Academic excellence through quality technical education: Challenges and opportunities

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Inter-Disciplinary Program in Educational Technology
IIT Bombay

AICTE sponsored national seminar
Thakur College of Engineering and Technology
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Our goals as educators

We want students to learn:

• Content
  how does it all fit together, hierarchy of concepts

• Engineering “abilities’
  complex problem solving, designing experiments, making predictions, checking solutions

• Attitudes and skills
  communication, ethics, teamwork, social responsibility
Our goals as educators

We also need to fulfill:

• Prepare students for the globalized 21st century world
• Make sure our students are employable
• NBA criteria
• Possibly target ABET criteria, Washington accord
• …
Challenges and solutions
# Teaching-learning scenario

## What did the teacher do?
- Explained logic circuits using truth table and Boolean expressions.
- Solved multiple problems to find Boolean expression for given logic diagrams, and vice-versa.

## What did students do?
- Studied all gates.
- Solved number of problems related to finding of Boolean expression for logic diagram and vice-versa.

## What were exam questions?
- Real life scenario was given in which students were supposed to identify the gates, draw logic diagram and write Boolean expression.

## What was the result?
- Most students were not able to solve this problem
- Students unhappy; teacher unhappy.
Who’s right?

Students’ comment:
The question was out of syllabus. We have not done such problems in the class.

Teacher’s comment:
The question is simple since students know truth table for gates. They just have to apply logic to the given scenario and solve the problem.

Vote
1) The teacher is right, but not the students.
2) The students are right, but not the teacher.
3) Both are in fact right.
Both are right … but what went wrong?

Teachers expectations not conveyed to students.

Students understanding not clear to teachers.

Lack of alignment: goals, strategies, assessment
Challenge #1: Mismatch

- Teachers’ expectations
- Teaching strategy
- Assessment questions
- Students’ study plan
Addressing the challenge

- Teachers’ expectations
- Teaching strategy
- Learning objectives
- Assessment questions
- Students’ study plan
<table>
<thead>
<tr>
<th>Today’s class</th>
<th>Description from syllabus</th>
</tr>
</thead>
</table>
| Section 2.3 from textbook | Logic gates  
AND, OR, NOR, NAND gates, logic diagram, Boolean expressions, gate combination |
<table>
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<tr>
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<tbody>
<tr>
<td>Section 2.3 from textbook</td>
<td>Logic gates AND, OR, NOR, NAND gates, logic diagram, Boolean expressions, gate combination</td>
<td>On completion of this class, the student will be able to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Draw symbol of logic gates.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Write truth table of AND, OR, NOR, NAND gates.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Draw logic diagram for given mathematical expression.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Calculate outputs for logic gate combinations.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solve real-life problem by identifying logic gate combination</td>
</tr>
</tbody>
</table>
## From syllabus … to learning objectives

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<td><strong>Logic gates</strong>&lt;br&gt;AND, OR, NOR, NAND gates, logic diagram, Boolean expressions, gate combination</td>
<td>On completion of this class, the student will be able to:&lt;br&gt;&lt;br&gt;<strong>Draw symbol of logic gates.</strong>&lt;br&gt;<strong>Write truth table of AND, OR, NOR, NAND gates.</strong>&lt;br&gt;<strong>Draw logic diagram for given mathematical expression.</strong>&lt;br&gt;<strong>Calculate outputs for logic gate combinations.</strong>&lt;br&gt;<strong>Solve real-life problem by identifying logic gate combination</strong>&lt;br&gt;<strong>Precise, measureable</strong></td>
</tr>
</tbody>
</table>
Why learning objectives?

Learning objectives will help us answer:

- What knowledge, skills, attitudes do we want students to develop?
- How should we structure the content of your material?
- What resources and strategies should we use in our instruction?
- How should we assess the students’ learning?

Learning: systematic process
Teaching: systematic process
Assessment: Clear, fair, accurate
What is a learning objective?

Indicates specific measurable performance outcome of learner

Recall –
On completion of this class, the student will be able to:
• Draw symbol of logic gates.
• Write truth table of AND, OR, NOR, NAND gates.
• Draw logic diagram for given mathematical expression.
• Calculate outputs for gate combinations.
• Solve real-life problem by identifying logic gate combination.
Is this a valid learning objective?

Students will know how logic gates work.

VOTE - 1) Yes    2) No
Is this a valid learning objective?

Students will know how logic gates work.

VOTE - 1) Yes 2) No
Is this a valid learning objective?

Students will know how logic gates work.

VOTE - 1) Yes  2) No

How will you measure?

The “knowing” is inside students’ head.
Is this a valid learning objective?

Students will be able to understand the function of logic gates.

VOTE - 1) Yes    2) No
Is this a valid learning objective?

Students will be able to understand the function of logic gates.

VOTE - 1) Yes 2) No

What precisely do you mean by “understand?”

Different interpretations -

1) Students should be able to describe function of given logic gate.
2) Students should be able to convert the logic diagram to a mathematical expression.
2) Students should be able to apply the function of a gate to solve a real-life problem.
Is this a valid learning objective?

Students will be able to understand the function of logic gates.

VOTE - 1) Yes  2) No

What precisely do you mean by “understand?”

VOTE -
1) Students should be able to describe function of given logic gate.
2) Students should be able to convert the logic diagram to a mathematical expression.
2) Students should be able to apply the function of a gate to solve a real-life problem.
Is this a valid learning objective?

• Students will appreciate real-life potential of logic gates.

VOTE -- 1) Yes 2) No
Is this a valid learning objective?

- Students will appreciate real-life potential of logic gates.

VOTE -- 1) Yes   2) No

How can we measure if students “appreciate”?
Is this a valid learning objective?

- Students will appreciate real-life potential of logic gates.

VOTE -- 1) Yes  2) No

How can we measure if students “appreciate”? 
Constructing learning objectives

Indicates **specific measurable performance outcome** of learner

<table>
<thead>
<tr>
<th>DON’T</th>
<th>Instead DO</th>
<th>Need to be</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understand logic gates</td>
<td>Formulate using “action” verbs: identify, list, describe, explain, solve, analyze, design, compare</td>
<td>Specific and measurable</td>
</tr>
<tr>
<td>Know how logic gates work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appreciate potential of logic gates</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Is this a valid learning objective?

• Give lecture on function of logic gates.
  1) Yes  2) No

• Show visualization of how logic gates work
  1) Yes  2) No
Is this a valid learning objective?

• Give lecture on function of logic gates.
  1) Yes  2) No

• Show visualization of how logic gates work
  1) Yes  2) No

Learning objectives should be concerned with learners’ actions, not teacher’s.
# Constructing learning objectives

Indicates **specific measurable performance outcome** of learner

<table>
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<tr>
<th>DON’T</th>
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</table>
| • Understand logic gates  
• Know how logic gates work  
• Appreciate potential of logic gates  
• Lecture on logic gates  
• Show visualization of logic gates function | Formulate using “action” verbs: identify, list, describe, explain, solve, analyze, design, compare | Specific and measurable |
| The student will be able to … | Concerned with learner |
How to write learning objectives

Start with: The student should be able to ...

Use **action verbs**

- identify, list, describe, draw, explain, solve, analyze, compare, design
- (avoid understand/know)
How to incorporate “difficulty” of cognitive level in learning objectives

- Draw symbol of logic gates.
- Write truth table of AND, OR, NOR, NAND gates.
- Draw logic diagram for given mathematical expression.
- Calculate outputs for gate combinations.
- Solve real-life problem by identifying logic gate combination.
- Design circuits for math operations using gates.

**Formal theory:** Hierarchy of cognitive levels
Revised Bloom’s Taxonomy – 6 levels
## Hierarchy of cognitive levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Action verbs</th>
<th>Example Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recall</td>
<td>Recognize, recall facts</td>
<td>cite, label, list, define, quote, identify, state</td>
<td>Define the AND operation using a mathematical expression. Draw symbol for OR gate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Define the AND operation using a mathematical expression.</strong> Draw symbol for OR gate</td>
</tr>
<tr>
<td>Understand</td>
<td>Grasp meaning, explain, interpret, translate, paraphrase</td>
<td>explain, rephrase, convert, give examples, summarize, translate, illustrate, reword, interpret, Paraphrase</td>
<td>Explain why NAND and NOR gate are called universal gates. <strong>Give an example of …</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Give an example of …</strong></td>
</tr>
<tr>
<td>Apply</td>
<td>Use knowledge in a new situation. Involves rules, methods, laws, principles</td>
<td>Apply, relate, solve, classify, predict calculate, prepare</td>
<td>Calculate the output of:</td>
</tr>
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# Hierarchy of cognitive levels

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<tr>
<th>Level</th>
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<th>Action verbs</th>
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</tr>
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<tbody>
<tr>
<td>Analyze</td>
<td>Separate whole into parts until structure of whole and relation between parts is clear.</td>
<td>analyze, infer, examine, ascertain, associate, dissect, discriminate,</td>
<td>Get the output given by the following equation: $A + AB + AB$</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Judge value based on criteria, decision making.</td>
<td>assess, conclude, decide, contrast, compare, evaluate</td>
<td>Decide if it is better to use NAND or NOR gate for goal</td>
</tr>
<tr>
<td>Create</td>
<td>Combine parts to make (new) whole, creative behaviours, propose plans</td>
<td>design, combine, devise, modify, plan, extend, compile, generalize</td>
<td>Design a half adder circuit using AND, OR, NOT gates.</td>
</tr>
<tr>
<td>Challenge (#1)</td>
<td>Address</td>
<td>Benefits</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>---------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>Mismatch between teacher expectation, student study plan, exam questions</td>
<td>Write valid learning objectives for course, module, lecture unit. Set exam questions aligned to learning objectives</td>
<td>Our goals met – deep content, engineering skills NBA criteria met Students’ employability increases.</td>
<td></td>
</tr>
</tbody>
</table>
More challenges ....
and some solutions
Challenge of student engagement

How many of you have faced this in your class: Students not engaged, bored, tuned out …

1) All the time!
2) Often
3) Sometimes
4) Never
Challenge of student engagement

How many of you have faced this in your class:

Students not engaged, bored, tuned out …

1) All the time!
2) Often
3) Sometimes
4) Never

Leading to decrease in learning
Examples – challenge and addressal

Effect of Think-Pair-Share in a Large CS1 Class:
83% Sustained Engagement

Challenge: Engage students in a 1st year programming class
Strategy: Think-Pair-Share

Program Visualization as a Pivotal Tool Of Instruction In a Large Resource Constrained Classroom to Teach Novice Learners Computer Programming wi

Challenge: Student learning of basic programming concepts
Strategy: Students interact with a program visualization
Examples – challenge and addressal

3Pf: Prepare-Present-Positive feedback –
An Active Learning Approach for Low Achievers

Challenge: Low achieving students lack confidence, poor communication skills
Strategy: Active learning approach focused on low achievers

Demystifying Networking: Teaching Non-Majors via Analogical Problem-Solving

Challenge: Non-CS majors find details of n/w course daunting
Strategy: Use real life analogies and group problem solving
Strategies based on education research

Peer instruction w/ clickers
Think-Pair-Share
Collaborative problem solving
Just-in-time-teaching
Use of computer-visualizations
Concept maps
...

Not just tool, but also pedagogy
Converting challenges to opportunities through Educational Technology
Converting challenges to opportunities through Educational Technology
Which of the following would you consider to be educational technology?

1) Use ICT tools – computers, WWW, ppt, LMS, wiki
2) Design guidelines for an educational game
3) Plan group activities to be conducted in a classroom (such as collaborative project)
4) All the above
Educational Technology is technology of education as well as technology for education
What is Educational Technology?

The application of methods, strategies and tools that facilitate the teaching-learning process, with a focus on current technological tools.

Simply using ppt in lecture is NOT educational technology.
All-round academic excellence through educational technology

- How do people learn?
- What are its implications for pedagogy and technology?
- Who is the target audience? What are the goals?
- Which teaching strategies best address above?
- What technology tools provide best advantages for above?
- How to systematically design educational material?
- Did it all work?
Converting challenges to opportunities through Educational Technology
What you can do

Attend workshops : T10KT, QIP, within college …

Participate in NMEICT projects

Conduct ET action research in your class

Consider PhD in ET
Participate in faculty development workshops

• Effective teaching strategies for engg education

• Integrating educational technology in engg courses

• Research methods in ET

Offered through T10KT, IITB-QIP, other colleges …

See video tutorials on IITB ET webpage ➔ Resources

Opportunity:
Go beyond “showing ppt”
Learn new strategies and effective ET tools,
Implement in your class
Resources

Think – Pair – Share (TPS) – Talk by Prof. Sridhar Iyer – December 2013

- TPS resource sheet: Download - [.pdf], [.docx]
- TPS session slides: Download - [.ppsx], [.pptx]
- Session Video: [will be available soon]

Conducting and Reporting an Educational Technology Research – Templates to assist in ET Research Study

- Tutorial on Conducting Educational Technology(ET) Research Study – [.pptx]
- Guidelines for conducting ET Research Study – [.pdf]
- How to use the Templates and Guidelines – Readme [.docx] [.pdf]
- Idea Proposal Template – IPT [.docx] [.pdf]
- Study Planning Template – SPT [.pptx] [.pdf]
- Paper Planning Template – PPT [.pptx] [.pdf]
- Paper Writing Template – PWT [.docx] [.pdf]
Participate in NMEICT Projects

MHRD - National Mission on Education through ICT

http://nptel.iitm.ac.in/

www.spoken-tutorial.org
300+ tutorials, 20 languages

http://oscar.iitb.ac.in
300 animations, simulations

Teach 10000 Teachers
www.it.iitb.ac.in/nmeict
### Mission and Vision of the Institute

- **Institute:****
  - Dept #1: Bachelors in XYZ Program educational Objectives
  - Dept #2: Course A Course objectives
  - Dept #3: (PEO)
  - Dept #3: (PEO)

### Department(s)

- **Dept #1:** Bachelors in XYZ Program educational Objectives
- **Dept #2:** Course A Course objectives
- **Dept #3:** (PEO)
- **Dept #3:** (PEO)

### Courses

- **Dept 2:** Course B Course objectives
- **Dept 2:** Course C Course objectives

### Modules

- **Course A:** Module 1 Objective
- **Course A:** Module 2 Objective
- **Course A:** Module 3 Objective
- **Course A:** Module 4 Objective

### Units

- **Module 2:** Unit 1 objectives
- **Module 2:** Unit 1 objectives
- **Module 2:** Unit 1 objectives
- **Module 2:** Unit 1 objectives

### Problems / Assignment

- Problem 1
- Problem 2
- Problem 3
- Problem 4
- Problem 5
- Problem 6
- Problem 7
- Problem 8
- Problem 9

### NMEICT - Pedagogy Project Curriculum Design

- **Curriculum Design:**
  - Module 2:
    - Unit 1 objectives
  - Module 2:
    - Unit 1 objectives
  - Module 2:
    - Unit 1 objectives
  - Module 2:
    - Unit 1 objectives

- **Problems / Assignment:**
  - Problem 1
  - Problem 2
  - Problem 3
  - Problem 4
  - Problem 5
  - Problem 6
  - Problem 7
  - Problem 8
  - Problem 9
Conduct ET action research

• Research enhances teaching

• Classroom “action research” to integrate research and teaching
  – Propose a novel teaching idea (for ex., new TEL strategy)
  – Implement teaching idea in your class
  – Execute research study in your class
    • collect and analyze data
    • reflect on findings
  – Write paper for ET conference such as T4E
    • position wrt related work
    • describe rigorous methodology
    • draw claims, conclusions

Improve quality of teaching and learning
Conduct research, publish papers
Conduct ET action research

**T4E 2013**

*Effect of Comic Strips as a Supplementary Material to Teach Computer Networks*

Lakshmi Ganesh
M.E. (second year pursuing), Department of Computer Engineering
Thakur College of Engineering and Technology
Mumbai, India
lakshmigesht@gmail.com

**ICCE 2012**

*Interactive visualization to teach engineering design competencies*

Madhuri MAVINKURVE & Sahana MURTHY
*Indian Institute of Technology Bombay, India
 mavinkur vemk@gmail.com

**Opportunity:** Conduct a study and submit a paper to IEEE International Conference on Technology for Education T4E

http://www.ask4research.info/t4e/2014/
IITB Educational Technology Inter-Disciplinary Programme

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

• Started April 2010
• Ph.D. programme
• 20 Ph.D. students
• Faculty:
  – Core faculty in Educational Technology
  – CS, engineering, science, social science, design...
• Courses in ET, research methods
• R & D projects
**Opportunity:** Do PhD

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

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### Student Theses

<table>
<thead>
<tr>
<th>Student Name</th>
<th>Guide, Co-Guide</th>
<th>Thesis Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Madhuri Mavinkurve</td>
<td>Sahana Murthy</td>
<td>Development and assessment of engineering design competencies</td>
</tr>
<tr>
<td>Yogendra Pal</td>
<td>Sridhar Iyer</td>
<td>Developing a framework for scaffolding to teach programming to Hindi learners</td>
</tr>
<tr>
<td>Atul Deshpande</td>
<td>Mahesh Patil</td>
<td></td>
</tr>
<tr>
<td>Sachin Kamble</td>
<td>B. L. Tembe</td>
<td>Applying instructional design model and concept maps on student performance in classroom teaching of thermodynamics</td>
</tr>
<tr>
<td>Kapil Kadam</td>
<td>Sridhar Iyer</td>
<td>Computer Based Training for Improvement of Spatial skills</td>
</tr>
<tr>
<td>Eranki Kiran</td>
<td>Kannan Moudgalya</td>
<td>Development and assessment of Programming competencies through Spoken Tutorial workshops</td>
</tr>
<tr>
<td>Gargi Banerjee</td>
<td>Sahana Murthy</td>
<td>Developing a customized evaluation framework for Learning Objects</td>
</tr>
<tr>
<td>Mrinal Patwardhan</td>
<td>Sahana Murthy</td>
<td>Effectiveness of Interactive Visualizations in Engineering Education: Analyzing interactivity level of visualizations in applying knowledge</td>
</tr>
<tr>
<td>Anita Diwakar</td>
<td>Santosh Noronha</td>
<td>Development of guidelines to design, implement and evaluate Virtual Labs with quality pedagogy</td>
</tr>
<tr>
<td>Anura Kenkre</td>
<td>Sahana Murthy</td>
<td>Development the scientific ability of modeling using learning objects</td>
</tr>
<tr>
<td>Vikram Vincent</td>
<td>Ravi Poovaiah</td>
<td></td>
</tr>
<tr>
<td>Aliabas Petiwala</td>
<td>Kannan Moudgalya, Pushpak Bhattacharya</td>
<td>Automation in the Construction of Syllabus Conforming Customized Textbooks from Lecture Transcripts</td>
</tr>
<tr>
<td>Pankha Ramesh</td>
<td>Sridhar Iyer-Mahesh Patil</td>
<td>Design an appropriate framework for generating an</td>
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</tbody>
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ET Research Areas at IITB

• **Pedagogy for technology enhanced learning.**
  Innovative pedagogies and assessment
  Learner-centered strategies
  Technology integration for teachers

• **Development of technology-enhanced learning environments**
  Visualizations - animations, simulations
  ITS and adaptive learning systems

• **Discipline based education research**
  Physics, CS, Electronics
An Appeal to Principals, Deans, AICTE...
An Appeal to Principals, Deans, AICTE…

Encourage your faculty to pursue Ph.D. in ET.

Recognize ET as a valid discipline for PhD

It is a tremendous opportunity towards achieving academic excellence in quality technical education
Thank you!

Contact:
Email: office.et@iitb.ac.in
       sahanamurthy@iitb.ac.in
Phone: +91-022-2576-4820
Info: http://www.et.iitb.ac.in
      (PhD admissions, workshops, resources)