Technology-enhanced Learning of Thinking Skills

Project TELoTS

http://www.et.iitb.ac.in/projects/telots/

Focus and Context
- Build a suite of research-based Technology-enhanced Learning Environments (TELE) to develop learners’ pan domain thinking skills (TS) such as design thinking, estimation, knowledge integration, troubleshooting, convergent-divergent thinking and science process skills.
- Predominantly for self-learning.
- TELoTS systems are primarily designed for tertiary education learners.

Highlights of Project
- TELoTS pedagogical framework\(^1\) applied for designing and developing learning environments.
- Design-based research methodology used for evaluating and improving learning environments.

The TELoTS Pedagogical Framework

Theoretical Foundations
- Inquiry-based learning with real-world problems.
- Series of interactive learning activities.
- Metacognitive reflection activities to facilitate progressive abstraction of skills by learners.

Learning via Progressive Abstraction of Thinking Skills

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Metacognition Level 3

Metacognition Level 2

Metacognition Level 1

Cognition

Doing

Evaluation

Synthesis

Abstraction

- There exist four progressive levels of cognition and metacognition – doing, evaluation, synthesis, and abstraction.
- Learning of a thinking skill happens when a learner is explicitly taken through the four levels.
- The learning path may take the learners iteratively between the levels.

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### TELoTS Systems

<table>
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<tr>
<th>TS/TELoTS System</th>
<th>Domain/ Context</th>
<th>Design Drivers</th>
<th>Key Results</th>
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</table>
| 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 developed 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 integration framework based on guided question posing | • Three broad exploratory question posing strategies identified  
• Local learning theories of student question posing and its relation to knowledge integration developed |
| Engineering Estimation/MEtttLE          | 3rd and 4th year Electrical and Mechanical Engineering undergraduates | • Interactive modelling tools  
• Different types of question prompts  
• Problem map and reflection | • Experts and novices (in MEtttLE) estimation process characterized  
• Roles of mental simulation and external representations identified |
| Expansionist-Reductionist Skills/FATHOM | Data Structures/2nd Year Computer Science Undergraduates | • Cognitive and metacognitive prompts  
• Drawing tool and text boxes  
• Formative feedback  
• Self and peer assessment | • Significant improvement in expansionist-reductionist skills from pretest to post-test  
• Good expansionist-reductionist behaviors of students identified |

### TELoTS Workshops
- Blender-based mental rotation training (TI MeR) for improving 1st year engineering undergraduates’ engineering drawing skills using the 3D interactive visualization tool, Blender, and Demo-Drill-Practice.

### TELoTS Systems in Progress
- **PHyTeR** system for troubleshooting skills for 3rd year computer science undergraduates.
- **Geneticus Investigatio** system for problem solving and process skills for bio-science engineering undergraduates.
- **History Maker** tool for historical thinking skill for History undergraduates.
- A TEL for conceptual design of open ended software design problems for senior computer science undergraduates
- A TEL for evaluation of a software system design for senior computer science undergraduates
- A TEL for convergent and divergent thinking for electrical engineering undergraduates.
- A TEL that enables learners to develop a tinkerer’s mindset for senior high school students and freshman engineering undergraduates.
- **GA Tutor** system for algorithmic thinking for computer science undergraduates.