it allow a learner to collaborate, work in teams and engage in self-learning?
7. Does it allow a learner to explore ethical and professional practices?

Depending on the technical requirements, Advanced Tools/Hardware or Alternate Solutions/Designs may need to be further explored. Defined strategies could be drawn up that will help achieve the desired outcomes. A nontraditional outlook towards problem-solving could be developed to encourage creativity and unconventional thinking. The assignment may be converted to technical problem statements, and students can be asked to develop theoretical and practical solutions. Group projects and collaborative assignments in continuous evaluation promote teamwork and communication skills, which are essential in engineering.

This framework not only integrates the concepts of well-established taxonomies such as Revised Bloom's Taxonomy and Dee Fink's taxonomy, but also attempts to address some of their limitations. For instance, instead of a pyramidal structure wherein in an assignment only a few levels of learning are assessed, whereas through the implementation of the proposed framework, elements of understanding, application, analysis, collaboration can all be a part of the same assignment. It attempts to achieve a more holistic level of learning through an integrated and interdisciplinary approach in engineering and technical assignments.

## 2.1 Experiences with Implementation

This model was successfully implemented in a few PG Courses: Design Thinking (July to December 2023), Biz Lab for 127 students (January to July 2024), and 27 M. Tech. Students (January to July 2024) for the course on Intellectual Property Rights.

The proposed model has been implemented as a pilot run while conducting the assignments of three courses at the postgraduate level (M.M.S. and M. Tech.) It can be extended to include B.Tech. Students and other allied domains

Verbal feedback from students has been taken regarding what they learned from implementing the proposed model, and overall, they have shared positive reviews of their learning experience. In the near future, the researchers intend to take the proposed model ahead on a larger scale. More structured feedback can be taken, analyzed, and researched further, as the proposed model is still being developed. Various technical academic institutions can take up this model to enhance the quality of assignments and make learning a more meaningful experience.

## 3 Conclusions

Continuous evaluation prepares students for real-world situations where ongoing review and improvement are critical. The proposed model of a seven-step approach to assignment, inspired by well-established taxonomies of Revised Bloom's approach and Dee Fink's approach, has emerged from the desire to make every assignment meaningful and outcome-oriented.

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# A Study on Tele-collaborated Project Based Learning for Designing of Career Maps

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**Abstract.** Scientific method of choosing career options plays an important role to design successful Career Maps of the students. A holistic approach in this aspect with Psychological Test, Career Aptitude Test, Employability Test with use of appropriate "Information and Communication Technology (ICT) tools is found useful in this practice-based study. Related resources made available in hybrid mode for Skill mapping, Re-skilling and Up-skilling that are found useful. A Project Based Learning (PBL) approach gave good insight to develop related skills among the career aspirants. A trained team of Career Counsellors with virtual mentoring from teaching community gave a directive role to help students for choosing Career options. Specific Information and Communication Technology Tools found useful to make tele-collaborative learning amongst the peers for effective feedback and also for smart process of career decision making. This practice has been tried out over the period of three decades with Career Test Models by the researchers.

**Keywords:** Career mapping, Skill maps, Career counseling, Career plan, Career aptitude

## 1 Introduction:

Career options widely available after Secondary School Certificate (SSC) and Higher Secondary School (HSC) are many times unknown to the students and parents. Selection of career options based upon the personality and behavioural factors and knowing self, plays a vital role to achieve educational settings and further to gain with successful career. From the study of Tupes, E., & Christal, R. [4], there are five fairly strong and recurrent factors emerged for personality factors; labelled as Surgency, Agreeableness, Dependability, Emotional Stability, and Culture. Psychological Test, Career Aptitude Test, Employability Test are the main components of designing the Career Plan. Structure of the career maps should be designed with Project Based Learning (PBL) for the related supportive skills to the chosen career path. Most of the students and parent are unaware of the scientific career mapping process. This is the main challenge that has

been addressed by the practitioners. This issue has been explored with the primary survey of the eighty SSC and HSC students of the Satara district. In general, to address this context, resources created for skills mapping, development of test for behavioural factors and knowing self, and a tool for understanding employability quotient. As an example from the study of Webb, T., Diamond-Wells, T., & Jeffs, D. [5] for nursing occupation, career mapping facilitates professional development of nurses by education specialists and nurse managers. On the basis of national Nursing Professional Development Scope and Standards, our education and professional development framework supports the organization's professional practice model and provides a foundation for the professional career map. It gives an insight for the supportive skills mapping for chosen occupation. Conceptual development of career mapping process has been provided through Google Classroom Platform and WhatsApp messenger Group. A team of Career Counsellors from teaching community provided the required resource inputs to the students who wish to plan their career using skill and career maps.

## **2 Evaluation Question(s):**

The research questions came out with the pilot survey are as follows:

1. Unawareness about various career options and related supportive skills.
2. Knowing self with behavioural factors was absent in relation with choosing Career options.
3. Concept of employability Quotient was absent.
4. Trends in advanced skills were known and not up to mark for skills mapping.
5. Process of Career Mapping and Career Plan was unknown.

## **3 Approach to address the challenge:**

In order to address the problems identified, researcher team created library of Career resources about various options in hybrid mode (Online and Offline) to create awareness about the various career options available for the study with various educational institutions. In order to know the self, "7-Point Career Aptitude Test" was developed by Tatpuje [2] that gives understanding of six personality traits, behavioural factors, employability quotient, aptitude towards career options. This test consists of seventy questions for the assessment with quotient of six behavioural factors and employability. It includes Emotional Intelligence, Openness, Neuroticism, Conscientiousness, Extraversion, Agreeableness, and employability. According to Chandrasekar, S., & Srinivasan, T. [1] there is a close association between personal characteristics like gender, age, community status, size of the family, number of graduates in the family, family income and his/her employability quotient. Career Aptitude Testing was taken with twenty questions with six-point scale covering one hundred twenty education sectors further classified into six categories. The career aspirants appeared for the 7-point career aptitude test. Employability quotient and quotients of six behavioural factors were

calculated to assess the personality factors. After knowing these quotients, expert online sessions were organised to design skills mapping, career mapping and further to make a career plan with PBL Methodology. Google Classroom, WhatsApp Messenger, Google Drive, Google Meet etc. were the tools used as per requirements. The integrated approach of the various technological tools is found useful for project based collaborative learning.

#### 4 Impact On Learning:

Students, teachers and parents gets empowered with these tools about choosing career options by scientific methods. All became able to plan career maps with supplementary mapping of the skills and understanding process of the reskills and upskills with the latest industrial trends. Choosing career option based upon the career aptitude gave good success in completion of the educational, vocational courses and thus to remain sustain in the changing industrial, corporate and other environments. Researcher team collected data after every five years of span to know the impact as shown in Table 1. As students choose their career option based upon their likings and personality factors, it gave the high successful rate of course completion as above the 88 percent over the period of all the five years. The results related to the percentage of students who did career mapping with skills and also their placing in the desired sectors is also encouraging.

**Table 1.** The impact on learning and placement in the relevant sectors.

Year	Percentage of Students successfully identified 1 <sup>st</sup> Class	Percentage of Students completed in Course	Percentage of students who did career mapping with skills	Percentage of students placed in the desired Sector
2023	98		87	72
2022	94		72	89
2021	97		91	79
2020	89		95	82
2019	91		83	89

The use of Google Classroom and shared Google Drive found useful for collaborative learning and related aspects to improve and modify their present designing of the career maps. Information exchange, mentoring and fruitful interactions were possible with Google Meet and collaboration through Google Slides. This experiment gave remarkable impact on the process of using of IT tools for the specified task and hence understanding real meaning of applied Google tools.

## 5 Community adoption and recommendations:

In last five years, researcher find increasing trend of attending virtual capacity development programs instead of programs in person. In rural areas, Psychological and Career Aptitude tests were done offline with availability of parents and teachers in person. Tests in regional Marathi language gave more impactful assessment of the aspirants to come in, the scientific process of career mapping, skills mapping and choosing career options for better future. Local Community Service Organisations (CSOs) were involved to arrange in-person camps of the Career Aptitude Tests and Counselling sessions. Involvement of local school level teachers played a role to understand the role of parents along with their financial investment in the education of their wards. It is highly recommended that the tools of assessment should be available in the regional language especially for the students of the marginal community. Online Platform like Google Classroom and other Google tools with WhatsApp Messenger found useful to get connected for tele-collaboration for designing Career Maps.

## 6 Conclusions

There is need of holistic approach with Psychological Test, Career Aptitude Test, Employability Test to choose the main stream of the education for successful career of the youths. Skill mapping, Reskilling and Upskilling trends are useful to design career plan for the specified duration of time slot. According to Mahakud, G. C. [3], the more scientific way of career choice usually follows aptitude test next to intelligence, personality and interest tests. As it is not quite possible to administer the entire above-mentioned tests, it can be possible to administer the aptitude test and intelligence test for a better career choice. A Project Based Learning (PBL) approach found useful to develop related skills among the career aspirants. A trained team of career counsellors from teaching community plays a directive role to help students and parents for choosing their career options. Various Information and Communication Technology Tools found useful to make tele-collaboration amongst peers for effective feedback and also for smart process of decision making.

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# Gamification elements in Virtual Lab and its effects

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**Abstract.** Students can connect their theoretical learning to a real-world activity in the laboratory sessions, making it a crucial element in the learning process. During the pandemic, this methodology was not feasible; hence, an alternate teaching method while students remained in their comfort was required. Virtual Laboratory was one of the solutions to overcome this challenge. Integrating gamification into educational contexts has shown promise in enhancing student engagement and learning outcomes. Hence, this research proposes developing a Gamified Virtual Lab for a school-level physics topic to explore its effect on users learning gain and engagement. A mixed-method approach consisting of Pre- and post-assessments can help in commenting on the learning gain and engagement can be measured using interaction logs, surveys, structured interviews, and a validated tool.

**Keywords:** Virtual laboratory, Gamification, Engagement, Learning gain, Human-Computer Interaction

## 1 Introduction

Many students perceive traditional lab courses as ineffective due to their boring nature, hence, schools need help with students to be motivated and engaged [1]. The primary challenges include factors like the Risk of accidents, Expensive equipment (primarily faced in the Indian context), and Overcrowded labs causing low motivation and engagement [2, 3] and the pandemic challenged the instructors on laboratory learning. To overcome this, instructors explored various methods to teach lab courses including Remote labs, Network applets, Virtual Reality labs, and Simulation-based labs. Virtual Laboratory (VL) a computer-based simulation learning environment that provides the ease and convenience of conducting experiments online by mimicking the physical laboratory procedure and features like animations, 3D views, and high-resolution graphics was one of the best solutions. Also, they are cheaper, faster, and non-risky. Hence, there is a need to motivate users (teachers and students) to use VL in their day-to-day activities and ensure students, in particular, are encouraged to use all the facilities and features provided [4].

Gamification is an effective way to boost motivation and engagement by encouraging different behaviors. It can enhance certain abilities by introducing objectives that give learning a purpose and engage students by optimizing learning [5]. To overcome

the issues of VL like No Real experience, working in isolation, Inadequate guidance, and variation from physical lab activities, gamification elements (GE) like Levels, Storytelling, Visual cues, and Rewards are introduced.

The Research Questions under consideration are:

RQ1 - “What effect do gamification elements have on users’ engagement in a Virtual Lab”

RQ1.1 - “Does the relationship between users’ engagement and gamification elements vary over educational stages”

RQ 1.2 - “Does the combination of color schemes and gamification elements affect engagement”

RQ2 - “What effect do gamification elements have on users’ learning gains in a Virtual Lab”

## **2 Gamified Simple Pendulum Virtual Lab**

A lab for 3D printing training was developed by Pai-Hsun Chen [6] which suggests GE enhances students’ motivation or engagement. F. Vahdatikhaki and team [7] developed a lab consisting of graphical representations in a 3D environment where the user can imitate the physical laboratory activities. M. Sanzana and team [8] used Labster as the base and created a storyline to provide lab instructions and important safety information. Labster a VL platform has been used by many researchers as a wrapper for their lab activities, using its affordances of interaction with 3D models, feedback mechanisms, and Visual and Interactive Design.

Based on the literature and the design principles, the proposed solution, gamified VL is developed in Figma by inclusion of gamification elements like Levels, Visual cues, Storytelling, and Rewards for Simple Pendulum topic taught to Class 9 students of CBSE Board in India. The screens are designed in consideration of Mayers’ Multimedia Design Principles [9] like Signaling, Contiguity, Segmenting, and Multimedia, and Normans’ principles like Making things visible, Getting the mapping right, clarifying what does what, and Designing for errors.

The lab is divided into the following four sections:

1. Theory Section: Theoretical content with graphical representations and video is provided in this section. The textual content is chunked for easy understanding and helps users concentrate and not get overwhelmed. A badge is provided after the assessment. Coins can be used to buy Hints. GE used – Progress bar, Coins, Badges, and one ped-agent (Storytelling).

2. Procedure Section: Ped-agent, explains the lab components and the procedure using visual cues to experiment. Again a Badge is provided on qualifying the assessment. GE used – Levels, Badges, visual cues, and two Ped-agents.

3. Simulation Section: Actual lab activity is performed here. GE used – Levels, Badges, visual cues, coins, and four Ped-agents.

4. Assessment Section: Five questions are used to check their understanding of the topic and their interpretation of the readings noted during the experiments. Here hints are free of cost. GE used – Badges, progress, and a certificate.

### 3 Proposed Methodology

Through this study, researchers can investigate the impact of gamification elements on users' learning gain and engagement within a learning environment for the Simple Pendulum topic taught to class 9 of the CBSE Board. A mixed-methods research design can be employed, combining quantitative and qualitative approaches to provide a holistic view of student engagement. The study should involve students of classes 8 to 10, and data can be collected through pre-post tests and interviews.

The study can be conducted in both, physical and online modes. The setup should include a desktop, a web camera to capture learners' facial expressions, voice recording hardware, screen recording software like OBS Studio, and the internet. For online users, Google Meet can be used as the platform. Pre-post tests can be designed using Google Forms.

Data can be collected in the form of pre-and post-tests to measure the learning gain. The pre-test can include their basic and demographic details, perception of VL, and questions to understand their current knowledge. User interaction data in the learning environment like, clicks, feature usages (hints, coins, and downloading badges), time spent, and learners' facial expressions will help understand engagement. All these can be further validated with retrospective interviews that help understand the effectiveness of the color schemes, the narration style, and the usage of GE. On analysis, one can comment if there is any variation in the effect of gamification elements on users' age.

### 4 Proposed Future work

This research aims to investigate the effect of gamification elements like Levels, Visual cues, Storytelling, and Rewards on users' learning gain and engagement. Researchers can develop a gamified virtual lab using the design presented here. Studies should be conducted, preferably one-on-one. To generalize the results, users and educational boards should be from across the country. In the end, one can prepare a guideline for the development of a virtual lab.

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# Leveraging Instructor Presence and Multilingual Communication to Enhance Peer Learning in MOOCs: The MahaSWAYAM Initiative

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**Abstract.** This study examines the MahaSWAYAM initiative, Maharashtra's state-level MOOC platform, focusing on the role of instructor presence and multilingual communication in enhancing peer learning and participation. Guided by the Learning-Centric Model (LCM), the program trained educators to create learner-centric MOOCs addressing accessibility barriers for non-English-speaking and rural learners. Quantitative and qualitative analyses revealed strong engagement, with an average course grade of 63.13% and 100% participation in at least two assessments. Multilingual live sessions and WhatsApp-based peer learning were key drivers of participation. While live interactions fostered a sense of community, discussion forum engagement remained low due to workload challenges. Overall, 95% of participants rated the course Outstanding or Excellent, underlining its impact on inclusive learning.

**Keywords:** Instructor Presence, Multilingual Communication, Peer Learning.

## 1 Introduction

The Government of Maharashtra, aligned with NEP 2020, is advancing digital learning through MahaSWAYAM, a state-level platform aimed at enhancing accessibility and quality in higher education. This initiative unifies public universities, including Mumbai, Pune, Kolhapur, and YCMOU, to create inclusive, learner-centric MOOCs, addressing gaps in the national Swayam platform. MahaSWAYAM leverages the Academic Bank of Credits (ABC) framework to provide online content, assessments, and forums tailored to diverse learners, overcoming geographical and language barriers. A flagship course, 'Designing Learner-Centric MOOCs' (LCM), trained 61 educators across Maharashtra to create MOOCs focused on Indian Knowledge Systems (IKS). A significant challenge was fostering collaboration in a multilingual setting (Marathi, Hindi, and English). This study investigates how instructor presence and multilingual communication can improve peer learning and engagement, offering a model for inclusive digital education to bridge accessibility gaps and empower educators statewide.

## **2 Literature Review and Significance of the study**

Various studies such as [1], [2], [3], and [4], demonstrate the effectiveness of the LCM model in fostering engagement through structured activities like LeDs, LbDs, LxIs, and LxTs. While global research emphasizes active learning and peer interaction, there is limited focus on regional initiatives in India. The MahaSWAYAM initiative addresses this gap by training educators to create culturally relevant, language-inclusive MOOCs for diverse and underserved learners. This study explores the role of regional language integration, instructor presence, and peer learning forums in enhancing engagement and completion rates, offering valuable insights for similar contexts in digital education.

## **3 Research Questions**

1. How does instructor presence impact learner engagement and peer learning in MahaSWAYAM's learner-centric MOOCs?
2. What role does multilingual communication play in enhancing completion rates and engagement for non-English-speaking learners in MahaSWAYAM MOOCs?
3. Which behavioral interventions, such as feedback mechanisms and peer interaction, are most effective in increasing engagement and completion rates in MahaSWAYAM MOOCs?

## **4 Research Methodology**

This study utilizes a mixed-methods approach, collecting data through Google form feedback, focus group discussions, and performance tracking of top-engaged learners selected via a K-point ranking system. Independent variables include instructor presence, multilingual support, and feedback mechanisms, while dependent variables include engagement levels, peer interaction, and completion rates. Pre-course surveys gauge educators' perceptions of MOOCs, while week 1 qualitative feedback prompts participants to create analogies based on course content on learner engagement. Post-course feedback captures the effects of various interventions, such as bilingual discussion forums, weekend quizzes reflective of forum discussions, graded quizzes, and weekly multilingual live sessions for real-time interaction with instructors and teaching associates.

## **5 Approach to address the challenge**

- **Pedagogical Strategies:** The course was structured around the Learner-Centric MOOC (LCM) model, incorporating weekly quizzes and a capstone project where participants developed MOOCs on Indian Knowledge Systems (IKS). The goal was to empower participants to create their own MOOCs.
- **Technological Interventions:** The use of "RightScripts" software for scriptwriting and platforms like Google Hangouts and WhatsApp for communication facilitated

both vertical (teacher-student) and horizontal (peer-to-peer) interactions. This helped address participants' requests for additional technical support.

- **Implementation:** The approach was implemented over 5 weeks, combining synchronous and asynchronous learning with live weekly sessions. Key stakeholders included professor learners from various universities across Maharashtra, supported by teaching associates (Discussion Forum Moderator). The approach is currently in progress as participants are actively engaged in course development.

## **6 Impact on learning**

The first batch of the MahaSWAYAM LCM program showed promising results, with 100% of participants completing at least two assessments out of four. Studies have indicated that the LCM model significantly enhance learner participation and completion rates [3]. An impressive 95% rated the course as “Outstanding” or “Excellent,” appreciating the well-organized structure, the high quality of video content, and the inclusivity of using regional languages during live sessions. Feedback suggests that participants valued the course's alignment between learning objectives, resources, and assessments, noting particularly the effectiveness of live sessions and collaborative activities in reinforcing key learning points. Several MOOC prototypes created during the course by the learners demonstrate practical applications of the LCM framework, providing a stable foundation for future courses in diverse topics relevant to India's educational landscape.

## **7 Community adoption and recommendations**

The use of regional languages in live sessions, especially Marathi, proved effective in enhancing communication. WhatsApp became a valuable tool for peer-to-peer learning, promoting strong community building through shared resources and collaboration. This approach can be adapted by other educational institutions by considering factors such as language diversity and technological support for effective communication.

Feedback analysis shows high satisfaction with learning resources, praised for their relevance and organization, and with live sessions that fostered a strong sense of community. However, assessments received lower ratings, with participants citing unclear guidelines and perceived fairness issues.

**Recommendations:** To enhance future course offerings, it is recommended to:

- Revise assessment strategies to ensure they are clear, fair, and aligned with learning objectives.
- Gather more detailed qualitative feedback specifically on assessment experiences to inform improvements.
- Continue leveraging strong areas like learning resources and synchronous interactions while ensuring they remain relevant and engaging for diverse learner demographics.

- By addressing these areas, the course can better meet the needs of its participants and improve overall satisfaction in subsequent offerings.

## 8 Conclusion

The MahaSWAYAM initiative's inaugural batch successfully equipped educators with essential skills for designing effective MOOCs. Future research will explore empowering more instructors to create MOOCs that cater to regional languages using the LCM model. Future inquiries will focus on:

- Empowering more MOOC instructors to prepare courses that cater to regional language speakers.
- Engaging other state professors to develop LCM-centric MOOCs with final projects delivered in their regional languages.
- Additionally, exploring how rural and regional contexts can benefit from this approach remains a key area for future inquiry.

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