The IDP-ET offers a Ph.D. programme in Educational Technology

Established 2010

The IDP-ET offers a Ph.D. programme in Educational Technology

Indian Institute of Technology Bombay
Mumbai, India

Inter-disciplinary Programme in Educational Technology

Our Vision
To be a source of ideas and innovations in technology for education and pedagogies for technology-enabled learning and teaching

Our Mission
To nurture research, innovation, and outreach leadership among faculty and student, in areas of educational technology that are critical to the Indian context
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**Post Doctoral Researcher**

| Dr. Renumol V.G. | mentor: Prof. Sahana Murthy |

**Alumni**

| Dr. Jagadish M. | advisor: Prof. S. Iyer     |
| Dr. Madhuri Mavinkurve | Prof. S. Murthy        |
| Dr. Ramkumar Rajendran | Prof. S. Iyer & Prof. S. Murthy |
| Dr. Sachin Kamble | Prof. B.L. Tembe         |
| Dr. Sameer S. Sahasrabudhe | Prof. S. Iyer & Prof. S. Murthy |
| Dr. Yogendra Pal   | Prof. S. Iyer            |

For more information visit [http://www.et.iitb.ac.in/Students.html](http://www.et.iitb.ac.in/Students.html)
Research focus

**Technology-Enhanced Learning of Thinking Skills (Project TELoTS)**

- Thinking skills (TS) are cognitive processes that human beings apply for sense-making and problem-solving.
  - e.g.: Structuring Open Problems, Knowledge Integration, Micro-Macro Thinking, Spatial Skills, Convergent-Divergent Thinking.
- Developing Technology Enhanced Learning Environments for Thinking Skills (TELoTS systems), based on the pedagogical strategies of inquiry-based learning, formative assessment and metacognitive reflection.
- Learning activities in the TELoTS systems harness technology affordances such as interactive simulations, adaptive and personalized feedback, and pedagogical agents to provide the required instructional support.

**Teacher Use of Educational Technology Tools and Strategies (Project TUET)**

- We aim to empower teachers to effectively integrate Information and Communication Technologies (ICT) tools effectively in their teaching.
- Our research in this area focuses on:
  - Training teachers in effective ICT integration, creating constructively aligned learning designs and assessment through online (MOOC), blended and face-to-face workshops.
  - Work in this area includes - Model for teacher training of ICT integration (A2I2), In-Class activity constructors, Teacher assisting tools (CuVis, IQuE, iSAT, ADVIcE) etc.

Development focus

- Technology Enhanced Learning Environments for Thinking Skills
  - TELE-EDesC, MICOMAP, MEttLE, IKnowiT, DCT-TELE, GI, PHyTeR
- Technology Tools for Teachers
  - to aid ICT integration by Teachers: CuVIS, ADVIcE, IQuE
  - to aid Visual Learning Analytics: iSAT
- Handbooks for ET Researchers and Practitioners
- Open Educational Resources
  - Researcher Resources: Templates that help researchers to start from devising meaningful educational intervention and going all the way to writing research papers about them.
  - Teacher Resources: Projects such as OSCAR, VLab and Spoken Tutorials have resources that teachers can use in their teaching. Activity constructors such as Flipped Classroom, Think-Pair-Share (TPS), Peer Instruction (PI) can assist them to create student centered in-class activities for active learning.
Project TELoTS: Technology-Enhanced Learning of Thinking Skills

Focus
Build a suite of research-based TELoTS systems to develop learners pan domain thinking skills (TS) such as Design thinking, Hypothetico-Deductive reasoning, Estimation, Knowledge Integration and Troubleshooting.

Context
• Predominantly for self-learning.
• Target the higher education sector.

Overview of Project TELoTS

- TELoTS pedagogical framework applied for designing and developing systems.
- Design-based research methodology used for evaluating and improving systems.

TELoTS pedagogical framework

Choose the thinking skill, topic & problem solving context
- Identify the competencies
- Create learning outcomes
- Consider assessment measure

Characterize the Thinking Skill
- Analyze expert actions & learner needs
- Decide instructional strategies and supports
- Identify technology features
- Create a sequenced learning activities

Design the learning activities

Architect the components & interfaces


Theoretical foundations

- Inquiry-based learning with real-world problems
- Sequences of interactive learning activities
- Formative assessment and feedback for self-regulated learning
- Metacognitive reflection activities to facilitate progressive abstraction of skills by learners

An illustrative learning path for acquisition of Thinking Skills

- Abstraction Level: Abstract how to operationalize the sub-skills to solve any problem
- Recognition Level: Recognize the sub-skills required to solve other similar problem
- Execution Level: Do all the activities in the learning environment to solve the given problem

The horizontal lines represent levels of abstraction of the thinking skill, with progressive increase of abstraction from bottom to top.

Level of learning outcome achieved in the context of a problem in given topic.

$T_i$: Tasks in learning environment such as: Learning Activities, Customized Feedback, Synthesis & Reflection Activities, etc. At least one $T_i$ for all $i$ is required.

As we go up the level: Generally the learning tasks are of “reflect-type”.
As we go down the level: Generally the learning tasks are of “apply-type”.

problems from topic 1
problems from topic 2
problems from farther domain
## TELoTS systems developed

<table>
<thead>
<tr>
<th>Thinking Skills</th>
<th>Domain / Context</th>
<th>Theoretical Basis &amp; Design Drivers</th>
<th>Key Results</th>
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<tr>
<td><strong>Structure open problem</strong></td>
<td>Analog Circuits, 2nd year Engineering undergraduates</td>
<td>Interactive experimentation, question prompts, personalized feedback.</td>
<td>Structure open problem competency developed. Productive actions of high achievers identified.</td>
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<tr>
<td>TELoTS system</td>
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<tr>
<td><strong>Micro-Macro thinking</strong></td>
<td>Physics &amp; Electronics, 1st year BSc students</td>
<td>Variable manipulation simulation, Prediction, justification &amp; reasoning questions, Customized feedback</td>
<td>Students develop Observe-Predict-Test-Revise skills. Interaction patterns and productive actions identified.</td>
</tr>
<tr>
<td>MicOMaP</td>
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<tr>
<td><strong>Knowledge integration</strong></td>
<td>Data Structures, 2nd year Computer Science undergraduates</td>
<td>Interactive activities for the knowledge integration framework based on guided question posing</td>
<td>Three broad exploratory question posing strategies identified. TEL features were developed and evaluated.</td>
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<td>IKnowIT</td>
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<td><strong>Engineering estimation</strong></td>
<td>3rd and 4th year Electrical and Mechanical Engineering undergraduates</td>
<td>Visual modeling using interactive tools, Evaluation questions, problem mapping and reflection.</td>
<td>Experts model-based estimation process, roles of mental simulation and external representations identified.</td>
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<tr>
<td>MEttLE</td>
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## TELoTS workshops

Blender-based mental rotation training for improving 1st year engineering undergraduates engineering drawing skills using the 3D interactive visualization tool, Blender and Demo-Drill-Practice

## TELoTS systems under development

- **PHyTeR** system for Troubleshooting skills for 3rd year computer science undergraduates.
- **Geneticus Investigatio** system for Hypothetico-Deductive reasoning for Bio-Science engineering undergraduates
- **DCTEL** system for convergent-divergent thinking for 2nd year Computer Science undergraduates
- **History Maker** tool for Historical thinking skill for History undergraduates
- **Geometry-via-Gestures**, an embodied cognition-based TEL system for 9th standard Geometry
- **GA Tutor** system for Algorithmic thinking for Computer Science undergraduates
- TEL systems for
  - Design Decomposition skills for Computer Science undergraduates
  - Deductive reasoning for novice researchers.
  - Convergent and Divergent thinking for Electrical Engineering undergraduates.

For more information and to see a complete list of publications, visit the website [http://www.et.iitb.ac.in/projects/telots/](http://www.et.iitb.ac.in/projects/telots/)
**Project TUET: Teacher Use of Educational Technology**

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<th>Focus</th>
<th>Context</th>
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</table>
| Empowering teachers in effective technology integration practices in their own teaching-learning context | • Instructor-mediated classrooms  
• Classrooms where students cannot directly manipulate ICT.  
• Target the Engineering Education sector. |

### Overview of the Project TUET

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<th>Problem</th>
<th>Selection of technology</th>
<th>Familiarity of use of technology</th>
<th>Knowledge of effective teaching &amp; assessment strategies</th>
<th>Alignment: Objective Strategy Tool Assessment</th>
<th>Effective integration</th>
<th>Translate into practice</th>
<th>... Sustained practice</th>
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<tr>
<td>Theoretical Basis</td>
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<td>Constructivism practices</td>
<td>Constructive alignment Meaningful learning with ICT</td>
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<td>Immersivity</td>
<td>Immersivity</td>
<td>Immersivity, Pertinency</td>
<td>Transfer of ownership</td>
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<td>Frameworks developed</td>
<td>A2I2: Attain-Attain-Integrate-Investigate</td>
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<td>Viab, LoTaAs</td>
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<td>Training workshop curriculum, Videos, Activity constructors, Learning Design blueprint, Content repositories (subject-wise examples, questions, activities, LDs)</td>
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<td>Implementation</td>
<td>18 Workshops conducted</td>
<td>10 Face-to-face</td>
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<td>7 Blended online (3 Large scale, 1 Medium)</td>
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<td>1 – MOOC</td>
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### Research Contribution

**Attain-Align-Integrate-Investigate (A2I2) Model:** Trains teachers in applying ET principles in creating learning designs (LDs) with ET tools like wikis

**Customized Visualization Integration System (CuVIS) Framework:** Guides teachers in creating customized, constructively aligned, meaningful learning designs (LDs) using visualization (video/animation/simulation).

**Vlab Learning objectives-Tasks-Assessment (Vlab LoTaAs) Framework:** Guides teachers to generate customized laboratory manuals for teaching using Vlabs.

**Assessment instrument Quality Evaluator (IQuE) Framework:** Facilitates teachers in automatic evaluation of quality of assessment instruments based on constructive alignment.

### Teacher Training

- **6 training programmes** in 3 different modes (Face-to-Face, Blended Online, MOOC)  
- **Total of 16,225 participants** trained. (23 in face-to-face, 10883 in Blended, 5329 in MOOC)  
- **90%** teachers conveyed positive intentions of applying strategies learnt during training
Professional Developments through xMOOC

- Teacher professional development (TPD) MOOC courses through IITBombayX
- Educational Technology for Engineering Teachers [ET601Tx]
  (5390 registered, 3427 active, 1281 certified participants)
- Use of ICT in education for online and blended learning
  (5041 registered, 2193 certified participants)

Key Features of our MOOC Course

- Course designed on principles of
  - Pertinency - Immersivity - Constructive alignment
- New Pedagogies
  - Learning dialog videos (LeD) within-built reflection spots,
  - Learning by doing (LBD) activities with personalized and detailed feedback,
  - Practice focused discussion forums (DF)
- Communities of practice developed by participating teachers themselves to assist in applying the learnings through sustained practice.

MOOC Results

67.5% registered participants actively participated
47.1% of active learners participated in discussion forums through discussion threads and comments
36.58% completion rate for TPD MOOC

Research Studies on Active Learning in Face-to-Face Classroom of IITB

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<th>Active Learning Strategy</th>
<th>Results</th>
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<td>Computer programming (CS101)</td>
<td>Think-Pair-Share, Peer Instruction</td>
<td>i) 83% students engaged (based on observation protocol)</td>
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<td>ii) Higher learning than lecture (controlled-experiment)</td>
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<td>iii) High student perception (survey, course evaluation)</td>
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<tr>
<td>Foundations of projects in Electrical Engineering (EE 590)</td>
<td>GPGP Guided Problem-solving and Group Programming</td>
<td>i) Significant pre-post gain on problem-solving skills</td>
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<td>ii) High perception of learning</td>
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<td>Neuromorphic Engineering (EE 746)</td>
<td>Delayed Guidance in-class ill-structured problem solving</td>
<td>i) Higher problem solving skills compared to traditional methods (controlled-experiment)</td>
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<td>ii) Wider range of problem solving heuristics</td>
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<td>Data structures and algorithms (CS 213)</td>
<td>Think-Pair-Share</td>
<td>i) Relative gain twice for TPS topic than traditionally taught topic</td>
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<td>ii) Majority students wanted more TPS topics</td>
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<tr>
<td>Computer networks (CS 716)</td>
<td>Analogical problem solving, Think-Pair-Share, Peer Instruction</td>
<td>Students able to apply concepts from real life to solve networking problems in new unseen topic</td>
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For more information and to see a complete list of publications, visit the website http://www.et.iitb.ac.in/projects/tuet/
Technology Enhanced Learning (TEL) Environments for Students

Focus
Teaching-Learning of Thinking Skills such as engineering design, knowledge integration, estimation, troubleshooting, scientific inquiry

Context
- Student centered self-learning environments
- Tertiary Education

MicOMaP
- Develop students’ Micro-Macro scientific thinking skill in the domain of Basic Electronics.
- Activities based on “predict-observe-explain”.
- Features such as Microscopic dynamics simulation, Linked macroscopic visualization, Pedagogical agent.
- Experimental Studies (N=73) found that the learning environment was effective in developing students modeling abilities.

MEttLE
- TELE for developing engineering estimation skills for the topics of power and energy.
- Learning environment gets students to create functional, qualitative and quantitative models, followed by calculation and evaluation of values, and reflection on the estimation process.
- Salient features: Mapping tool, fully manipulable simulation, equation builder, question prompts.

IKnowIT
- A TELE to improve students’ knowledge integration (KI) processes.
- Engages students with exploratory question posing based activities which are aligned to the different processes of the KI framework.
- Students ask new questions around given topics and collaboratively categorize and criticize each others’ questions.

PHyTeR
- A TELE to develop troubleshooting skills for CS undergraduates for topics in computer networks.
- Students work on authentic scenarios, thus giving them practice and insights on phases of troubleshooting.
- Network Simulator based system having scaffolds such as process history viewer, hypotheses prioritizer
- Learners can draw functional & causal topologies, run test on simulator, compare with expert solution while solving a scenario.
Technology Tools for Teachers

Focus
Empower teachers to integrate technology tools effectively in their teaching.

Context
• Face-to-face classroom and laboratory settings
• Tertiary Education

iSAT
Interactive visualization to assist cohort analysis.
- Get proportions of cohorts based on preset criteria on attribute values and trace their transition across attributes.
- Free online tool assists researchers and instructors to find patterns of transitions in educational dataset.
- Researchers have used the tool to extricate pattern, explain trends and assist in their decision-making.
- SUS score: 71.58 (N=30).
http://www.et.iitb.ac.in/iSAT

CuVIS
Guides instructors on creating effective constructively aligned learning designs using visualizations.
- 1200 instructors have found CuVIS tool to be highly useful and usable (SUS score = 78.85)
- Use of CuVIS led teachers to shift from lecturing to designing student-centered activities
- CuVIS use also led to increase in teacher's total TPACK in creating LDs.
http://www.et.iitb.ac.in/cuvis/

IQuE
Measures alignment of assessment instrument (AI) with a set of learning objectives (LOs)
- Provides a visual representation of alignment.
- Utilizes ontology based knowledge representation mechanism to integrate syllabus contents, LOs and AI.

ADVicE
Guides teachers on selecting learning objectives and virtual labs aligned to it, designing activities and assessment questions aligned to learning objectives.
- Generates a dynamic lab manual for customized to teacher inputs on learning objectives, tasks, assessment questions.
- 82% of teachers using the tool found it useful in experiment design.
http://vlabs.iitb.ac.in/vlabs-dev/vlab_tool/main_index.php
Handbooks for ET Researchers and Practitioners

Focus
Curriculum, Framework and Research aids

Computer Masti Curriculum
• A Model Computer Science Curriculum for K-12 Schools.
• Key Features: Thinking Process Skills, Thematic Integration, Spiral Curriculum, Scalability, Grade-wise Topics, Learning Objectives, Recommended teaching-learning strategies.
• Curriculum used by 0.5 million students directly in 200+ schools as of 2014.
• E-Books downloaded in more than 130 countries.

Technology Enhanced Learning of Thinking Skills
• Pedagogical Framework for developing thinking skills using Technology Enhanced Learning (TEL) environments.
• Helps researchers characterize thinking skill, design productive learning activities and supports, and architect technology features.
• Forms basis of TEL environments: TELE-EDeSc, MICOMAP, IKnowIT, MEttLE, GI, PHyTeR.

Research Methods in Educational Technology
• Guidelines and Templates for planning, conducting and reporting research in Educational Technology.
• Focus on teaching-learning interventions that involve a technology-based instructional strategy or development of an ET tool.
• Target Users: Instructors who wish to carry out action research, Researchers who develop new ET tools.
• Highlights criteria used by reviewers to evaluate research papers.
• Includes templates to be used in various stages of research, guidelines to carry out research steps.

Learning Object Evaluation
• Learning Object Evaluation Instrument customized for learning objects (LOs) that include visualizations (animations / simulations) and associated components like assessment banks and learning designs.
• Useful for evaluating LOs as a teaching-learning resource and learning design aid.
• Based on constructive allignment.
• Developed instrument pilot tested for reliability & validity.

For more details visit http://www.et.iitb.ac.in/handbooks
Open Educational Resources

Focus
ET Research Resources Templates
Teaching Strategy Templates
Multimedia Learning Object

Target Users
• ET researchers for action research
• Teachers interested in designing and implementing student centered activities

Researcher Resources

Templates to conduct ET research studies:
(i) Idea Proposal Template (IPT)
(ii) Study Proposal Template (SPT)
(iii) Paper Planning Template (PPT)
(iv) Paper Writing Template (PWT)

The templates offer scaffolds to the researcher during various stages of research, so that reviewers’ criteria are effectively addressed.
• Scope of these resources: teaching-learning interventions, in the form of technology-based instructional strategies or development of tools to aid specific teaching-learning problems.
• 2000+ engineering teachers have been trained to use these templates.

For more details refer RMET Handbook or visit http://www.et.iitb.ac.in/ResearchResources.html

Teacher Resources

Research based teaching strategy templates for learner centered in-class activities

Templates are organized as:
• Activity Constructors - In-class student-centered activity design guidelines for strategies like Peer Instruction (PI), Think-Pair-Share (TPS) and Flipped classroom.
• Learning Design Blueprints - Guidelines for creating learning designs for teaching using visualizations (animations/simulations).
• Writing of learning objectives and assessment questions aligned to Bloom’s level.
• Evaluation rubric for instructor designed in-class learning activities such as PI, TPS.
• Other Open Education Resources - e.g. Lesson Activity in Moodle for Concept Maps.

For more details visit http://www.et.iitb.ac.in/projects/tuet/et4et/resources.html

Other OERs

Oscar
Open Source Courseware Animation Repository
oscar.iitb.ac.in

VLabs
Virtual Labs in various Science and Engineering disciplines
vlabs.iitb.ac.in

Spoken Tutorial
Spoken Tutorials on various Free and Open Source Software
spoken-tutorial.org
Consultancy
- Education Technology Industry (e-learning)
- Multimedia Content Creation
- Instruction Design
- Development of Training Programs
- Evaluation Research

Continuing Education Programmes
We conduct in-house and open courses for professionals in industry and academia in various areas in educational technology. These courses are conducted through the Continuing Education Programme (CEP) of IIT Bombay. These are some courses that have been conducted through CEP:

- Pedagogy for effective use of ICT in Engineering Education
- Teaching strategies for engineering and science college faculty
- Research methods in Educational Technology
- Instructional design for multimedia content creation
- Blender open-source software for 3D animation

If you are interested in a CEP course, please contact the IIT Bombay CEP Office http://www.cep.iitb.ac.in/

Honorary Activities
We have been actively participating in the following activities:

- Executive Committee members of Asia-Pacific Society for Computers in Education (APSCE)
- Steering Committee Members of Technology for Education (T4E)
- Co-ordinators of IEEE TCLT Working Group
- Program and Track Chairs of conferences: ICCE, ICALT, T4E, LaTiCE, epiSTEME in multiple years
- Reviewers of ET journals and conferences
- Participation in India’s National Mission in Education through ICT