A Study of Various Interactive Pedagogy and Its Impact on Engineering Student Learning and Participation

Priyanka Deshmukh[1], Vinod Salunkhe[2], Shrikrishna Sonwane[3], Mahesh Biradar[4]

[1] Assistant Professor, Engineering Sciences & Humanities, Thakur College of Engineering and Technology, Maharashtra, India
[2] Assistant Professor, Engineering Sciences & Humanities, Thakur College of Engineering and Technology, Maharashtra, India
[3] Assistant Professor, Engineering Sciences & Humanities, Thakur College of Engineering and Technology, Maharashtra, India
[4] Assistant Professor, Engineering Sciences & Humanities, Thakur College of Engineering and Technology, Maharashtra, India

ABSTRACT

The landscape of higher education, particularly within engineering disciplines, is undergoing a significant transformation. Traditional lecture-based and passive learning models are gradually giving way to more dynamic, student-centred approaches. In today's academic environment, students are increasingly placed at the core of teaching and learning processes, encouraging them to become active participants in their own educational journey. This study explores a range of interactive pedagogical strategies that have the potential to enhance students' study skills, academic performance, and overall engagement. These strategies include peer teaching, role-plays, mind mapping, collaborative problem-solving, and the integration of digital technologies.

Beyond achieving basic pedagogical objectives, these interactive methods support the development of higher-order thinking skills such as critical analysis, creativity, teamwork, and conceptual understanding as opposed to rote memorization. The growing use of artificial intelligence-based instructional tools and game-based learning environments offers highly personalized learning experiences, enabling educators to tailor lessons to the diverse needs of engineering students. Such tools not only assist in delivering instruction more effectively but also make the learning process enjoyable and interactive.

When compared with conventional teaching techniques, these learner-centred approaches have demonstrated marked improvements in students' interest, confidence, participation, and comprehension levels. The adoption of inclusive, technology-supported interactive pedagogies contributes to a richer and more meaningful learning experience. Ultimately, these approaches foster essential cognitive abilities, effective communication, and problem-solving competencies that are crucial for students' academic success and future careers in the field of engineering.

Keyword: - *Interactive Pedagogy1, Engineering Education2, Student Engagement3, Technology in Learning4, Gamification5, Active Learning6, Student-Centered Instruction7, etc*

---

1. INTRODUCTION:

In this era of technological advancement, a higher learning institution is required to do much more than class instruction. An engineering student is expected to have, in addition to the technical know-how, life skills such as critical thinking, collaboration, flexibility, real-life problem-solving, and other aspects to fulfill societal and industry expectations. (Freeman, 2014, Prince, 2004)

From my practical experiences, I noticed that many students struggle with bridging the gap between, theory and practical application. My observation reveals that traditional lectures addressing the core concepts could be effective; however, most of them do not provide adequate opportunities for nurturing the higher-order skills needed. Most passive learning experiences do not engage students, and as a result, stifle creativity and active participation. (Freeman, 2014, Prince, 2004)

This challenge could be addressed through more developed institutions adopting interactive and learner-centered teaching methods. With strategies like peer teaching, mind mapping, dramatization, contextual problem-solving, and others, students are becoming the focus of teaching. These techniques motivate learners to contribute, ask questions, reflect, and deepen their understanding of concepts while building confidence and enduring interest in the subject matter taught. (Michael, 2006, Topping, 2005)

This transformation is facilitated by the increasing use of technology in teaching, including as ICT instruments, gamified modules, and AI-assisted platforms which change how students engage with content. These tools foster a personalized experience, allowing students to progress through the material at their own pace, revisit challenging areas, and receive tailored feedback. This is especially useful in technical fields like engineering, where students need to have a clear understanding of concepts. (Al-Azawei, 2016, Hamari, 2014)

Moreover, active teaching implements cooperation and learning beyond the classroom—important for the engineering field. Group debate, design thinking, and real-case studies provide students with opportunities to apply theoretical concepts, thereby preparing them to face integrated challenges in their professions. (Thomas, 2000, Herreid, 2011)

This paper looks in detail at modern engineering education with regard to integrating these contemporary teaching methods. It analyzes students' perceptions and level of engagement before and after these methods were implemented with specific attention to the changes in participation levels, self-efficacy, and curiosity about learning. With this, the study calls attention to the need for a more responsive, comprehensive, and technologically advanced framework for pedagogy and curriculum design.

The following section delves deeper into the ongoing transformation of engineering education through these pedagogical shifts.

2. LITERATURE REVIEW

In the past 20 years, there has been a transformational change to engineering education, which now reflects the needs of both the industry and students. Graduates are expected to go beyond being capable in their area of study; they need to be sophisticated, innovative, and productive right from the start. This transformation has led to a broad adoption of active and constructivist pedagogies that are more student-centric and go beyond simple rote memorization and lectures. (Freeman,2014)

I have observed student engagement and understanding through my teaching experience. The engagement is really poor, and while the traditional classroom methods cater to learners, they do not significantly enhance understanding deeply. These gaps are being filled by many institutions, including ours, which are adopting more interactivity-driven reflective and collaborative strategies.

Active learning is about enhanced engagement such that learners are content with being active participants instead of just passive consumers. This is a defining feature of education change. Such active participation improves performance in STEM, as Prince (2004) explains. In practice, active participation takes the form of peer instruction, problem-solving in groups, and open discussions. These methods do not improve the score only. They enhance communication and teamwork as well, which are essential to every real-world engineering roles. (Michael, 2006)

Latest research has only strengthened the importance of such methods. For example, a 2025 publication in Education for Chemical Engineers analyzed interactive strategies like the Jigsaw technique and H5P video-based learning. While the study emphasized substantial improvements in student participation and immediate retention, it still brought attention to the fact that sustained understanding—who, as educators, must keep this in mind when creating lesson plans—requires considerable support. (R. Maceiras, 2025)

Another striking example comes from Perez and Keleş (2025) who applied virtual reality (VR) technology in mechanical engineering classes. Their findings indicated that immersive settings help simplify the understanding of advanced subjects while also increasing motivation, something that I believe would be highly impactful in our labs, especially in relation to visual learning in thermodynamics or manufacturing processes. (Padilla Perez, 2025)

Nnamdi et al. (2025) showcased an unconventional combination of problem-based learning (PBL) with generative AI tools in biomedical engineering. Their outcomes were striking as students tackling real-world problems actively participated in more constructive collaboration and stronger analytic reasoning. What is remarkable here is the role that AI, when meaningfully applied, can play in aiding—rather than replacing—the learning process by providing intelligent support. (Nnamdi, 2025)

Methodologies are underpinned by constructivist learning theories, as put forward by Piaget (1954) and Vygotsky (1978). Their core tenants on learners actively constructing knowledge through interaction and experience continues to shape pedagogy today. Instruments such as mind mapping and dramatization enable students to order and visualize custom representations of challenging concepts, particularly in control systems or material science. In addition, as noted by Kao and O'Neill (1998) (Piaget,1954,Vygotsky,1978,Kao,1998), dramatization, albeit rare, has been particularly effective in fostering understanding of empathy and ethical reasoning.

These shifts in pedagogy have been greatly enhanced by technology. These changes are fueled by digital platforms, AI-based teaching tools, and even gamified content that enable customization and ease of access. Al-Azawei et al. (2016) brought to light how such tools enable inclusive education by meeting different learning preferences and paces (Al-Azawei,2016). In the same breath, the contribution by Hamari, Koivisto, and Sarsa (2014) remind us how the use of gaming principles turns unappealing content into engaging and meaningful experiences—especially in hefty, theory-laden subjects. (Hamari, 2014)

We identified peer-assisted learning as another useful approach, and so did other practitioners in our community. Topping (2005) contends that students have a better understanding when they explain the concepts to their peers. I've observed this firsthand—when students take ownership of a topic to present or debate, their confidence and retention improve dramatically. (Topping, 2005)

Meanwhile, project-based learning (PBL) and case-based learning (CBL) remain among the most effective ways to bridge theory with practice. Thomas (2000) emphasized how real-world tasks enhance higher-order thinking. In engineering education, CBL allows students to explore real industrial scenarios—be it through design case studies or industry-linked mini-projects—which adds authenticity to their learning experience. (Thomas, 2000, Herreid, 2011)

That said, adopting these methods isn't without challenges. Their success depends heavily on faculty mindset, curricular flexibility, and a shift away from rigid assessment patterns. In many institutions, including ours, we are still navigating these changes. Nevertheless, literature and classroom evidence alike strongly support the long-term value of interactive pedagogy in producing not just academically strong engineers, but well-rounded professionals who can thrive in diverse and evolving environments. (Ertmer, 2015)

The upcoming section explores these methodologies in action and their direct impact on students.

3. METHODOLOGY:

This study adopts a mixed-methods approach to examine how interactive pedagogical strategies influence students' engagement, conceptual understanding, and participation in an undergraduate engineering course. The methodology is structured in two core phases: first, the implementation of learner-centered instructional techniques; second, an analysis of student feedback gathered both prior to and following the pedagogical intervention.

3.1 Classroom Implementation of Interactive Teaching Strategies

To create a more engaging and reflective learning environment, several student-focused methods were embedded into the semester-long teaching plan. These were not standalone activities but intentionally integrated with the syllabus to support both technical understanding and essential soft skills.

•Peer Teaching: Instead of listening to their instructor explain concepts, the students were given micro-topics to teach their classmates. This method also aided in their own learning through clear articulation and peer accountability. Students were able to learn from each other's perspectives which, as Topping's research indicates, supported cooperative interactions among students in the classroom. (Topping, 2005).

•Mind Mapping: Students were also encouraged to create visual maps that integrated key theories and applications in thermodynamics and circuit analysis. This was particularly useful with more abstract topics and was effective for enhancing long-term retention of information, which Michael noted with regard to spatial and visual learning. (Michael, 2006).

•Dramatization and Role Play: In classes that focused on ethics in engineering, sustainability, and other historical innovations, students acted out modern engineering problems or historical inflection points. These activities made for lively class discussions and heightened, deeper emotional engagement, as highlighted in other works by Kao and O'Neill. (Kao, 1998)

•Problem Solving Derived from Real-Life Engineering Problems: Students were put into groups and given real engineering problems to solve, such as how to optimize tr.Tags: Pilot study, different perspectives, cooperative learning, bridge design. This experiential mode of learning aligned with project-based learning (PBL) methodologies and helped bridge theory with practice. (Thomas, 2000)

•Gamified Quizzes and Interactive Tools: During the review sessions, H5P and Kahoot were used to enhance assessment feedback and break the monotony of classroom activities. Students seemed to appreciate this format as the competition was helpful for their concentration and motivation. These insights confirm the observations made by Hamari et al. related to the impact of gamification on engagement. (Hamari, 2014)

•Use of ICT and Collaborative Platforms: Tools like Google Classroom, interactive simulation activities, and even asynchronous video lessons became part of the weekly lesson plans. In addition to facilitating resource access and learning outside of class sessions, these tools enabled students to revisit content multiple times. Such instructional design is in line with the principles of the Universal Design for Learning (UDL) advanced by Al-Azawei et al. as it fosters open and diverse participation, leading to increased inclusion and accessibility. (Al-Azawei, 2016)

Following fig 1 illustrates the flow chart of methodology-Interactive Pedagogy in Engineering Education

Fig 1-Flow chart of methodology-Interactive Pedagogy in Engineering Education

3.2. Study Sample and Data Collection

The study involved a group of 55 undergraduate engineering students enrolled in a core course during the academic semester. These students formed a diverse mix in terms of learning styles, academic preparedness, and interest levels offering a realistic snapshot of a typical engineering classroom in an Indian institution.

To assess the influence of the interactive teaching methods, we conducted surveys before and after the intervention. The surveys combined Likert-scale items (to capture quantifiable shifts in attitude and engagement) with open-ended questions, which offered deeper insights into students' thoughts and reflections.

The key areas explored in these surveys included:

- Interest and motivation towards the subject
- Confidence in grasping core engineering concepts
- Participation in classroom discussions and group activities
- Regularity of attendance
- Comfort level within the learning environment

This structure allowed us to not only track measurable progress but also understand the 'why' behind the numbers, which is often just as important in education research.

3.3 Data Analysis

We used a dual-layered analysis approach, combining quantitative metrics with qualitative interpretations to understand how effective these teaching strategies truly were.

In terms of data analysis, we looked into the most important indicators as metrics using a 5-point Likert scale before and after the pedagogical intervention. Therefore, measuring the improvement in subject interest, participation, academic self-concept, and attendance was possible.

For instance, many students perceived their participation as a 2 or 3 within the pre-intervention phase. However, after the intervention, the participants seemed to lean towards the 4 or 5 mark. We calculated the difference in scores as percentage improvement to observe the impact of the strategy across several measures of participation.

More importantly, the responses to the open-ended questions added useful context to the study beyond the figures. Many students gave accounts of how they became more engaged due to active learning, some advanced beyond their initial reluctance due to collaborative learning, and some mentioned how complex ideas became tangible due to drama. We could figure out not only what was effective but why it was effective through sorting these responses into consistent patterns.

The evaluation drawing upon both quantitative and qualitative approaches enabled us to capture the underlying nuances within the figures and analyze the indirect influence of teaching methods on students' behavioral patterns, showcasing the profound impact on students beyond mere numbers.

3.4 Ethical Considerations

As students directly participated in the research, ethical responsibility was observed throughout the study. Prior to data collection, students were provided in the objective and scope of the research using layman's terms. Participation on their part was voluntary, and clearly explained that choosing to withdraw would have no consequences academically.

We opted for verbal consent to avoid written consent as reasoning can feel daunting in a classroom setting. This fostered trust as well as transparency. No names or personal details were recorded. Everything was stripped of any relevant identifying detail. Responses were collected anonymously and coded only for the purpose of analysis. We adhered to the institution's ethical standards and maintained respect, confidentiality, and fairness throughout each stage of the study—from data collection to interpretation. All ethical principles were duly observed.

4. RESULTS AND DISCUSSION

The survey was conducted for those students who have used pedagogy for the subject. The results provide valuable insights into the effectiveness of innovative pedagogies in improving student engagement, understanding, and participation. The findings are structured into key areas: effectiveness of pedagogy, interest levels, confidence improvement, participation, subject understanding, and attendance. To evaluate the effectiveness of the implemented interactive pedagogy strategies, a structured survey was administered to 55 undergraduate engineering students both before and after the intervention. The data reflect noticeable improvements in multiple academic and behavioral dimensions. Below are the key findings:

4.1 Increase in Student Interest

•Before Intervention: Average rating – 2.0/5
•After Intervention: Average rating – 3.0/5
•Improvement: +50%
Following fig 2 shows the increase in student

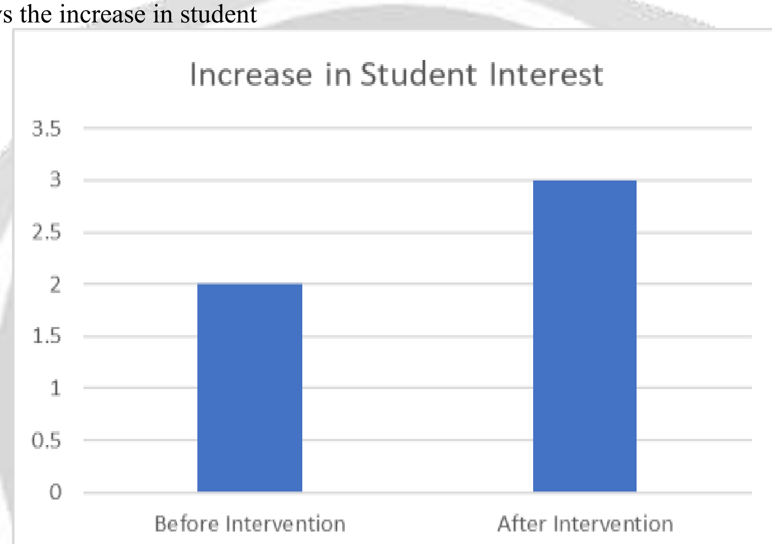

Fig 2 Increase in students' interest

The increase in interest signifies that interactive element such as dramatization, gamified learning, and real-life application had a tangible impact on student motivation. This finding echoes Michael (2006), who asserted that active learning improves curiosity and student-driven engagement in technical education contexts. (Michael, 2006)

4.2 Improved Confidence in Subject Understanding

•Before: 2.2/5
•After: 3.0/5
•Improvement: +36%
Following fig 3 shows the improved confidence in subject understanding

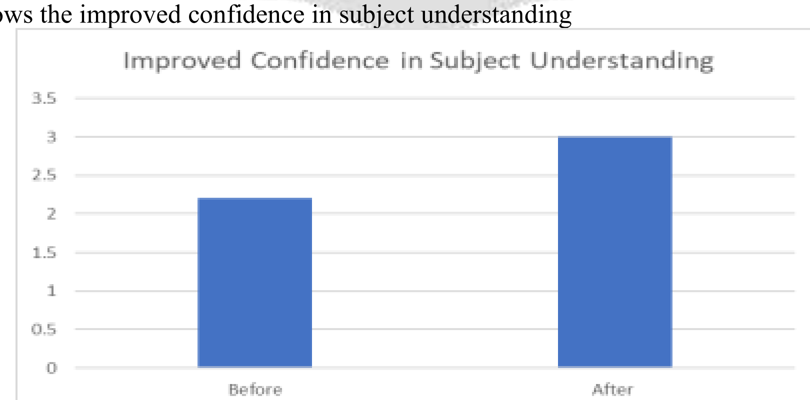

Fig 3 Improved confidence in subject understanding

Students reported greater ease in grasping and applying engineering concepts. This is consistent with the work of Freeman et al. (2014), who found that active learning significantly boosts academic confidence and comprehension in STEM disciplines. (Freeman, 2014)

4.3 Participation in Classroom Activities

•Before: 77.1% participated occasionally or rarely

•After: 100% active participation reported

Following fig 4 shows the participation of students in classroom activities

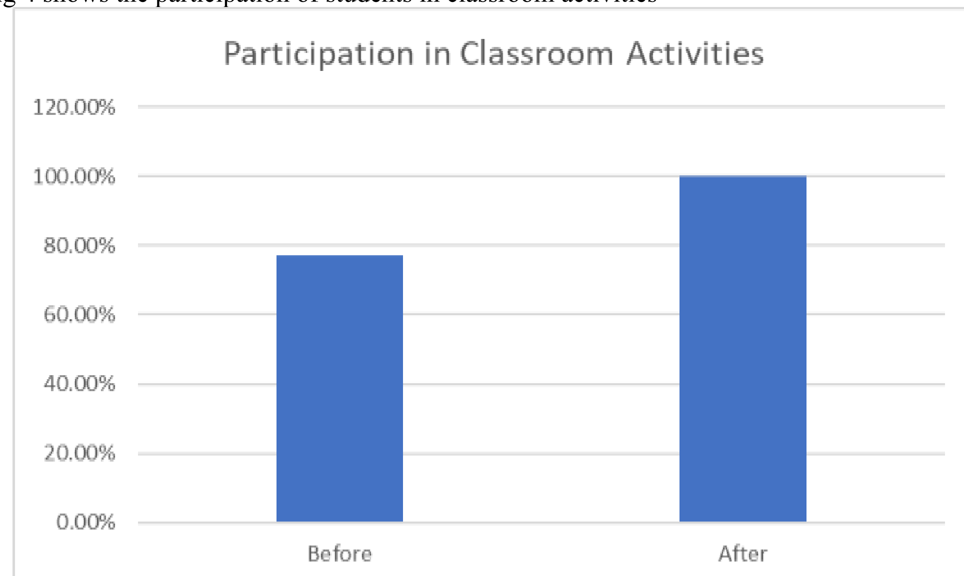

Fig 4 Participation of students in classroom activities

The complete shift to full engagement can be attributed to inclusive group activities like the Jigsaw method, role-play scenarios, and peer learning tasks. This goes hand-in-hand with social constructivism by Vygotsky (1978) on social and collaborative interactions as essential for learning. (Vygotsky,1978)

4.4 Positive Impact on Attendance

•Before: Irregular attendance

•After: 100% reported improvement

Improved attendance indicates a higher level of commitment and perceived value in the classroom experience. Active pedagogies, as Prince (2004) noted, create emotionally resonant learning spaces that encourage regular participation. (Prince, 2004)

4.5 Enhanced Understanding of Subject Concepts

•Before: Limited conceptual clarity

•After: 100% students reported improved understanding

Every participant acknowledged a significant boost in comprehension, largely due to the use of visual tools (e.g., mind maps), collaborative exercises, and real-world problem-solving projects. Thomas (2000) emphasized that these methods promote deeper learning and long-term retention in technical education. (Thomas, 2000)

4.6 Increased Comfort and Inclusivity in Learning

Students indicated they felt more comfortable contributing in class due to peer support and flexible formats of assessment. The implementation of think-aloud strategies and collaborative tasks fostered a psychologically safe learning space, enhancing inclusivity even among students who were previously hesitant to participate. (Topping,2005)

4.7 Role of ICT and Gamification

The integration of tools like Google Classroom, H5P, and gamified quizzes significantly improved engagement. Students appreciated the immediate feedback and collaborative elements. This supports findings by Hamari et al. (2014), who noted that gamification boosts motivation and cognitive focus in learning environments. (Hamari, 2014)

4.8 Summary of Key Outcomes

Table 1: Summary of key indicators for the pedagogy after and before implementation of pedagogy

Indicator	**Before**	**After**	**Improvement**

Interest in Subject	2.0 / 5	3.0 / 5	+50%
Confidence in Understanding	2.2 / 5	3.0 / 5	+36%
Class Participation	77.1% Passive	100% Active	Fully Improved
Attendance	Inconsistent	100% Regular	Fully Improved
Conceptual Understanding	Limited	100% Improved	Fully Improved
Comfort & Inclusivity	Moderate	High	Positive Shift

These findings affirm the insights presented in recent pedagogical literature:
•Active Learning Works: The results support Michael (2006), Prince (2004), and Freeman et al. (2014), who all advocate for learner-centered strategies in technical education. (Freeman, 2014)
•Peer and Collaborative Learning Boost Confidence: Vygotsky (1978) and Topping (2005) emphasize that structured peer interactions enhance learning and self-efficacy. (Topping,2005, Vygotsky,1978)
•Technology Enhances Engagement: Al-Azawei et al. (2016) and Hamari et al. (2014) found that gamification and digital tools make learning more inclusive and responsive—findings strongly echoed in this study. (Al-Azawei, 2016)

5. **CONCLUSION**:

The classroom experiences and student feedback from this study make a compelling case for moving beyond conventional, lecture-heavy teaching. The incorporation of interactive pedagogies and technology-based tools brought visible and measurable shifts in student engagement, confidence, and participation.
Methods such as Mind Mapping, Peer Teaching, and the strategic use of ICT platforms helped students connect more deeply with the subject matter. Rather than being passive recipients of information, students became co-creators in the learning process—a transformation that was reflected in both their behavior and their feedback.
Some of the most notable results include:
•80% of students found the revised pedagogical approach to be effective, while the rest held a neutral stance indicating general acceptance, with no negative reactions.
•Students' interest in the subject rose from an average of 2.0 to 3.0 on a 5-point Likert scale, reflecting an improvement in how engaging they found the content.
•Confidence in understanding core concepts also increased, from 2.2 to 3.0, indicating that the shift in methodology helped make abstract or difficult topics more accessible.
•Encouragingly, every single student reported improvements in three key areas: class participation, subject understanding, and attendance.
From a teaching perspective, these results reaffirm a belief many educators already hold—that active, student-centered learning is more than just a buzzword. It leads to real engagement and better comprehension, even in rigorous courses like engineering. The data collected from my own classroom demonstrates this clearly.
Furthermore, what stood out to me while reviewing the students' open-ended responses was the sense of ownership they felt over their learning. Several students mentioned that being involved in peer teaching or real-world problem-solving gave them a sense of purpose in the classroom—something they rarely experience through passive note-taking.

6. CHALLENGES AND REFLECTIONS

Even though some outcomes appear promising, the challenges associated with them are equally concerning. The digital divide is still one of the major issues for developing economies, especially in areas where there is little access to high-speed Internet and personal gadgets. In our case, the setting of our institution was urban, so we were able to utilize Google Classroom and Kahoot. It is unlikely that such a model would be used by other rural or underfunded colleges without adequate support.
On the pedagogical side, the adoption of a new approach entails time, training, and perhaps most importantly, a shift in approach. Most teaching professionals, especially those who have been in the field for a while, are accustomed to a standard operating procedure and may feel lost amid a plethora of digital tools or, worse, may be afraid to try them out. It is very important in this case to provide institutional support and ongoing training.

From operational perspectives, management provided me with, I can assert that changes will endure only when they are implemented at the foundational level, that is, beyond the classroom, involving other units within the administration framework.

7. RECOMMENDATIONS FOR FUTURE PRACTICE

To build on the positive momentum and scale these benefits across educational contexts, I propose the following recommendations:

•Extend active learning practices across disciplines—not just in STEM, but also in areas like business, humanities, and the arts. The core principles of student engagement are universally relevant.

•Broaden the use of gamified tools and digital platforms in a way that's meaningful and not just decorative. For instance, using quizzes for instant feedback or collaborative documents for brainstorming can make a real difference.

•Strengthen teacher training programs to ensure faculty are not only introduced to new pedagogical tools but also given space to practice and reflect on them. Peer mentoring among faculty could be a useful support system.

•Conduct longitudinal studies to observe the long-term academic and behavioral impact of interactive pedagogy. It would be insightful to track whether students retain conceptual understanding and remain engaged in future courses.

•Most importantly, personalize learning wherever possible. Recognizing that not every student learns in the same way, we must integrate models that support diverse learners—whether through differentiated instruction, varied assessment formats, or modular content delivery.

8. REFERENCES:

1)Al-Azawei, A., Serenelli, F., & Lundqvist, K. (2016). Universal Design for Learning (UDL): A content analysis of peer-reviewed journal papers from 2012 to 2015. Journal of the Scholarship of Teaching and Learning, 16(3), 39–56. https://doi.org/10.14434/josotl.v16i3.19295

2)Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. Journal of Research on Technology in Education, 42(3), 255–284. https://doi.org/10.1080/15391523.2010.10782551

3)Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

4)Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? – A literature review of empirical studies on gamification. In 2014 47th Hawaii International Conference on System Sciences (pp. 3025–3034). IEEE. https://doi.org/10.1109/HICSS.2014.377

5)Herreid, C. F. (2011). Case study teaching. Buffalo, NY: National Center for Case Study Teaching in Science. https://sciencecases.lib.buffalo.edu

6)Kao, S. M., & O'Neill, C. (1998). Words into worlds: Learning a second language through process drama. Stamford, CT: Ablex.

7)Maceiras, R. (2025). A recent study evaluating how active learning methods contribute to knowledge retention among engineering students. Education for Chemical Engineers, 51, Article 101260. https://doi.org/10.1016/j.ece.2024.101260

8)Michael, J. (2006). Where's the evidence that active learning works? Advances in Physiology Education, 30(4), 159–167. https://doi.org/10.1152/advan.00053.2006

9)Nnamdi, M. C., Tamo, J. B., Shi, W., & Wang, M. D. (2025). Generative AI as a learning partner in problem-based biomedical engineering education. arXiv. https://arxiv.org/abs/2503.16558

10)Padilla Perez, R., & Keleş, Ö. (2025). Immersive virtual reality as a tool for embodied learning in engineering education. arXiv. https://arxiv.org/abs/2503.16519

11)Piaget, J. (1954). The construction of reality in the child. New York, NY: Basic Books.

12) Prince, M. (2004). Does active learning work? A review of the research. Journal of Engineering Education, 93(3), 223–231. https://doi.org/10.1002/j.2168-9830.2004.tb00809.x

13)Thomas, J. W. (2000). A review of research on project-based learning. San Rafael, CA: The Autodesk Foundation. https://my.pblworks.org/resource/document/review-research-project-based-learning

14)Topping, K. J. (2005). Trends in peer learning. Educational Psychology, 25(6), 631–645. https://doi.org/10.1080/01443410500345172

15)Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.