

## Flipping the Classroom with AI: Student Perceptions and Learning Outcomes of Collaborative Learning Environment in Undergraduate Professional Courses

Dr. Mansi Gupta

*School of Management, Model Institute of Engineering and Technology, Jammu, J And K, India*  
mansi.mba@mietjammu.in

**Abstract**—In an era where artificial intelligence (AI) is transforming education, particularly in India's professional undergraduate programs, reimagining teaching and learning strategies is imperative. This study investigates the effectiveness of AI-integrated flipped classrooms in enhancing student engagement, collaboration, and academic performance. Grounded in the Technology Acceptance Model (TAM) and Social Constructivist Theory, a quasi-experimental design was used involving two student groups from engineering and management courses. The experimental group used AI tools such as ChatGPT, Curipod, and Synthesia, whereas the control group followed conventional methods. Quantitative data from pre-tests and post-tests and perception surveys were analysed using paired t-tests, ANCOVA, and Mann-Whitney U tests, while qualitative feedback was interpreted using thematic analysis. The results revealed statistically significant improvements in academic performance and technology acceptance indicators, perceived usefulness, ease of use, and behavioral intention among the experimental group. Thematic insights highlighted benefits like personalised support and improved peer collaboration. These findings support the adoption of AI tools in flipped pedagogies to promote active, student-centered learning in line with the goals of India's NEP 2020. This study also offers theoretical implications for extending TAM to collaborative learning environments and practical guidance for instructors and institutions aiming to scale AI-enhanced teaching models. The limitations and future research directions are discussed to inform the development of scalable and inclusive AI-driven teaching ecosystems. Future research could explore the longitudinal impacts and broader institutional adoption across disciplines and regions.

**Keywords** - AI in education, collaborative learning, flipped classroom, student engagement, TAM, undergraduate professional courses.

**ICTIEE Track: Innovative Pedagogies and Active Learning** **ICTIEE Sub-Track: Collaborative and Experiential Learning Models**

### I. INTRODUCTION

#### A. Contextual Background

The incorporation of Artificial Intelligence (AI) into education is rapidly reshaping teaching and learning ecosystems worldwide, with notable developments emerging in India as well. AI technologies, such as generative language models (e.g., ChatGPT), adaptive learning platforms, and automated assessment tools, are increasingly being used to personalise instruction, automate content delivery, and support data-driven decision-making in classrooms (Zawacki-Richter et al., 2019; Holmes et al., 2023). One of the most prominent innovations driven by this transformation is the flipped classroom model, which reverses traditional teaching by assigning lecture content as homework (via videos, readings, or simulations), and reserving classroom time for active, collaborative, and experiential learning (Lo & Hew, 2017; Lopez, 2022).

In the Indian context, this model is gaining traction across higher education institutions, particularly in undergraduate professional courses such as engineering, business management, computer applications, and allied health sciences, where skill application, teamwork, and real-world problem-solving are core competencies. For example, business schools and engineering colleges under the National Institutional Ranking Framework (NIRF) have increasingly begun to implement AI tools to redesign pedagogy and foster self-directed learning (AICTE, 2022). Platforms like SWAYAM, NPTEL, and AICTE's NEAT initiative have also been promoting AI-based educational tools and flipped classrooms across professional programs to improve learning outcomes and employability skills (NIC, 2022). Moreover, the rise of tools such as ChatGPT, Curipod, Google's Socratic, and Fireflies AI has opened up possibilities for automating lecture content, summarising concepts, generating quizzes, and supporting peer learning. These tools offer students immediate, personalised assistance outside of classroom hours, and free up in-class time for active learning strategies, such as group case discussions, business simulations, design thinking exercises, and coding sprints. This shift from passive reception to active participation is particularly relevant in the Indian higher education context, where large class sizes and exam-centric learning have traditionally limited student engagement and creativity.

This study is supported by the Technology Acceptance Model (TAM) which asserts that individuals' attitudes toward adopting a technology are largely influenced by their perceptions of its usefulness and ease of use (Davis, 1989). These constructs are highly relevant for understanding how students engage with AI-powered tools in flipped learning environments. Moreover, Social Constructivist Theory guides the pedagogical rationale for collaborative and experiential learning with AI. Together, these frameworks provide a foundation for investigating the impact of AI-driven flipped instruction on student engagement, academic outcomes and their perceptions, in the Indian higher education context.

#### B. Problem Statement

Despite growing interest in flipped classroom approaches supported by AI, there is limited empirical research in India evaluating their effectiveness on student learning and collaboration, especially in undergraduate professional education, where classroom dynamics, curricular goals, and student expectations differ significantly from liberal arts or K-12 contexts. Most existing studies focus on technological feasibility or theoretical potential, but a few have assessed how students perceive and experience these AI-powered learning models, or how such tools influence academic outcomes and teamwork in real classroom settings.

#### C. Purpose of the Study

This study seeks to empirically investigate how AI-integrated flipped classrooms influence student engagement, academic achievement, and collaborative learning experiences in professional undergraduate programs in India. Using a quasi-experimental design, the study compares outcomes before and after the implementation of AI-powered flipped instruction, capturing both quantitative learning gains and qualitative student experiences.

#### D. Research Objectives

- To evaluate changes in students' perceptions of learning after engaging with AI-based flipped classroom instruction.
- To measure differences in academic performance before and after the AI intervention.
- To assess the effectiveness of student collaboration facilitated through AI tools during in-class activities.

#### E. Research Questions

- RQ1: In what ways does AI-enhanced flipped classroom content impact students' engagement in the learning process?
- RQ2: To what extent does integrating AI into flipped classrooms enhance students' academic performance?
- RQ3: What are students' perceptions of collaborative learning using AI tools?

## II. LITERATURE REVIEW

### A. *Redefining Instructional Models through Flipped Class- room Pedagogy*

The flipped classroom model has gained considerable attention over the last decade as an instructional approach that inverts the traditional teaching methods (Da Ten et al., 2024). In this model, students are first exposed to learning materials like videos, readings, or interactive modules outside of class, while in-class time is utilized for active and collaborative tasks such as discussions, problem-solving, or case analysis (Lopez, 2022). Research shows that flipped learning improves student engagement, autonomy, and critical thinking (Chen et al., 2014). In professional education contexts such as management or engineering, flipped classrooms support skill-based learning by integrating theoretical knowledge with applied practice (Gough et al., 2017).

However, challenges still persist. Effective flipped instruction requires high-quality pre-class materials and structured in-class activities to avoid cognitive overload (Lo & Hew, 2017). Students may also resist the model if they lack digital readiness or intrinsic motivation to learn. This has led to calls for integrating AI and adaptive tools to personalise the flipped experience and support diverse learners more effectively.

### B. *Artificial Intelligence in Education: Enhancing Personal- isation and Engagement*

AI technologies have emerged as powerful tools in education by enabling personalisation, automation, and real-time feedback (Gupta, 2025). AI applications range from predictive analytics and intelligent tutoring systems to natural language processing and generative tools like ChatGPT (Zawacki- Richter et al., 2019; Holmes et al., 2023). These technologies can support both students and instructors in various ways: creating summaries, designing quizzes, identifying learning gaps, and facilitating student-instructor interaction.

In flipped classrooms, AI has shown promising results in compiling pre-class material for learning, like customised text, graphics or videos, automated knowledge checks, and chat-based guidance (Chen et al., 2020). Recent research indicates that AI-generated materials may improve students' understanding and retention if designed appropriately (Eslit, 2025). Moreover, AI can reduce faculty workload by automating administrative and grading tasks, which indeed allows educators to effectively focus on mentoring and providing feedback (Luckin et al., 2022).

In the Indian context, initiatives such as AICTE's NEAT (National Educational Alliance for Technology) and SWAYAM have been integrating AI-based edtech tools to bridge learning gaps and improve access to quality education (AICTE, 2022). These programs aim to propagate digital education and introduce AI-enabled adaptive learning systems across diverse academic programs.

### C. *Collaborative Learning in Professional Courses*

Collaborative learning is a core principle in professional education, where peer-to-peer interaction, team-based problem solving, and group decision-making are essential. Vygotsky and Cole's (1978) "Social Constructivist Theory" suggests that social interactions pave the path for learning, particularly in the "zone of proximal development", where peers and instructors support the learning process. In flipped classrooms, this principle is operationalised through group discussions, simulations, and cooperative projects during in-class sessions. Empirical studies have shown that structured collaborative tasks improve not only cognitive outcomes but also interpersonal skills, self-efficacy, and student satisfaction (Johnson & Johnson, 2009; Yilmaz, 2017). When AI tools are embedded into these environments, for instance, by offering real-time feedback, facilitating brainstorming, or summarising group conversations, they may further enhance collaborative learning (Hwang et al., 2020).

### D. *Student Perceptions and Learning Outcomes in AI-Flipped Classrooms*

Student perception is a focal point of the success of any pedagogical innovation. Lin and Chen (2024) found that students responded positively to AI-based flipped classrooms when the tools were user-friendly and provided meaningful feedback. Factors such as engagement, motivation, perceived usefulness, and ease of use significantly influence their acceptance of AI-driven learning tools (Davis, 1989; Venkatesh & Davis, 2000). Empirical evidence also indicates that flipped learning, when combined with AI, results in measurable improvements in academic outcomes (Salleh, 2022). However, the extent of impact varies across disciplines, with professional courses like business, healthcare, and computer science showing higher effectiveness due to their practice-oriented nature (Chen et al., 2020). Despite these findings, research in the Indian higher education context is still nascent. While technological infrastructure is improving, challenges such as faculty readiness, digital literacy, and student mindset remain critical barriers (NIC, 2022). Thus, there is a pressing need to explore how AI-enhanced flipped models affect Indian undergraduate students, both in terms of perceived learning experience and measurable outcomes.

### E. *Theoretical Background*

This study draws upon two key theoretical frameworks to explain the effects of integrating artificial intelligence (AI) into flipped classroom environments: the "Technology Acceptance Model (TAM)" and "Social Constructivist Theory". These frameworks provide a dual lens, one technological and the other pedagogical, through which the adoption, engagement, and collaborative learning outcomes can be interpreted for AI-empowered active learning models.

1) *Technology Acceptance Model (TAM)*: The Technology Acceptance Model (TAM), originally proposed by Davis (1989), is one of the most widely used theories for understanding how individuals accept and use technology. According to TAM, two primary factors are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), which influence an individual's attitude toward a technology, that is their "Behavioural Intention to Use" (BI) it. In educational settings, these constructs have been extensively used to evaluate student and faculty readiness and acceptance of various digital learning tools (Venkatesh & Davis, 2000).

In this study, usage of TAM explains how students' perceive the usefulness and usability of AI tools embedded within the flipped classroom model. For example, AI-based systems such as personalised recommendation engines, automated quizzes, or AI teaching assistants can enhance learner engagement if students perceive them as valuable and easy to use (Scherer et al., 2019). In Indian higher-education, where exposure to technology is highly variable, students' attitudes toward AI-enhanced learning are significantly influenced by these perceptions.

2) *Social Constructivist Theory*: Complementing TAM, this study also draws from "Social Constructivist Theory", which emphasizes on the social-interaction, peer collaboration, and contextual learning in the construction of knowledge (Vygotsky, 1978; Hofmann & Asmundson, 2017). According to this theory, learning is not a passive process but occurs actively through dialogue, negotiation, and shared experiences.

In flipped classrooms, where face-to-face sessions are repositioned for problem-solving, discussion, and collaboration, the principles of social constructivism are highly applicable. The integration of AI tools further enhances this model by acting as scaffolding mechanisms, for instance, through chatbots that support discussions, adaptive learning platforms that recommend group tasks, or AI tools that provide instant feedback during peer assessments (Mena-Guacas et al., 2023; Gupta, 2025). These AI applications

help facilitate collaborative knowledge building, especially in large classes or resource-constrained institutions where faculty-student ratios are high. In India's professional undergraduate programs, such as engineering, management, or law, the need for collaborative, hands-on learning is high, but implementation challenges persist due to curriculum rigidity and technology access issues. Social constructivism offers a valuable lens for understanding how students interact with peers and AI tools to co-construct meaning and apply concepts in real-world scenarios. By integrating the Technology Acceptance Model (TAM) with Social Constructivist Theory, this study establishes a robust theoretical foundation that addresses both the acceptance of AI technologies and the pedagogical mechanisms through which they influence collaborative learning and academic performance. This dual framework allows for a more holistic evaluation of how AI-enhanced flipped classrooms function in real educational settings, particularly within the diverse and evolving context of Indian higher education.

#### F. Research Gaps

Most existing literature focuses on flipped classrooms or AI in isolation. There is limited empirical work examining the combined effect of AI-enhanced flipped instruction on collaborative learning and academic performance, particularly in India's undergraduate professional programs. Furthermore, while international research suggests positive outcomes, it is unclear whether similar results apply to Indian classrooms with varied technological access and student demographics.

### III. METHODOLOGY

#### A. Research Design

A quasi-experimental pre-test/post-test design with a non-equivalent control group was adopted, a recognised methodology in educational research where randomisation is impractical (MacCoun, 2003; Creswell et al., 2023). This design facilitated the examination of how a flipped classroom enhanced with AI, affects students' perceptions, learning-outcomes, and collaborative engagement.

The perception survey was designed based on the core constructs of the "TAM" to evaluate how students perceived the relevance and accessibility of AI tools used in the flipped classroom. These constructs allowed for a structured and theory-driven approach to measuring technology acceptance among students.

#### B. Participants

Participants were drawn from two intact undergraduate classes enrolled in professional programs at private autonomous institutes in northern India. The experimental group ( $n = 45$ ) received AI-curated flipped instruction, while the control group ( $n = 43$ ) received conventional instruction or traditional flipped content. This non-random assignment reflects the natural classroom setting common in Indian higher-education institutions (Kember, 2000).

#### C. Intervention Procedure

1) *Duration:* The intervention spanned six weeks, aligning with modular topics within core professional subjects.

2) *Experimental Group:* Students in the experimental group engaged with AI-generated videos, summaries, quizzes, and flashcards using tools such as ChatGPT, Curipod, and Synthesia. These tools support generative learning and adaptive content delivery (Luckin et al., 2022; Chen et al., 2020).

Classroom time was used for collaborative learning, including brainstorming, case analysis, and group simulations, which are proven methods for effective learning in flipped and active learning environments (Bishop & Verleger, 2013).

3) *Control Group:* The control group used traditional methods, such as faculty-developed content or textbook materials, without AI support. Classroom activities included lectures and peer discussions, with no technological augmentation.

#### D. Instruments

1) *Academic Performance:* Pre-test and post-test were developed in alignment with course outcomes and validated by subject experts, a common practice in quasi-experimental educational research (Patricia et al., 2022).

2) *Perception Survey:* Perception survey was adapted from Davis's (1989) "Technology Acceptance Model (TAM)" and Lin and Chen (2024), covering "perceived usefulness", "ease of use", "engagement" and "collaborative learning". Reliability was tested using Cronbach's alpha, ensuring an internal consistency above 0.7 (Nunnally & Bernstein, 1994).

3) *Focus Group Discussion:* A qualitative component was included to offer student-driven insights (Braun & Clarke, 2006).

#### E. Data Collection

Week 1: Pre-test and baseline survey.

Weeks 2-6: Intervention across both groups. Week 6: Post-test and final surveys.

Week 7: Focus group discussions.

#### F. Data Analysis

To achieve the research objectives and evaluate the proposed hypotheses, a combination of quantitative and qualitative data analysis techniques was employed in this study. The analysis strategy was chosen to suit the quasi-experimental design and mixed-method nature of the study.

##### 1) Paired Sample t-Tests:

Before and after the intervention, paired-sample t-tests were conducted for control and experimental groups to measure within-group learning gains. This statistical test is appropriate for evaluating whether the two related means vary significantly, which here, refers to the students' performance on the pre-test and post-test assessments within each group (Chapman, 2017). The results provide insight into whether the AI-integrated flipped-classroom model had a measurable impact on students' academic performance within the experimental group, and how it compares to learning gains under conventional instruction.

##### 2) Analysis of Covariance (ANCOVA):

An Analysis of Covariance (ANCOVA) was performed in order to compare "post-test performance" between the two groups while controlling for any pre-existing differences. ANCOVA adjusts the "post-test scores" by accounting for the influence of "pre-test scores" as a covariate, thereby isolating the effect of the intervention (Gravetter and Wallnau, 2017). This method indeed strengthens the validity of the study by minimising the impact of baseline differences in academic performance between the control and experimental groups, which is particularly important in "quasi-experimental designs" where random assignment is not advisable.

##### 3) Descriptive Statistics for Perception Data:

Students' perceptions of the learning environment, AI tools, engagement, and collaboration were gathered through a structured questionnaire using a Likert scale format. Descriptive statistics, including means, standard deviations, and frequency distributions, were used to summarise and present this data. These statistics help identify trends in student responses and offer a clear snapshot of how learners

perceive the usefulness and effectiveness of the AI-supported flipped classroom model (Creswell et.al., 2023).

These items were theoretically mapped to core TAM constructs as follows:

- "Perceived Usefulness (PU)": e.g., "The AI tool helped me understand course concepts better."
- "Perceived Ease of Use (PEOU)": e.g., "The AI tool was easy to access and operate."
- "Behavioural Intention (BI)": e.g., "I would like to use such AI tools in future courses."

A comparison of mean scores between groups was done for these TAM constructs. A higher mean in the experimental group indicates greater technology acceptance, supporting the hypothesized benefits of AI integration.

4) *Thematic Analysis for Qualitative Feedback:* In addition

to quantitative measures, open-ended responses were gathered from students in the "experimental group" to obtain qualitative insights into their flipped learning experience. These responses were analyzed using thematic analysis, which is a flexible approach to identify, examine, and report patterns within qualitative data (Braun Clarke, 2006).

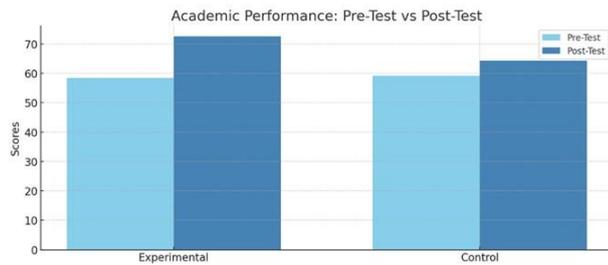


Fig. 1. Academic Performance

By combining these analytical techniques, this study offers a robust and multidimensional understanding of both learning outcomes and student experiences in AI-powered flipped classrooms.

#### IV. RESULTS AND ANALYSIS

##### A. Overview of Data Analysis

Both quantitative and qualitative data were analyzed to assess the effectiveness of the AI-powered flipped classroom, both quantitative and qualitative data were analysed. The Quantitative results address the research questions related to academic performance and student perceptions, while qualitative feedback enriches the understanding of collaborative experiences with AI.

##### B. Pre-test and Post-test Academic Performance

1) *Within-Group Comparison:* We conducted a paired sample t-test to examine the improvement in academic performance:

- Experimental Group:
  - Mean Pre-test Score:  $M = 58.40$ ,  $SD = 9.25$
  - Mean Post-test Score:  $M = 72.60$ ,  $SD = 8.45$
  - $t(44) = 9.73$ ,  $p < .001$  → Statistically significant improvement.
- Control Group:
  - Mean Pre-test Score:  $M = 59.15$ ,  $SD = 10.10$
  - Mean Post-test Score:  $M = 64.30$ ,  $SD = 9.60$
  - $t(42) = 3.91$ ,  $p < .01$  → Moderate improvement.

Fig. 1 shows a significant improvement in the scores for the experimental group using the AI-powered flipped classroom whereas a moderate improvement in the control group is observed.

2) *Between-Group Comparison:* Students in the experimental group reported higher ratings across all indicators like perceived usefulness of AI, engagement, collaboration ease, and motivation, highlighting the positive influence of AI integration (Fig 2).

"ANCOVA" was performed to compare post-test scores while controlling for the pre-test scores.

- The results reveal that the experimental group significantly outperformed the control group:  $F(1, 85) = 12.84$ ,  $p < .001$ ,  $\eta^2 = 0.131$ . This suggests that the flipped classroom with AI had a substantial impact on students' academic performance.



Fig. 2. Student Perception

##### C. Student Perceptions of Engagement and Collaboration

Descriptive statistics (Likert-scale survey, 5-point) revealed strong positive perceptions in the experimental group.

The results from the perception surveys showed that students in the "experimental group" consistently rated the AI-supported learning environment higher across TAM-aligned constructs:

- Perceived Usefulness (PU) had a group mean of 4.45 (experimental) vs. 3.15 (control).
- Perceived Ease of Use (PEOU): 4.29 (experimental) vs. 3.10 (control).
- Behavioural Intention (BI): 4.51 (experimental) vs. 3.28 (control).

These findings indicate that students found AI tools both beneficial and user-friendly, which positively influenced their motivation and intention to continue using such tools in the future.

Qualitative data further reinforced this interpretation. Students frequently mentioned that AI tools "simplified difficult concepts,"

“provided instant help,” and “made learning more interesting,” reflecting the PU and PEOU dimensions of TAM. Collectively, these findings suggest that the TAM framework offers a valid and reliable lens for interpreting student engagement and adoption of AI tools in a flipped classroom setting.

TABLE I

COMPARISON OF PERCEPTION VARIABLES BETWEEN EXPERIMENTAL GROUP AND CONTROL GROUP

Perception Variable	Experimental Group (M ± SD)	Control Group (M ± SD)
Perceived Usefulness of AI Tools	4.45 ± 0.53	3.15 ± 0.62
Engagement in Learning Activities	4.38 ± 0.49	3.42 ± 0.68
Ease of Collaboration using AI	4.29 ± 0.58	3.10 ± 0.71
Motivation to Learn Outside Class	4.51 ± 0.45	3.28 ± 0.66

A Mann-Whitney U test was performed to compare students' perceptions of AI-based flipped learning between the control and experimental groups. The test revealed that students in the experimental group reported significantly higher perceived usefulness scores (Mdn = 4.5) than those in the control group (Mdn = 3.1),  $U = 142.00$ ,  $z = -4.23$ ,  $p < .001$ ,  $r = .55$ .

Similar significant differences were observed for the following:

- Perceived Ease of Use:  $U = 151.50$ ,  $z = -4.10$ ,  $p < .001$ ,  $r = .53$
- Behavioural Intention:  $U = 138.00$ ,  $z = -4.45$ ,  $p < .001$ ,  $r = .58$ 
  - Motivation to Learn:  $U = 147.20$ ,  $z = -4.15$ ,  $p < .001$ ,  $r = .54$

The results indicated statistically significant differences across all measured variables, with students in the experimental group reporting higher scores for perceived usefulness, ease of use, engagement, and motivation. This non-parametric result supports the conclusion that the experimental group perceived the learning environment as significantly more effective and engaging than the control group.

#### D. Focus Group Insights: Thematic Summary

Two student focus groups (one per group) provided qualitative feedback for this study. Using thematic analysis (Braun & Clarke, 2006), the following themes emerged for the experimental group:

- 1) “Personalised Exploration” – Students appreciated how AI tools adapted to their pace and helped clarify difficult concepts (e.g., “ChatGPT explained the case better than the book”).
- 2) “Collaborative Engagement” – AI tools facilitated ideation and peer interaction.
- 3) “Initial Tech Discomfort” – Some students struggled with tech adoption but gradually adapted with guidance.

In contrast, the control group reported fewer positive experiences with engagement or collaboration and cited a greater reliance on faculty explanations.

#### E. Summary of Findings

- AI-flipped classrooms significantly improved students' learning outcomes.
- Students' perceptions of engagement, motivation, and collaboration were higher with AI integration.
- Qualitative feedback supported the value of generative AI in facilitating teamwork and independent exploration.

### V. DISCUSSION AND IMPLICATIONS

The results demonstrate that the integration of AI into a flipped classroom significantly enhances both **academic performance** and **student perceptions** in undergraduate professional courses. The experimental group's larger gain in post-test scores ( $M = 14.20$ ) compared to the control group ( $M = 5.15$ ) confirms that AI-generated materials and in-class AI-assisted collaboration can deepen conceptual understanding and retention. Moreover, the large effect size ( $\eta^2 = 0.131$ ) from the ANCOVA suggests that the AI intervention accounted for a meaningful proportion of the variance in learning gains, beyond what might be expected from a standard flipped model. On the perceptual front, students in the AI-flipped condition reported significantly higher ratings of usefulness, engagement, ease of collaboration, and motivation (all  $p < .001$ ). The higher perception scores among students in the experimental group suggest a strong alignment with the TAM constructs. Students rated AI tools as useful and easy to use, which likely influenced their overall engagement and intention to continue using such tools for academic learning. These findings align with the Technology Acceptance Model predictions that perceived usefulness and ease of use drive the acceptance of instructional technologies. Moreover, when AI tools were embedded into collaborative activities, students appeared more motivated and autonomous, suggesting a positive behavioural intention toward continued use of AI in educational settings. Qualitative themes such as “Personalised Exploration” and “Collaborative Engagement” further illustrate how AI tools inspired peer learning and peer-to-peer support more competently than traditional methods.

#### A. Theoretical Implications

This study extends current understanding of social constructivist theory by showing how AI can act as a mediating variable in the Zone of Proximal Development, providing real-time support during group tasks. It also extends the Technology Acceptance Model into collaborative pedagogical contexts, confirming that AI's impact on learning outcomes is partially mediated by students' attitudes toward technology. By empirically validating these frameworks in an Indian professional education setting characterised by large class sizes and exam-oriented pedagogy, investigation offers new insights for the global AIED (AI in Education) literature.

#### B. Practical Implications

For **instructors**, the findings suggest that adopting AI tools to generate pre-class materials (e.g., summaries, quizzes, chatbots) can free up class time for meaningful collaboration and higher-order thinking exercises. Therefore, faculty development programs should include training on AI platforms such as ChatGPT and Synthesia, as well as strategies for designing AI-assisted group activities.

At the **institutional level**, universities and policymakers, particularly in India, should invest in strengthening digital infrastructure (e.g., LMS integration, reliable connectivity) and support initiatives like NEAT or SWAYAM to scale AI-enabled flipped models across diverse disciplines. This could enhance access to quality education in remote or resource-constrained settings, aligning with the national goals of educational equity. Finally, for **curriculum designers**, embedding structured AI-mediated collaborative tasks such as case simulations, peer tutoring, and real-time feedback loops can improve not only cognitive outcomes but also skills like problem-solving, teamwork, and digital literacy.

## VI. LIMITATIONS AND FUTURE RESEARCH

While this study provides valuable insights, certain limitations need to be accredited. Firstly, the study was conducted among undergraduate students enrolled in professional courses at private autonomous institutes in North India. This restricts the generalizability of the findings to different academic disciplines, institutions, and geographic contexts. Future research could extend the sample to include diverse learners from varied

socio-economic backgrounds, particularly those from rural areas in India where access to digital infrastructure remains uneven.

Secondly, the duration of the intervention was relatively short, limited to one academic module that spanned six to eight weeks. While this allowed for a focused examination of immediate learning outcomes and student perceptions, it might not have fully accounted for the longer impacts of AI-based flipped instruction on knowledge retention, cognitive development, or collaborative skills. Longitudinal studies are needed to assess sustained effects and behavioural shifts over time.

Thirdly, although the use of AI tools was integrated into the flipped classroom model, the variation in students' access to and familiarity with these tools may have influenced their engagement and overall experience. Although many students were digitally literate, there is still a digital divide in India, and students from less privileged backgrounds may struggle with continuous access to AI platforms or high-speed Internet, limiting the equity of such interventions.

Future research should also consider comparative studies of different AI tools (e.g., chatbots, auto-assessment systems, and intelligent tutors), explore faculty readiness for implementing AI-enabled pedagogies, and investigate institutional support mechanisms that facilitate or hinder their large-scale adoption. Such investigations can contribute to more inclusive, scalable, and contextually relevant AI-driven collaborative learning models in the Indian higher education ecosystem

## VII. CONCLUSION

The integration of artificial intelligence into flipped classroom models marks a significant shift in the pedagogical landscape of higher education, particularly within the Indian context where digital transformation is accelerating. This study sought to examine the impact of AI-enabled flipped classrooms on student engagement, perceptions, collaboration, and academic performance in undergraduate professional courses.

The findings from the quasi-experimental research design revealed that students in the AI-supported flipped learning environment demonstrated improved academic outcomes and higher engagement levels compared to those in traditional instruction. They also expressed more positive perceptions regarding the usefulness of AI tools, ease of collaboration, and overall learning motivation. These outcomes underscore the AI's potential to elevate student-centred learning experiences and foster more effective collaborative learning ecosystems. These findings reinforce the applicability of the "Technology Acceptance Model (TAM)" in higher education contexts where AI tools are introduced. To ensure the successful use of such technologies, it is essential to comprehend how students see their utility and usability. Institutions seeking to scale AI-based pedagogies must therefore consider not just access to technology, but also how it is perceived and experienced by students. By embedding AI tools, like the intelligent content recommendation systems, assessment automation, and virtual assistants within a flipped pedagogical framework, educators can shift from content delivery to facilitation, allowing more time for problem-solving, discussion, and peer interaction. This approach aligns well with India's National Education Policy (NEP 2020) goals of promoting experiential and technology-integrated learning.

However, successful implementation requires addressing access and equity issues, ensuring digital readiness among both students and faculty, and providing adequate institutional support. While this study offers initial evidence of the promise of AI-enabled flipped learning, a broader, multi-contextual research is needed to establish its long-term implications along with refining models that are scalable, inclusive, and pedagogically sound.

In a nutshell, flipping the classroom with AI not only transforms how content is delivered and consumed but also redefines the roles of learners and educators in a collaborative, future-ready academic ecosystem.

## REFERENCES

- [1] Bishop, J., & Verleger, M. (n.d.). The Flipped Classroom: A Survey of the Research. *2013 ASEE Annual Conference & Exposition Proceedings*. Retrieved August 7, 2025, from <https://doi.org/10.18260/1-2-22585>
- [2] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- [3] Chapman, S. J. (2017). Review of discovering statistics using IBM SPSS statistics, 4th edition. *Journal of Political Science Education*, 14(1), 145–147.
- [4] Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264–75278. <https://doi.org/10.1109/access.2020.2988510>
- [5] Chen, Y., Wang, Y., Kinshuk, & Chen, N.-S. (2014). Is FLIP enough? Or should we use the FLIPPED model instead? *Computers & Education*, 79, 16–27. <https://doi.org/10.1016/j.compedu.2014.07.004>
- [6] Creswell, J., Poth, C. N., & Rawlins, P. (2023). Mapping Design Trends and Evolving Directions Using the Sage Handbook of Mixed Methods Research Design. In *The Sage Handbook of Mixed Methods Research Design* (pp. 527–537). Sage Publications Ltd. <https://doi.org/10.4135/9781529682663.n50>
- [7] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319. <https://doi.org/10.2307/249008>
- [8] Da Teng, Xiangyang Wang, Yanwei Xia, Yue Zhang, Lulu Tang, Qi Chen, Ruobing Zhang, Sujin Xie, Weiyong Yu. "Investigating the utilization and impact of large language model-based intelligent teaching assistants in flipped classrooms", *Education and Information Technologies*, 2024.
- [9] Eslit, E. (2025). *Beyond Access: A meta-synthesis on inclusive and ai-supported learning materials in higher education*. MDPI AG. <https://doi.org/10.20944/preprints202506.2255.v1> 319. <https://doi.org/10.2307/249008>
- [10] Gough, E., DeJong, D., Grundmeyer, T., & Baron, M. (2017). K-12 teacher perceptions regarding the flipped classroom model for teaching and learning. *Journal of Educational Technology Systems*, 45(3), 390–423. <https://doi.org/10.1177/0047239516658444>
- [11] Gravetter, F. J., & Wallnau, L. B. (2017). *Statistics for the behavioral sciences* (10th ed.). Cengage Learning.
- [12] Gupta, M. (2025). Integrating AI into online engagement models for engineering education: A comprehensive review. *Journal of Engineering Education Transformations*, 38(IS2), 329–336. <https://doi.org/10.16920/jeet/2025/v38is2/25039>
- [13] Hofmann, S. G., & Asmundson, G. J. G. (2017). *The science of cognitive behavioral therapy*. Academic Press.
- [14] Holmes, W., Bialik, M., & Fadel, C. (2023). Artificial intelligence in education. In *Data ethics: building trust: how digital technologies can serve humanity* (pp. 621–653). Globethics Publications. <https://doi.org/10.58863/20.500.12424/4276068>

- [15] Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, 38(5), 365–379. <https://doi.org/10.3102/0013189x09339057>
- [16] Kember, D. (2000). Misconceptions about the learning approaches, motivation and study practices of Asian students. *Higher Education*, 40(1), 99–121. <https://doi.org/10.1023/a:1004036826490>
- [17] Lin, H., & Chen, Q. (2024). Artificial intelligence (AI) -integrated educational applications and college students' creativity and academic emotions: Students and teachers' perceptions and attitudes. *BMC Psychology*, 12(1). <https://doi.org/10.1186/s40359-024-01979-0>
- [18] Lo, C. K., & Hew, K. F. (2017). A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. *Research and Practice in Technology Enhanced Learning*, 12(1). <https://doi.org/10.1186/s41039-016-0044-2>
- [19] Lopez, S. (2022). Book review – Flip Your Classroom: Reach every student in every class every day by Jonathan Bergmann & Aaron Sams. *Electronic Journal of Social and Strategic Studies*, 03(02), 258–264. <https://doi.org/10.47362/ejsss.2022.3208>
- [20] Luckin, R., Cukurova, M., Kent, C., & du Boulay, B. (2022). Empowering educators to be AI-ready. *Computers and Education: Artificial Intelligence*, 3, 100076. <https://doi.org/10.1016/j.caeai.2022.100076>
- [21] MacCoun, R. (2003). Experimental and Quasi-Experimental Designs for Generalized Causal Inference, by William R. Shadish, Thomas D. Cook, and Donald T. Campbell. Boston: Houghton Mifflin, 2001, 623 pp., \$65.56. *Journal of Policy Analysis and Management*, 22(2), 330–332. <https://doi.org/10.1002/pam.10129>
- [22] Mena-Guacas, A. F., Urueña Rodríguez, J. A., Santana Trujillo, D. M., Gómez-Galán, J., & López-Meneses, E. (2023). Collaborative learning and skill development for educational growth of artificial intelligence: A systematic review. *Contemporary Educational Technology*, 15(3), ep428. <https://doi.org/10.30935/cedtech/13123>
- [23] NIC, L. P. (2022). *Ministry of Education*. Government of India, Ministry of Education; MHRD. <https://www.education.gov.in/en/swayam>
- [24] Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory*. McGraw-Hill Humanities/Social Sciences/Languages.
- [25] Patricia, O. de P., Xi, Z., & Nabil, A., Mohammad. (2022). *Handbook of Research on Education Institutions, Skills, and Jobs in the digital era*. IGI Global.
- [26] Salleh, S. M. (2022). University student perceptions on the use of online-based technology in flipped classrooms. *International Journal of Computer-Assisted Language Learning and Teaching*, 12(4), 1–15. <https://doi.org/10.4018/ijcallt.310078>
- [27] Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, 128, 13–35. <https://doi.org/10.1016/j.compedu.2018.09.009>
- [28] Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, 46(2), 186–204. <https://doi.org/10.1287/mnsc.46.2.186.11926>
- [29] Vygotsky, L. S., & Cole, M. (1978). *Mind in society: Development of higher psychological processes*. Harvard University Press.
- [30] Yilmaz, R. (2017). Exploring the role of e-learning readiness on student satisfaction and motivation in flipped classroom. *Computers in Human Behavior*, 70, 251–260. <https://doi.org/10.1016/j.chb.2016.12.085>
- [31] Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1). <https://doi.org/10.1186/s41239-019-0171-0>