

# Learning from digital technologies – cognitive aspects

Sahana Murthy

Inter-Disciplinary Program in Educational Technology  
IIT Bombay



May 21, 2015

# A little about you ...

Before joining TISS, my background was in:

1. Science / Engineering
2. Education
3. Psychology
4. Other social science
5. Language or humanities

# A little about you ...

After graduating from TISS, I would like to:

1. Design curricular materials (for ex textbooks)
2. Teach in a school
3. Become a teacher educator
4. Do research → PhD
5. Work in a govt org / NGO (as ?)
6. Design online courses or e-learning materials
7. Other (?)

# Vote individually

After you graduate from MA-EE, you get a job as a teacher educator in a training institute. Your principal wants to launch an e-learning program for the 1<sup>st</sup> year students using popular new technological features such as games, simulations and social media, since today's youngsters are "into" these. What would you tell your principal?

- 1) Features such as games, simulations and social media are interesting and should be part of e-learning activities.
- 2) Features such as games, simulations and social media may interfere with learning and should not be part of e-learning.
- 3) Not sure which option I would choose

# Debate!

**Why use technology tools in education? /  
Why not use technology tools in education?**

Two groups:

Choice 1 – Why use technology

Choice 2 – Why not use technology

Choice 3 – ??

Each group has to write as many points as you can to  
answer your question.

1 minute only!

# Why use technology tools in education?

## *Your responses*

- improves access to knowledge – scaling, geography
- provide various sensory stimulation
- wide repository of info – www
- provides peer connectivity can provide opportunity for continuous learning, current learning
- improves efficiency

# Why not use technology tools in education?

## *Your responses*

- imagination can be reduced if too much reliance on tool, used in a rote manner
- certain cognitive skills are lost
- Social & emotional skills may be compromised (but note use of technology to improve such skills, for ex, for autistic children)
- We don't yet have sufficient evidence one way or the other whether e-learning works over a long time period

**\*\*lots of in class discussion \*\*\***

## *Takeaway from discussion -*

If tech tools are used merely for info transmission => learning is not effective

# Let's frame it differently

Instead of debate :

- Why / why not use technology tools in education?

Frame questions as:

- When and how\* does technology add value to learning?
- When does technology hinder learning? (and how to fix it)

*\* this is where learning sciences research comes into play – theories and empirical studies from psychology, cognitive sciences, neuroscience ...*



In order to answer:

When (and how) does technology add value to learning?

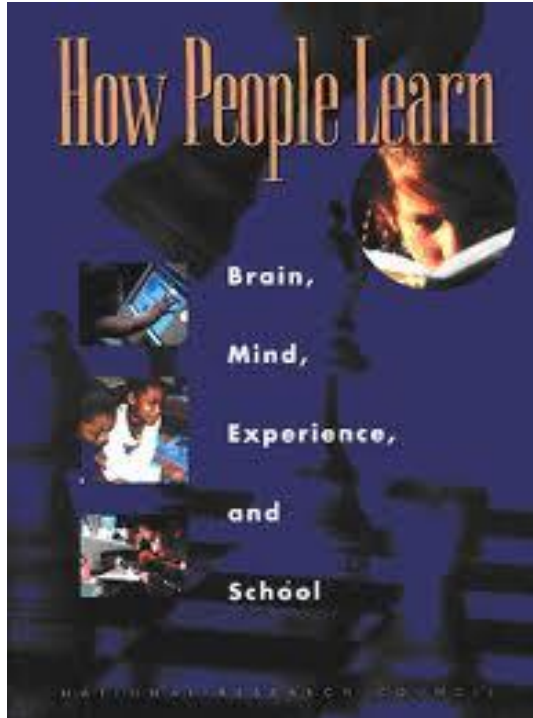
We need to first understand how people learn,  
We also need to understand how people learn with  
technology.

# Recall -

After you graduate from MA-EE, you get a job as a teacher educator in a training institute. Your principal wants to launch an e-learning program for the 1<sup>st</sup> year students using popular new technological features such as games, simulations and social media, since today's youngsters are "into" these. What would you tell your principal?

- 1) Features such as games, simulations and social media are interesting and should be part of e-learning activities.
- 2) Features such as games, simulations and social media may interfere with learning and should not be part of e-learning activities.
- 3) Right now, we do not know enough about human learning processes to make specific recommendations about which technological features to incorporate

# How people learn (broad)



## ToC

- How learning changes the physical structure of the brain.
- How prior knowledge affects what people notice and how they learn
- What the thought processes of experts tell us about how to teach.
- Learning potential of infants.
- Relationship of classroom learning and everyday settings of community and workplace
- Role of technology in education.

*United States National Academy of Sciences free e-book*

<http://www.nap.edu/catalog/9853/how-people-learn-brain-mind-experience-and-school-expanded-edition>

# How people learn – cognitive model

We'll examine features of the human cognitive model, especially memory, through a series of activities.

# Activity 1 - Memory

Memorize these numbers:

3 1 2 8 6 7 0 2 8 5 7 4

# Activity 1 - Memory

Memorize these numbers:

1 9 4 7 1 8 5 7 2 0 1 5

# Activity 1 - Memory

Memorize - 3 1 2 8 6 7 0 2 8 5 7 4

Memorize - 1 9 4 7 1 8 5 7 2 0 1 5

What happened?

# Activity 1 - Memory

Harder to memorize - 3 1 2 8 6 7 0 2 8 5 7 4

Easier to memorize - 1 9 4 7 1 8 5 7 2 0 1 5

Why?



# Cognitive model feature - memory

## Working memory is limited.

- Working memory can hold only  $7 \pm 2$  “units”
- Anything more – “cognitive overload”
- Can increase memorization capacity by **chunking** - group in smaller pieces of information into a larger, meaningful unit.
- Note the role of cultural and semantic knowledge here - India, so 1947, 1857 etc have meaning.

# Implications of memory features

DISCUSS –

1) Implications for learning ?

2) Implications for technology design ?

*ie suggest some features for how educational technology should be designed*

# Activity 2

Look at the painting below while reciting the numbers 1-10 in your head.



# Activity 2

What did the painting contain?

## Activity 2 (contd)

Read the text below while reciting the numbers 1-10 in your head

"I see that you came on the train this morning, " said he. The lady was amazed, and looked in surprise at my friend. "There is nothing strange, it is in fact elementary" my friend said with a smile. "There is dirt on the left arm of your jacket. I can see that it came there this morning. I think it happened when you were going to the station. I can also see a part of a ticket in your glove, so I know that you went on the train."

# Activity 2 (contd)

What was the story about?

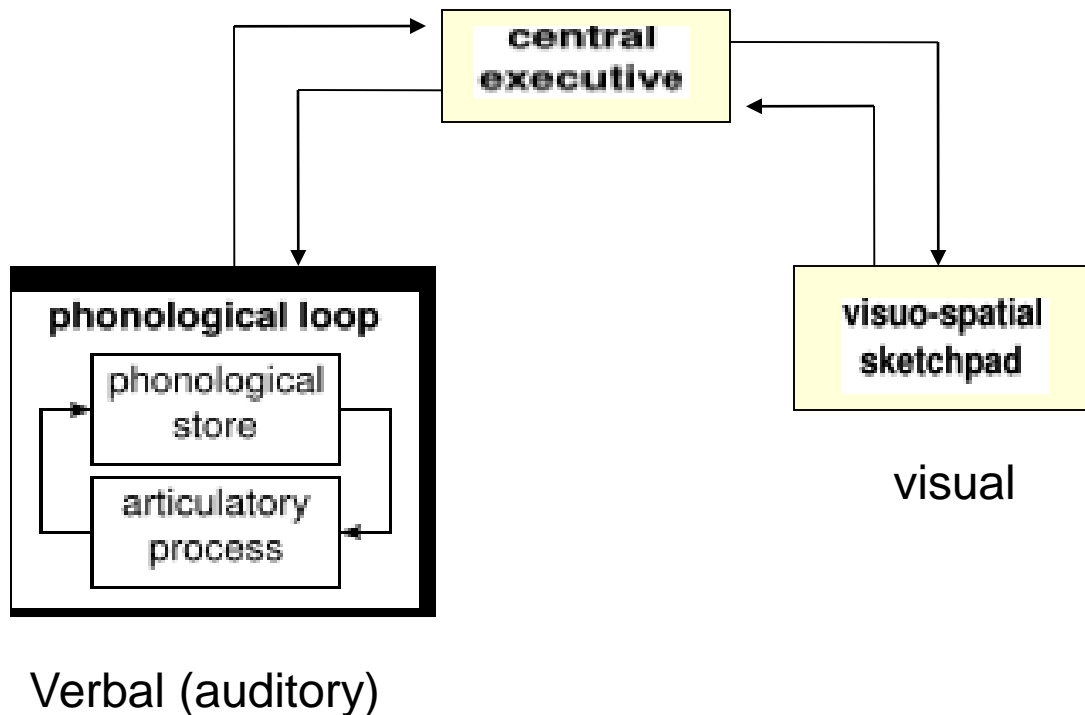
# Activity 2

So what happened?

Much easier to answer what the painting was about.  
Cannot even pay attention to story and counting simultaneously.

# Cognitive model feature – two channels for info processing

Working memory has distinct visual and verbal channels of information processing (dual coding theory)





# Implications of two-channel feature

## DISCUSS

1) Implications for learning ?

2) Implications for technology design?

# Cognitive model feature – Active Processing

*(no activity here)*

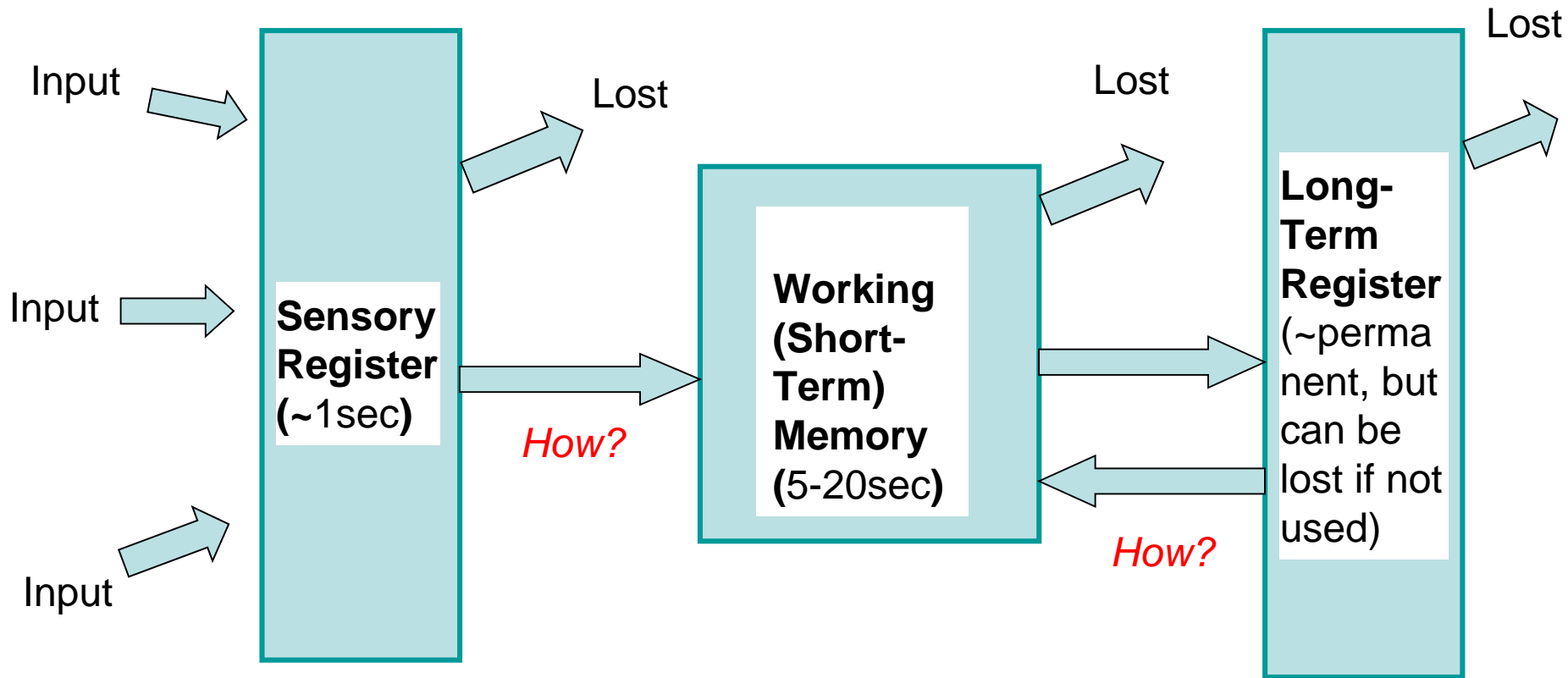
People construct knowledge in meaningful ways when they:

- pay attention to the relevant material,
- organize it into a coherent mental and
- integrate it with their prior knowledge.

# Implications of active processing

- 1) Implications for learning
- 2) Implications for technology design?

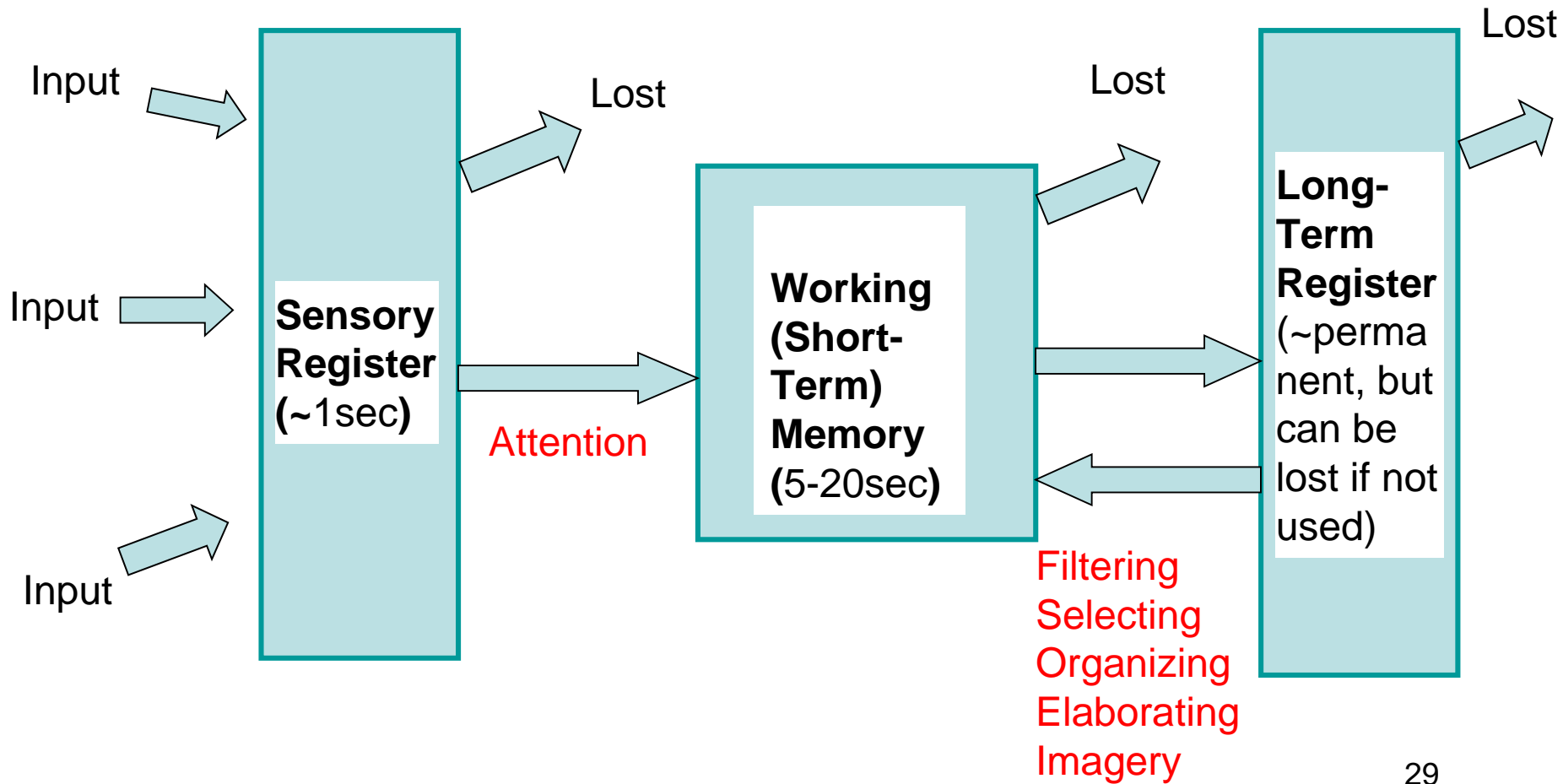
# Summary of cognitive memory model



28

Atkinson-Shiffrin memory model (1968);

# Summary of cognitive memory model



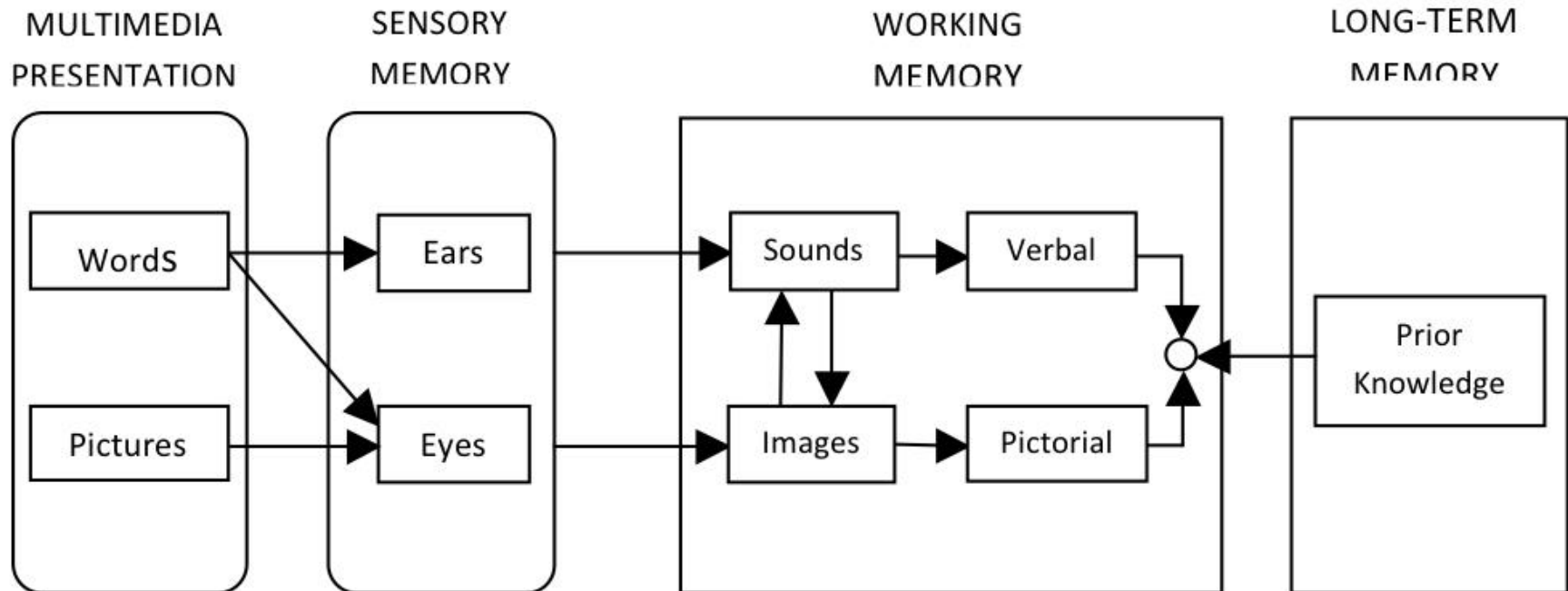
Atkinson-Shiffrin memory model (1968);

# More on implications → cognitive theory of multimedia learning

Theoretical basis

- 1) Limited capacity working memory
- 2) Dual channel information processing
- 3) Active processing

(Mayer, 2001)



# Recall ..

- When and how\* does technology add value to learning?
- When does technology hinder learning? (and how to fix it)

*Q. How does cognitive theory of multimedia learning exactly help us answer these questions?*

*A. Multimedia instructional principles (12 in all)*

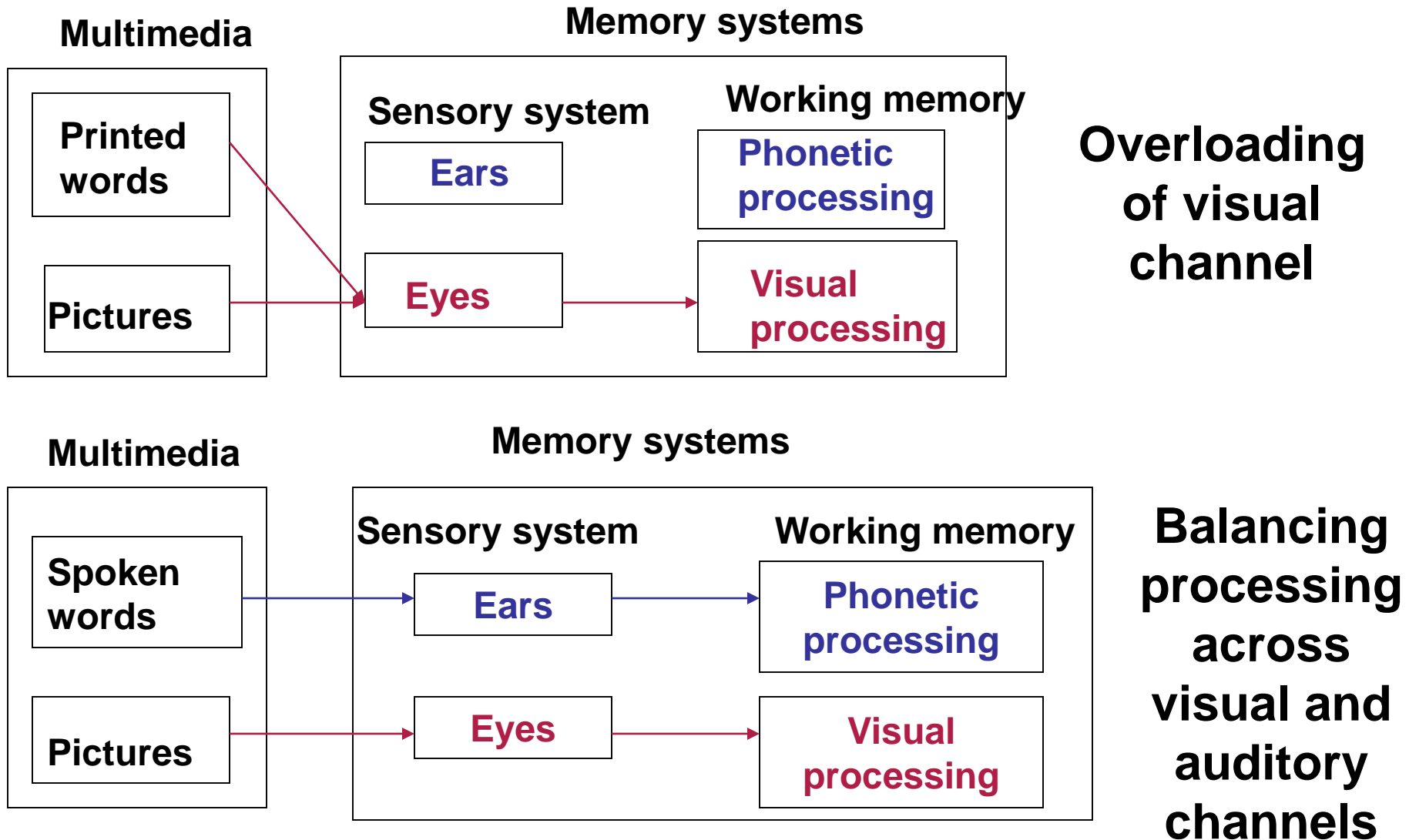
# Multimedia instructional principles

- Multimedia Principle – People learn better with words and images than words alone

Q1. Give an example of how this can be applied in educational technology.



# Justification from cognitive theory



# Multimedia instructional principles

- Multimedia Principle – People learn better with words and images than words alone

Q1. Give an example of technology use in learning for the above.

Q2. What is the basis of the above principle? (hint – we have already discussed it)

# Multimedia instructional principles

- What's wrong with this picture ? (part of an animation)

The image shows a screenshot of a multimedia instructional interface. On the left is a vertical navigation menu with a pink header that says "Learn Physics using Java". Below the header are several menu items: "Mechanics", "Light & Wave", "Electromagnetism", "Electronics", "Chinese Version", and "Download". The main content area features a background image of a large white building with a dome. Overlaid on this image is a portrait of Isaac Newton with the text "Isaac Newton 1642-1727". Below the portrait, the text reads: "Newton's first law of motion: Every body continues to be in a state of rest or move with uniform velocity unless a resultant force acts on it. All matter resists any change in its motion. This property is called INERTIA." At the bottom of the interface is a red banner with the text: "I hear and I forget, I see and I remember, I do and I understand."

# Multimedia instructional principles

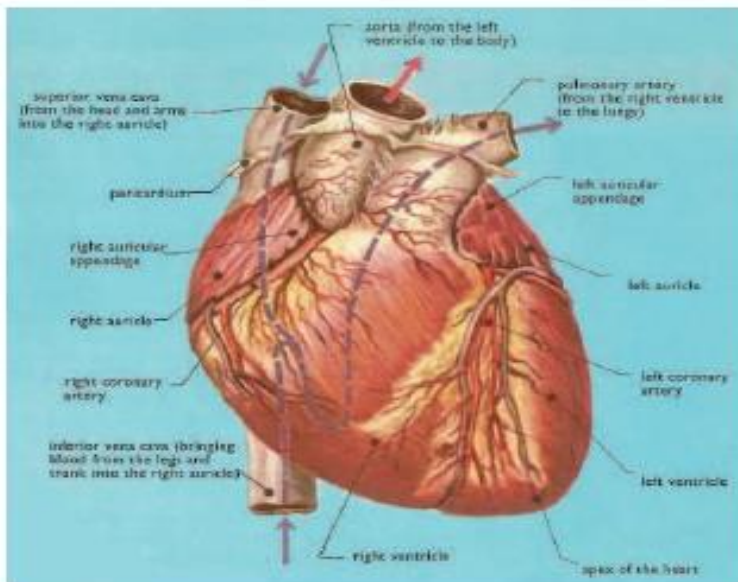
- Multimedia Principle – People learn better with words and images than words alone
- Coherence Principle – People learn better when extraneous material is excluded rather than included

Q1. What is the basis of the above principle? (hint – we have already discussed it)

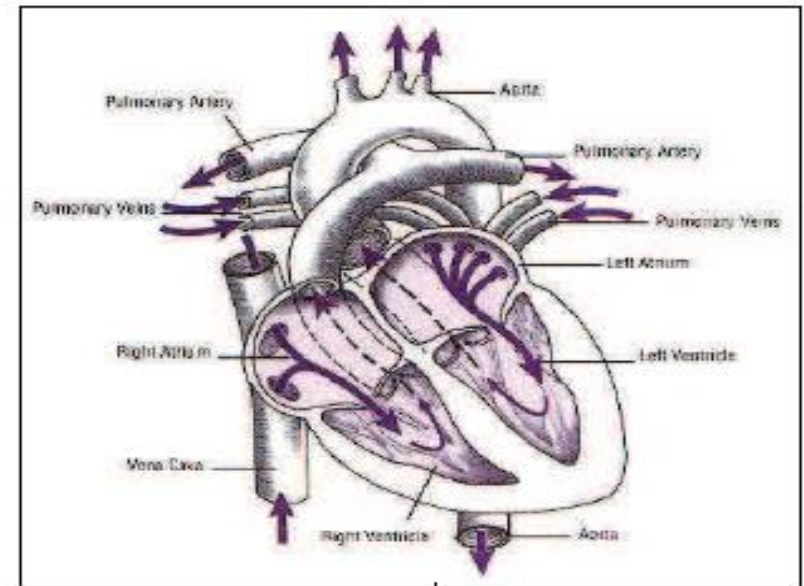
Comment: Extraneous material = extraneous graphics or sound

# Multimedia instructional principles

- A not-so-extreme and fairly common example violating Coherence principle



VS



↓  
**Performed better on subsequent tests**

# Multimedia instructional principles

- Multimedia Principle – People learn better with words and images than words alone
- Coherence Principle – People learn better when extraneous material is excluded rather than included
- Contiguity Principle – People learn better when printed words and corresponding pictures are placed near each other
- Segmentation Principle – People learn better when a multimedia lesson is presented in user-paced segments rather than as a continuous unit.

# One more application of technology in learning – Khan Academy video

[Play the video](#)

# One more application of technology in learning – Khan Academy video

What value does technology add for learning?

For what learning goals should we use such technology?



# One (almost) final application of technology in learning - PhET

[Show simulation](#)

# One (almost) final application of technology in learning - PhET

What value does technology add for learning?

- Provide rich, information, e.g through visualizations
- Simulate a complex environment for real-world experience
- Provide scaffolds

For what learning goals should use such technologies?

- Stress real world connections
- Build in collaborative activities
- Provide opportunities for active, open-ended exploration
- Foster Inquiry-based learning

# Takeaways

- Technology affordance should be aligned with learning goal
- Technology design should be based on cognitive principles

## From discussion:

*Our children \*are\* and will continue to use technology anyway. So how can we effectively harness its benefits to promote learning? Consider computer-based technologies for learning - interactive visualizations, games, etc. Make sure to:*

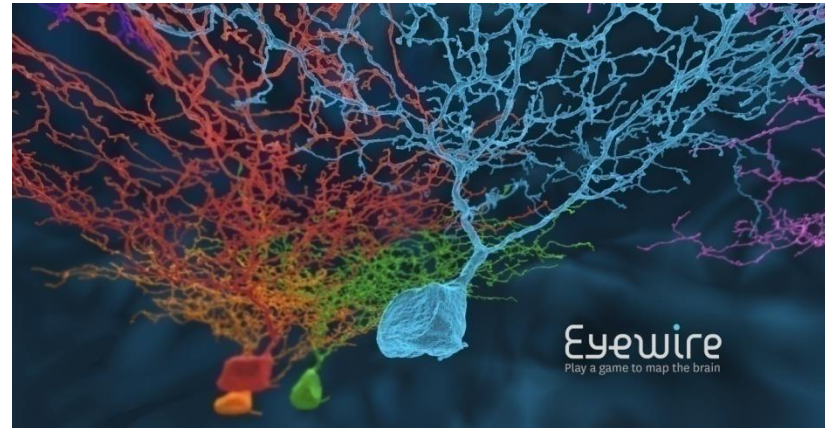
Choose them well

Use them well (ie do active learning – not in this talk!)

# Important points we did not touch upon

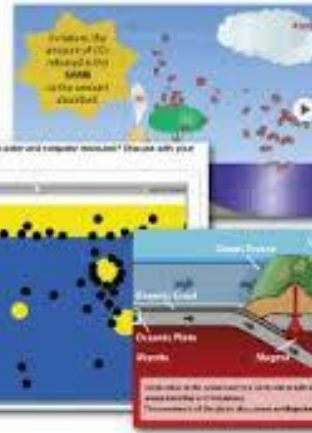
- How can technology help improve motivation?  
(... and hence possibly learning?)

## Games!



# Important points we did not touch upon

- How can technology be used to foster collaboration?  
(... and hence possibly learning?)



edmodo Search Calendar Grades Library Home Profile Account

Ms. Modo

Language Arts

Post: Note Alert Assignment Quiz Poll

type your note here...

Me to Language Arts

**Tuck Everlasting Quiz**

Turned In (0) **Oct 11, 2011**

6 questions - Good luck on today's in-class test!

Oct 11, 2011 | Reply | Public | Tag + | More -

Me to Language Arts

Check out the book trailer Megan created about Tuck Everlasting! To earn a "Peer Feedback" Badge, please provide Megan with some constructive feedback on her creation. Remember the guidelines for constructive criticism: Include two positive comments and one area for improvement.

SchoolTube - Tuck Everlasting Book Trailer

Language Arts

Group Code: **Midfx**

Request To Join URL

Group Settings

Subscribe Group To Feed

Public Page

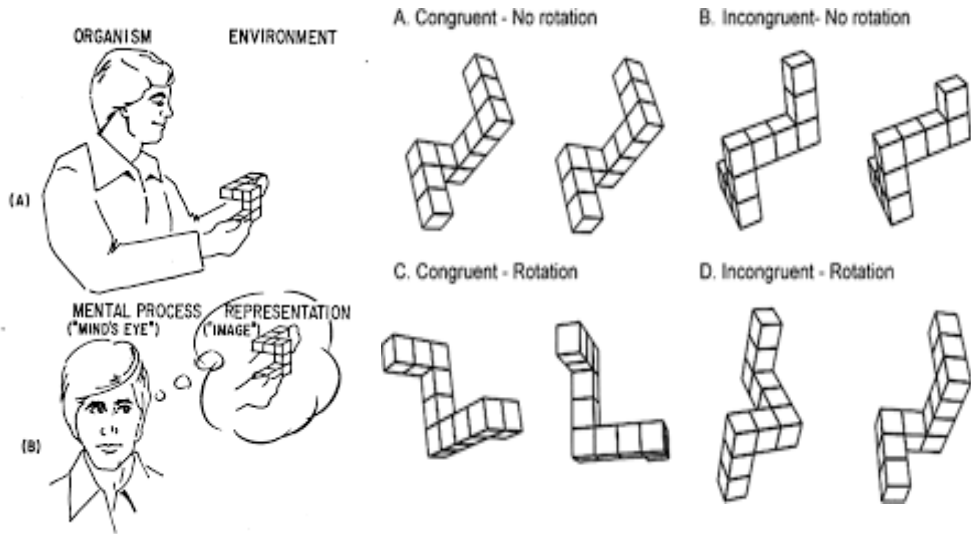
Members (7) Manage

Folders

Tuck Everlasting

# Important points we did not touch upon

- How can technology be used to do tasks we cannot do mentally alone? (and hence improve learning)



# So how can you use all of this?

(in your courses, in your careers ...)

## *Your responses*

- \*



# So how can you use all of this?

*One more possibility*

Do research in educational technology



# Inter-Disciplinary Programme in Educational Technology, IIT Bombay

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

- Started April 2010
- Ph.D. programme
- 25 Ph.D. students
- Faculty :
  - Core faculty in Educational Technology
  - CS, engineering, science, social science, design...
- Courses in ET, Games for learning, Research methods
- R & D projects
- Thesis

# Research Areas at IDP-ET, IITB

- **TEL Environments for pan-domain cognitive skills**

Problem-posing, algorithmic thinking, design, creation & revision of scientific models, data representation & analysis

- **Teacher use of ET tools and strategies**

Design of faculty development programs for effective integration of ET tools and strategies



## Student Theses

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

## Contact Us

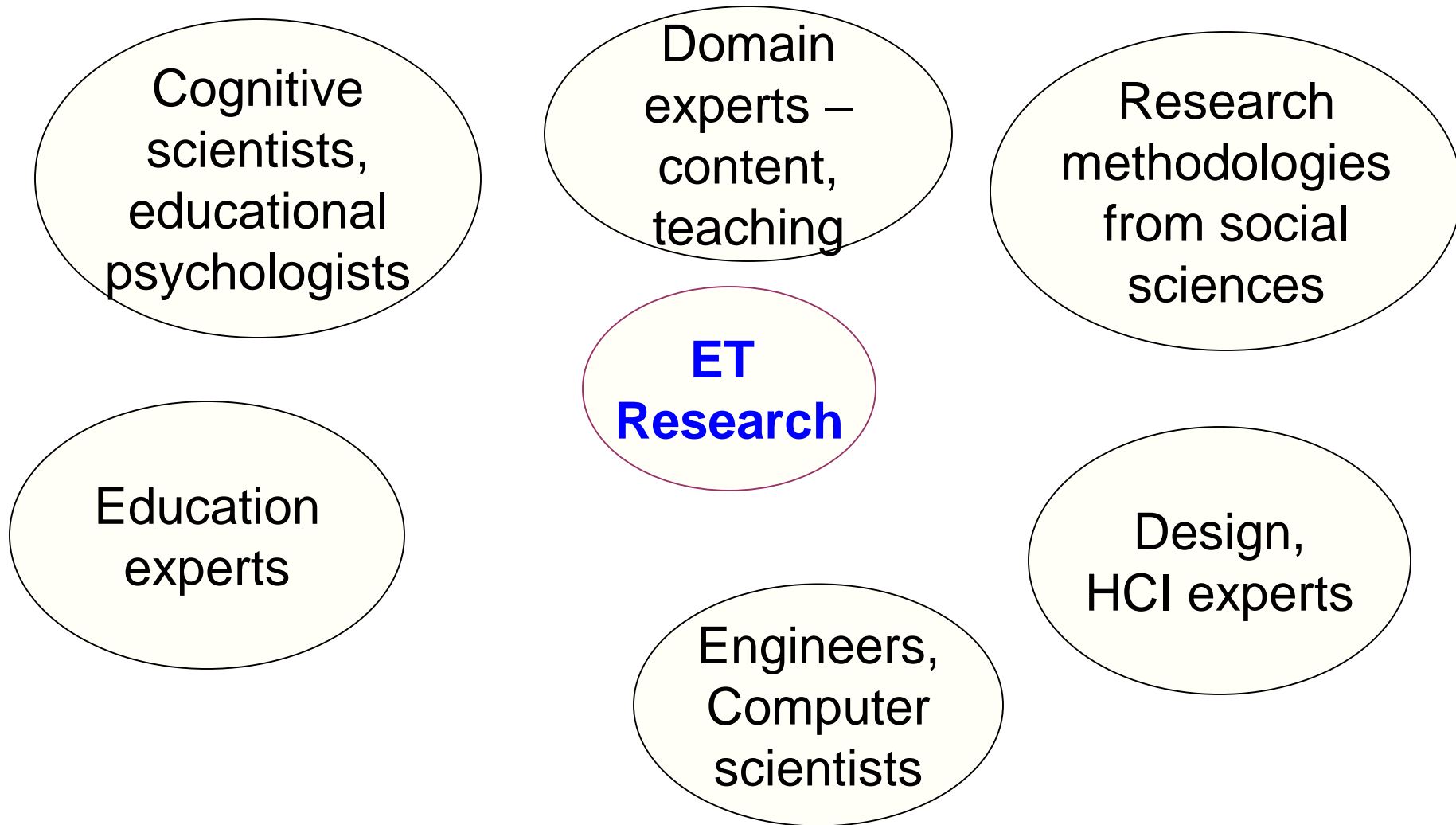
Email:

[convener.et@iitb.ac.in](mailto:convener.et@iitb.ac.in)

Phone(office): +91-

022-2576-4820

# ET Research is Inter-Disciplinary



# Is ET PhD @IITB right for you?

If you are have an MA in Education from TISS and want to do PhD in ET at IITB:

- you need to bring knowledge about learning theories, cognition, research methods ...
- you will have to learn about use of novel technologies for learning,
- you will need to design educational interventions based on technology tools to improve learning and do empirical studies

# Is technology in education relevant for me?

*(this slide has been added after the talk, based on a discussion with Alope & Prof Rajani)*

Dimensions that different technology-enabled-learning projects aim for:

- **Efficiency**: Aims to save time, effort, money, resources (for example, using a spreadsheet instead of a handwritten gradebook).
- **Accessibility**: Aims to improve access to learning to larger numbers, different populations (for example learning disabled children)
- **Attractiveness**: Aims to improve children's motivation, interest, engagement, affect
- **Effectiveness**: Aims to improve learning of concepts & skills.

- 1) You have to decide which dimension is important to your project. Do not choose all 4 in the same project. Pick 1, or at most 2, as the goal of your project.
- 2) Evaluate your project according to the goal you pick. For example, if improving scaling and access is your goal, ask – what populations and how many students has my intervention benefited?

# Sample technology-enhanced learning projects

Here is a sample of projects that target different goals:

1) Animations, simulations and virtual labs for school level as well as college level. Have been shown to improve engagement as well as learning.

PhET – <https://phet.colorado.edu/> , OSCAR - <http://oscar.iitb.ac.in/> , MERLOT - [www.merlot.org](http://www.merlot.org), PT3 - <http://paer.rutgers.edu/pt3/> , TEAL electromagnetism visualizations <http://web.mit.edu/viz/EM/>

2) Games for learning – teach science in a fun way.

[gameslearningsociety.org](http://gameslearningsociety.org), <http://www.dragonboxapp.com/> ,  
<http://www.gamesforchange.org/play/foldit/>

3) Spoken tutorial - <http://spoken-tutorial.org/> is a community based project to train people to learn and use open source software right from how to buy a train ticket on IRCTC to programming.

They have conducted 20,000 workshops and trained over 8 lakh students from all parts of the country (including remote areas – see <http://spoken-tutorial.org/statistics/> ).

*Thank you!*

Email: [sahanamurthy@iitb.ac.in](mailto:sahanamurthy@iitb.ac.in)

Phone: +91-022-2576-4820

Info: <http://www.et.iitb.ac.in>

(PhD admissions, workshops, resources)

[office.et@iitb.ac.in](mailto:office.et@iitb.ac.in)