

Recent Innovations in Teaching-Learning Processes

Department of Chemical Engineering, Haldia Institute of Technology

The Department of Chemical Engineering, Haldia Institute of Technology has progressively strengthened its teaching-learning processes by moving from conventional content delivery towards a more student-centric, technology-enabled, outcome-based and experiential learning environment. The innovations adopted by the Department are aligned with the requirements of Outcome-Based Education (OBE) and are continuously reviewed through student feedback, academic performance, CO-PO-PSO attainment, academic audit and stakeholder inputs. The Department follows a continuous **Plan → Implement → Monitor → Assess → Analyse → Improve** cycle for enhancing the effectiveness of teaching and learning.

The earlier teaching-learning practices included smart-board and conventional board teaching, PowerPoint presentations, animated videos, real-world examples, case studies, project-based learning, quizzes, group discussions, workshops, expert talks, internships, e-resources, open-source software and NPTEL/SWAYAM courses. Building on these practices, the Department has introduced and strengthened several recent innovations in pedagogy, digital learning, experiential learning, computational education, differentiated learning and outcome-based academic improvement.

1. ICT-Enabled and Multimedia-Based Teaching

The Department has enhanced the use of ICT-enabled teaching through smartboards, interactive panels and smart screens, PowerPoint presentations, videos, animations, digital learning resources, online learning platforms and subject-specific multimedia resources. These technologies are particularly useful in Chemical Engineering, where several concepts involve complex physical phenomena, process flows, equipment operation and visualization of industrial processes.

Multimedia-based teaching enables faculty members to supplement conventional explanations with visual representations, animations and process illustrations. The Academic Audit specifically records the use of smartboards, interactive panels, learning applications, pictures, videos and animations for explaining difficult topics.

2. Flipped Learning and Student-Centric Pedagogy

A significant recent innovation is the strengthening of flipped learning. Under this approach, students are encouraged to access basic learning material through videos, readings and online resources before the classroom session. Classroom time is then utilized more effectively for discussion, problem solving, clarification of concepts, projects and application-oriented activities.

The Department has also incorporated Problem-Based Learning (PBL), Project-Based Learning (PjBL), collaborative learning, activity-based learning, group discussions, student presentations, numerical and design exercises, case studies and real-life examples. These approaches provide opportunities for students to move beyond passive reception of information and participate actively in the learning process.

The Academic Audit 2024-25 identified the need for improved teaching methodologies and contemporary skill development. Consequently, ICT-enabled teaching, flipped learning, PBL, collaborative learning, problem-solving activities and hands-on learning were strengthened as part of the improvement process.

3. Integration of Real-World Industrial Problems

The Department has enhanced the connection between classroom learning and Chemical Engineering practice by incorporating industrial case studies, real industrial problems, process-based examples, design-oriented problems and real-time troubleshooting examples into teaching.

Interaction with industry experts, industrial visits, internships and industry-linked projects further reinforce this approach. For example, an industrial visit to Tata Steel Ltd. (Hooghly Met Coke) was conducted in March 2025 for third-year students, providing firsthand exposure to industrial processes and operations.

This approach enables students to understand how fundamental Chemical Engineering principles are applied to process operation, equipment, troubleshooting, safety and industrial decision-making.

4. Experiential and Laboratory-Based Learning

Laboratory teaching has been strengthened as an experiential component rather than being treated merely as an exercise-completion activity. Students are guided through the complete experimental cycle comprising objective and theoretical background, equipment familiarization, experimental procedure, safety, observation, data collection, analysis, interpretation and comparison with theoretical results.

Students perform experiments individually or in groups, analyse experimental data, prepare calculations and graphs, discuss sources of error and defend their understanding through viva voce. Thus, laboratory learning contributes directly to analytical ability, experimental skills, interpretation of results and problem-solving competence.

The Department has also strengthened practical and research exposure through industrial visits, internships, project-based learning and MSME-linked research facilities. Two such research facilities identified in the Academic Audit are Solar Water Treatment and a Portable Membrane Water Purification System, which also provide opportunities for student internships.

5. Computational and Software-Based Learning

Recognizing the increasing importance of computational skills in Chemical Engineering, the Department has strengthened exposure to MATLAB, Python and process simulation/computational tools. Faculty development activities have supported the adoption of computational tools, digital learning resources and application-oriented teaching.

The curriculum improvement process further introduced the Value Added Course MATLAB Simulation Software and strengthened computational learning. Other Value Added Courses include Auto CAD for Chemical Engineers, Green Technology, Industrial Corrosion and its Prevention, Industrial Waste Water Treatment, IoT Application in Process Industries, and Design and Concepts of Zero-Liquid-Discharge System.

These initiatives provide students with opportunities to acquire skills that complement conventional Chemical Engineering theory and laboratory education.

6. NPTEL, SWAYAM and Self-Learning

The Department promotes NPTEL and SWAYAM courses as structured avenues for self-learning and lifelong learning. Students are encouraged to undertake courses beyond the prescribed curriculum, enabling them to deepen their subject knowledge and access learning resources from external academic platforms.

Advanced learners are additionally encouraged to participate in technical competitions, hackathons, quizzes, paper presentations, research projects, technical seminars, workshops and advanced software training.

7. Differentiated Learning and Mentoring

The Department has adopted differentiated academic support for both slow and advanced learners. Students requiring additional support are identified through previous academic performance, continuous assessment, result analysis, faculty observations and mentor interaction. Remedial classes, bridge courses, additional tutorials, support sessions, self-learning resources and individualized academic guidance are subsequently provided.

At the same time, advanced learners receive opportunities for enrichment through competitions, research projects, technical activities, NPTEL/SWAYAM and advanced training.

The mentor-mentee system, with approximately 25-30 students assigned to each faculty mentor, provides individual monitoring of academic performance, attendance, career planning, skill development and learning difficulties.

8. Outcome-Based and Data-Driven Improvement

A major innovation is the integration of teaching-learning with the Department's OBE framework. CO, PO and PSO attainment is evaluated using direct and indirect assessment components. Attainment is compared with predefined targets and identified gaps are converted into academic interventions such as changes in teaching methodology, additional lectures, curriculum revision and industrial exposure.

The Academic Audit further confirms a systematic process of establishing targets, analysing attainment, identifying gaps, implementing corrective actions and monitoring subsequent attainment.

9. Feedback-Driven Continuous Improvement

Student feedback has been integrated into the teaching-learning improvement cycle. Feedback is collected through an online survey, analysed, and converted into documented Action Taken Reports. Based on feedback and academic evidence, the Department has adopted measures such as greater use of audio-visual aids, participative teaching, PBL, collaborative activities, remedial classes, reference notes, Value Added Courses and strengthening of student seminars.

The Academic Audit provides an institutional mechanism for reviewing the effectiveness of these interventions. The audit findings, student feedback, result analysis, CO-PO-PSO attainment and stakeholder inputs are used to identify further areas for improvement.

10. Overall Impact

The recent innovations have transformed the teaching-learning process from predominantly conventional classroom instruction into a blended, participative, experiential and outcome-oriented learning system. ICT-enabled teaching improves visualization; flipped and collaborative learning increases student participation; PBL and PjBL develop problem-solving and teamwork; laboratory and industrial exposure connect theory with practice; computational learning develops contemporary technical skills; NPTEL/SWAYAM promotes self-learning; and mentoring and differentiated support address individual learning needs.

The Department's Academic Audit records 167 faculty participations in conferences, seminars, workshops and FDPs, supporting continuous faculty development and adoption of contemporary teaching practices.

Thus, the Department of Chemical Engineering has established a closed-loop teaching-learning improvement mechanism in which planning, innovative delivery, continuous assessment, student feedback, outcome analysis and corrective action are interconnected. The current approach is not limited to syllabus completion; it focuses on measurable student learning outcomes, practical competence, computational skills, industry readiness and continuous academic improvement. The

documented linkage between academic audit findings and subsequent interventions demonstrates that innovation in teaching-learning is being institutionalized as an ongoing departmental practice.