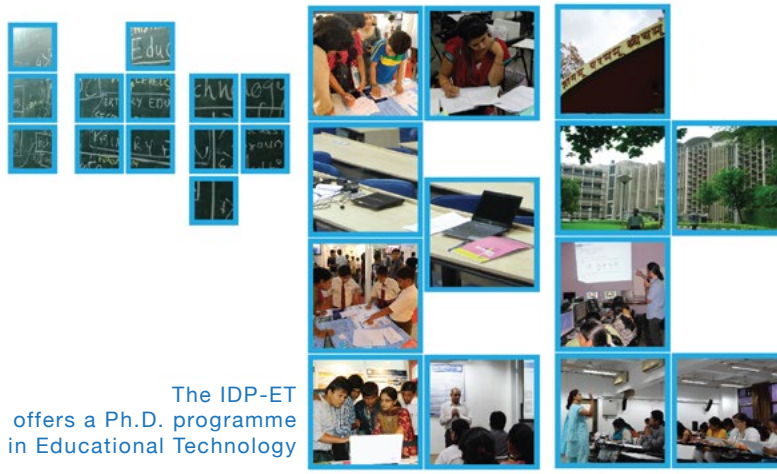


The IDP-ET
offers a Ph.D. programme
in Educational Technology

Established 2010

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

Indian Institute of Technology Bombay
Mumbai, India

Research Scholars

	Thesis Area	Faculty advisor
 Abhinav Anand	Teaching and Learning of Abstract Mathematical Concepts for Signals and Systems learners of Electrical Engg Students	Prof. Vikram Gadre
 Aditi Kothiyal	A Technology-Enhanced Learning Environment for Engineering Estimation Skills	Prof. Sahana Murthy
 Anita Diwakar	Development of Guidelines for Teaching and Learning with Virtual Laboratories in Engineering Education	Prof. Santosh Noronha
 Anura Kenkre	Designing a TEL Environment for developing Micro to Macro Thinking Skill by Self Mediated Learning.	Prof. Sahana Murthy
 Anurag Deep	Teaching-learning of Hypothetico-deductive reasoning skill for Bio-science undergraduates	Prof. P.Jayadeva Bhat, Prof. Sahana Murthy
 Eranki Kiran	A Collaborative approach to scaffold programming efficacy using spoken tutorials	Prof. Kannan Moudgalya
 Gargi Banerjee	A framework for enabling instructors to create effective customized learning designs with visualization (CuVIS)	Prof. Sahana Murthy
 Jayakrishnan M. Warriem	A Model for In-Service Teacher Training Design for Integrating ET in Engineering Education	Prof. Sahana Murthy, Prof. Sridhar Iyer
 Kapil Kadam	Computer Based Training for Improvement of Spatial skills	Prof. Sridhar Iyer
 Kavya Alse	Teaching-learning of troubleshooting skills for computer science undergraduates	Prof. Sridhar Iyer, Prof. Sasikumar M.
 Mrinal Patwardhan	Designing Interactivity Enriched Learning Environments in Signals and Systems Education	Prof. Sahana Murthy
 P. Deepti Reddy	Development of divergent and convergent thinking through open problem based learning.	Prof. Sasikumar M., Prof. Sridhar Iyer
 Prajish Prasad	A Technology Enhanced Learning Environment for Developing Deductive Reasoning Skills in Researchers	Prof. Sridhar Iyer
 Rekha Ramesh	Framework for generation and evaluation of assessment instrument (IQuE)	Prof. Shridhar Iyer, Prof. M. Sasikumar
 Rwitajit Majumdar	Visual Analytics of Educational Dataset	Prof. Sridhar Iyer, Prof. Aniruddha Joshi
 Shitanshu Mishra	Improving students' knowledge integration Proceses through exploratory question posing	Prof. Sridhar Iyer
 Soumya N.	Divergent and Convergent Thinking Skills in the context of Electronic Circuit Design	Prof. Sahana Murthy
 T.G.Lakshmi	Technology Enhanced Learning Environment for Developing Decomposition Skills	Prof. Sridhar Iyer
 Vikram Vincent	Technology framework for learning thinking skills in history	Prof. Ravi Poovaiah
 Ashutosh Raina	Computational Thinking in Engineering Undergraduates Using Makerspaces	1st year
 Pratidnya Hegde Patil	Teaching-Learning of Critical Thinking Skills for Engineering Undergraduates	1st year

Post Doctoral Researcher

Dr. Renumol V.G.

mentor: Prof. Sahana Murthy

For more information visit
http://www.et.iitb.ac.in/Students.html

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

Inter-disciplinary Programme in Educational Technology (IDP-ET)

An Overview

Research focus

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.

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

  - 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.

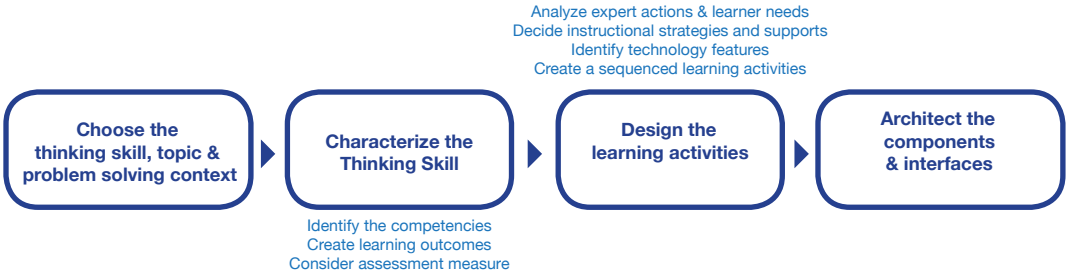
Context

- 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

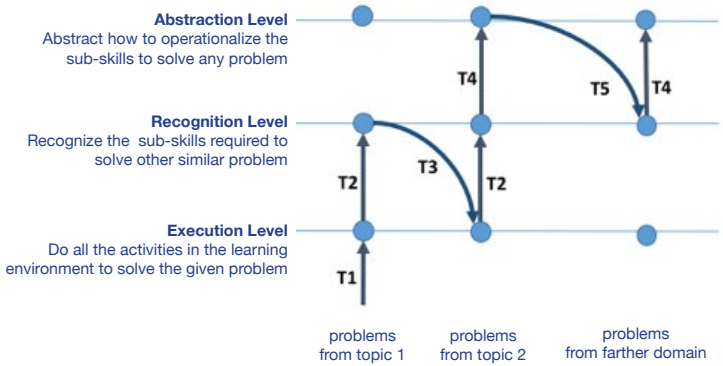


ref: S. Murthy, S. Iyer and M. Mavinkurve. **Pedagogical Framework for Developing Thinking Skills using Smart Learning Environments.** To appear in: Learning, Design, and Technology: An International Compendium of Theory, Research, Practice and Policy, AECT-Springer Online Major Reference Work.

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



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.

$\mathbf{T}_i$: Tasks in learning environment such as :Learning Activities, Customized Feedback, Synthesis & Reflection Activities, etc. At least one $\mathbf{T}_i$ 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".

TELoTS systems developed

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

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/

Project TUET: Teacher Use of Educational Technology

Focus

Empowering teachers in effective technology integration practices in their own teaching-learning context

Context

- Instructor-mediated classrooms
- Classrooms where students cannot directly manipulate ICT.
- Target the Engineering Education sector.

Overview of the Project TUET

Problem	Selection of technology	Familiarity of use of technology	Knowledge of effective teaching & assessment strategies	Alignment: Objective Strategy Tool Assessment	Effective integration	Translate into practice	… Sustained practice
Theoretical Basis	Taxonomies		Constructivisit practices	Constructive alignment Meaningful learning with ICT		Diffusion of Innovation	
Design Drivers	Pertinency	Immersivity	Immersivity	Immersivity, Pertinency		Transfer of ownership	
Frameworks developed	A2I2: Attain-Attain-Integrate-Investigate CuVIS Vlab, LoTaAs						
Tools			IQuE	CuVIS, ADVIcE			
Teacher Resources	Training workshop curriculum, Videos, Activity constructors, Learning Design blueprint, Content repositories (subject-wise examples, questions, activities, LDs)						
Implementation	18 Workshops conducted 10 Face-to-face || 7 Blended online (3 Large scale, 1 Medium) || 1 – MOOC						Mentoring for Action Research

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.

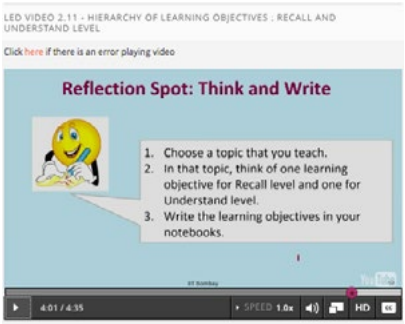
Teacher Training

- **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)

Reflection spot in an LeD video



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

Course	Active Learning Strategy	Results
Computer programming (CS101)	**Think-Pair-Share, Peer Instruction**	i) 83% students engaged (based on observation protocol) ii) Higher learning than lecture (controlled-experiment) iii) High student perception (survey, course evaluation)
Foundations of projects in Electrical Engineering (EE 590)	**GPGP** Guided Problem-solving and Group Programming	i) Significant pre-post gain on problem-solving skills ii) High perception of learning
Neuromorphic Engineering (EE 746)	**Delayed Guidance** in-class ill-structured problem solving	i) Higher problem solving skills compared to traditional methods (controlled-experiment) ii) Wider range of problem solving heuristics
Data structures and algorithms (CS 213)	**Think-Pair-Share**	i) Relative gain twice for TPS topic than traditionally taught topic ii) Majority students wanted more TPS topics
Computer networks (CS 716)	**Analogical problem solving, Think-Pair-Share, Peer Instruction**	Students able to apply concepts from real life to solve networking problems in new unseen topic

For more information and to see a complete list of publications, visit the website
http://www.et.iitb.ac.in/projects/tuet/

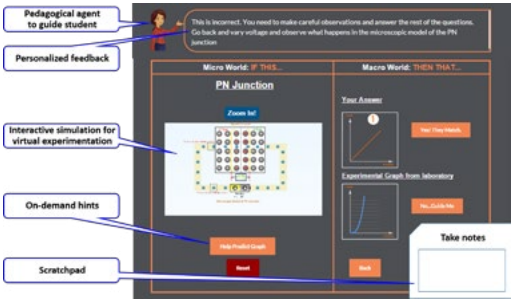
Technology Enhanced Learning (TEL) Environments for Students

Focus

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

Context

- Student centered self-learning environments
- Tertiary Education

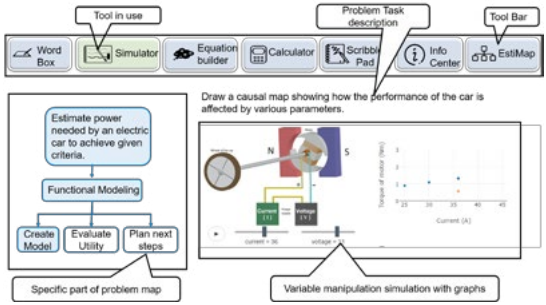


MicOMaP

- 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.

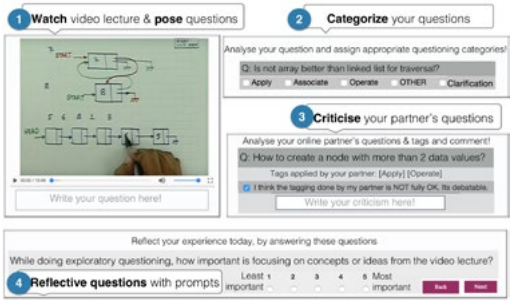
MEttLE

- 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.



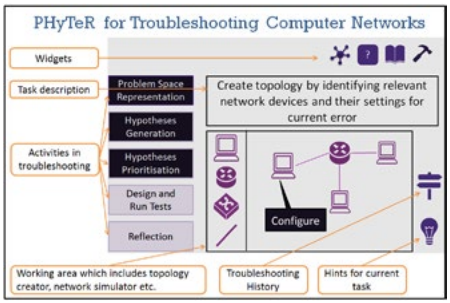
IKnowIT

- 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.



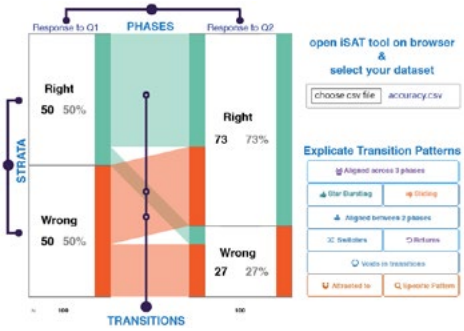
Technology Tools for Teachers

Focus

Empower teachers to integrate technology tools effectively in their teaching.

Context

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

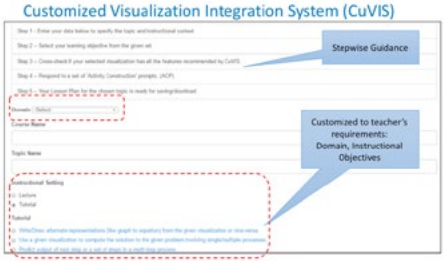


iSAT

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..iib.ac.in/iSAT

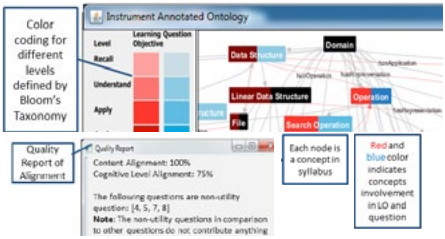


CuVIS

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.

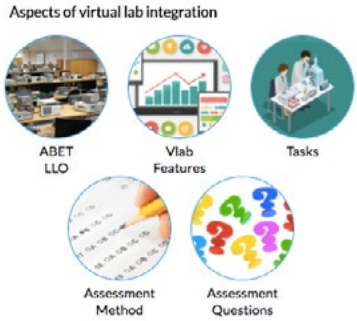
http://www.et.iitb.ac.in/cuvis/



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

Target Users

- ET researchers and practitioners

Computer Masti Curriculum

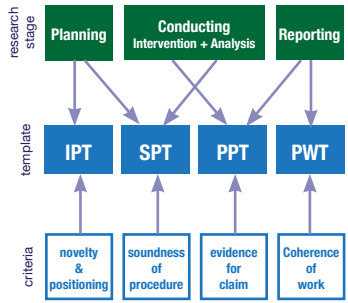
- A Model Computer Science Curriculum for K-12 Schools.
- Key Features: Thinking Process Skills, Thematic Integration, Spiral Curriculum, Scalability, Grade-wise Topics, Learning Objectives, Recommended teaching-learning strategies.
- Curriculum used by 0.5 million students directly in 200+ schools as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

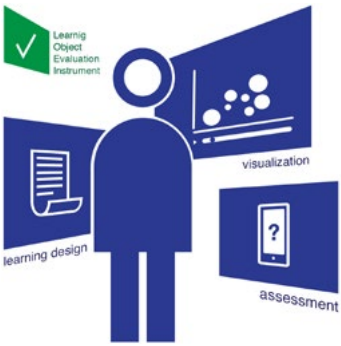
Technology Enhanced Learning of Thinking Skills

- 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 technolgy -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

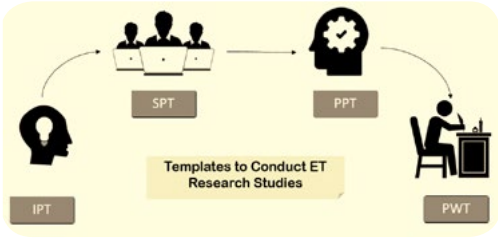
Focus

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)

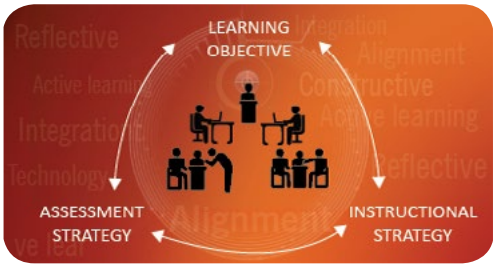
The templates offer scaffolds to the researcher during various stages of research, so that reviewers' criteria are effectively addressed.

- 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

Professional Services

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

IDP in Educational Technology
Indian Institute of Technology Bombay Powai,
Office: Mathematics Building, Near Central Library.
Mumbai, India 400 076
Tel: +91 22 2576 / 4820
Fax: +91 22 2576 / 4812
www.et.iitb.ac.in