Effective teaching-learning strategies from Physics Education Research

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Introductions

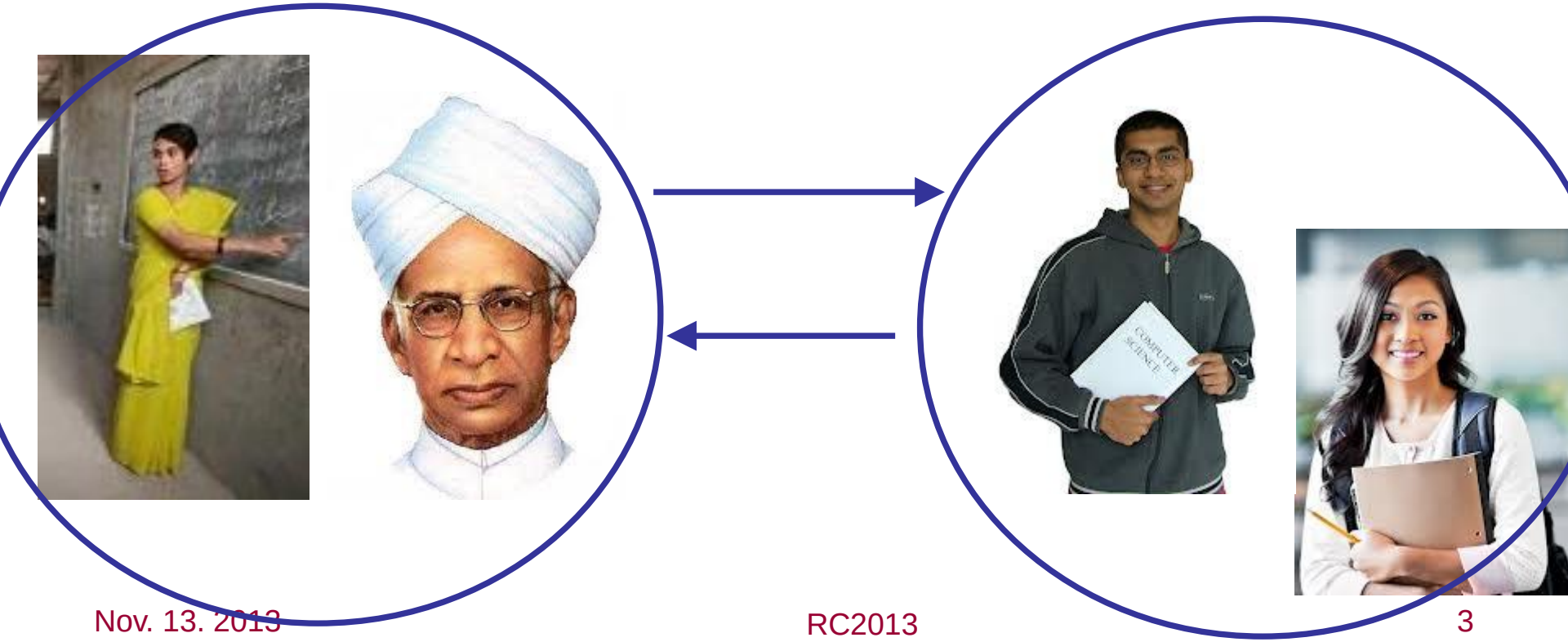
What is Physics Education Research?

What is Educational Technology?

Who are we?

Please allow me the liberty of ..

Asking you to assume multiple roles in this session -
Institute leader, Faculty member, Student



What can you expect?

By the end of this session, you should be able to:

- Identify effective teaching-learning strategies based on cognitive research principles
- Identify the ways of engaging students for deeper level reflections and discussion
- Devise activities for your students based on these strategies

Scenario

- Consider a large class, undergraduate students, varying levels.
- Imagine a 60-minute class in a traditional lecture mode in a large room.
- 20 minutes into the class, you take a snapshot of the students.
- Predict the percentage of students who may be showing “engaged behavior” (with the content of the lecture).

Vote individually

Predict the percentage of students who are engaged with the content of the lecture.

1) 0- 20%
2) 20-40%
3) 40-60%
4) 60-80%
5) >80%

Scenario (same as before)

- Consider a large class, undergraduate students, varying levels.
- Imagine a 60-minute class in a traditional lecture mode in a large room.
- 20 minutes into the class, you take a snapshot of the students.
- Predict the percentage of students who may be showing “engaged behavior” (with the content of the lecture).

Think – Pair - Share

THINK: (individually).

Draw a graph of student engagement versus time.

PAIR: Turn to your neighbour.

Examine each other's graph and converge on a single graph.

List 2 reasons why this might be happening.

SHARE: Share your responses with the team.

Create a combined list of reasons, ie challenges to effective teaching and learning.

Share your responses

- *

Challenges - summary

- Varying levels of students, varying interests, motivation
- Certain topics e.g. QM are “difficult”
- Students fall asleep, bored, tuned out
- Students mostly care about getting good marks

We discussed challenges and needs
(i.e. we defined a problem)

What are solutions?
Answer: We already implemented two!
(what are they?)

Can we find systematically find solutions?

Answer: Research in educational psychology, cognitive science, and engineering education research offers guidance on effective learning and teaching.

Principles from cognitive research

- Learning is not transfer of information. Learners actively construct their knowledge. (Constructivism)
- What people already know affects what they learn (prior knowledge)
- Effective learning happens when there is context (situated cognition)
- Learning happens effectively as social activity (social learning)

All good in theory, but how can a teacher practice these?

Student

Question - Vote individually

You toss an old 1-rupee coin and a new 1-rupee coin. Which is the most likely outcome:

1) Two heads
2) Two tails
3) One head and one tail
4) Each of 1, 2, 3 above is equally likely

Student

Discuss with your neighbour and vote again

You toss an old 1-rupee coin and a new 1-rupee coin. Which is most likely:

1) Two heads
2) Two tails
3) One head and one tail
4) Each of 1, 2, 3 above is equally likely

How many of you changed your answer?

Teacher "Peer Instruction" Method

Why does this work?

- Students actively engaged
- Students' pre-existing thinking is elicited, confronted, resolved
- Students learn from each other (social process, teach=>learn)
- Students who know the topic, also interested

Other benefits

- Immediate feedback to instructor
- Makes class interactive
- Students realize that even others are struggling
- Builds a friendly, yet academic atmosphere
- Improve communication

Teacher "Peer Instruction" Method

When to use Peer Instruction?

For what type of instructional goals?

Let's go through some examples.

Teacher "Peer Instruction" Method

Your role: Teacher

Please do: Identify instructional goal for each question.

Please do not: Answer the question!

Teacher

Example 1

What is meant by the term ‘Probability’?

1) I do not know what it means.
2) It is the chance that something will happen - how likely it is that some event will happen.
3) Probability is a branch of mathematics that deals with calculating the likelihood of a given event's occurrence, which is expressed as a number between 1 and 0.
4) Probability is expressed as a fraction: the denominator is the total number of ways things can occur, and the numerator is the number of things that you are hoping will occur.

Instructional goal?

Survey students’ prior background

Teacher

Example 2

If S is the finite sample space of an experiment and every outcome of S is equally likely; and if E is an event (i.e. E is a subset of S) then the probability that E takes place is defined as_____

1. P(E)= n(S) / n(E)
2. P(E)= n(E) / n(S)
3. P(E)= n(S) - (E)
4. P(E)= n(E) - n(S)
5. P(E)= (n(E) - n(S)) / n(E)

Instructional goal?

Recall knowledge

Teacher

Example 3

A coin has just been tossed 1000 times, and it landed heads 600 times and tails 400 times. What is the probability that the next toss of the coin will land heads?

1) 6%
2) 10%
3) 40%
4) 50%
5) 60%

Instructional goal?

Test conceptual understanding

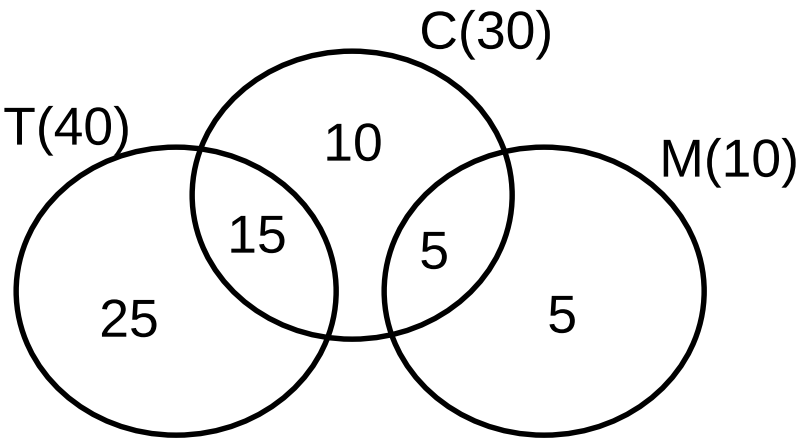
Teacher

Example 4

In a hostel with 100 students, some students drink tea, some coffee and some milk. Of these 15 take tea and coffee, 5 take coffee and milk and none takes tea and milk. If a student is picked at random, then the probability of him taking tea or coffee is 11/20.

Choose the Venn diagram which depicts this situation correctly.

A



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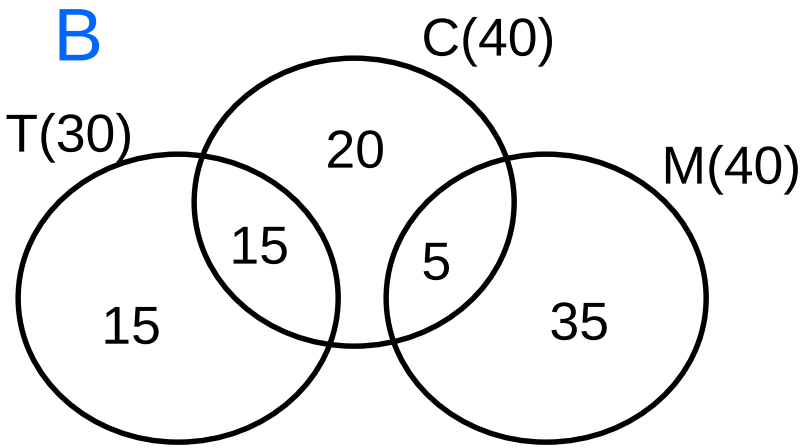

1. Only A
2. Only B
3. Both A and B
4. Neither A nor B

Instructional goal?

Teacher

Example 4

In a hostel with 100 students, some students drink tea, some coffee and some milk. Of these 15 take tea and coffee, 5 take coffee and milk and none takes tea and milk. If a student is picked at random, then the probability of him taking tea or coffee is 11/20.

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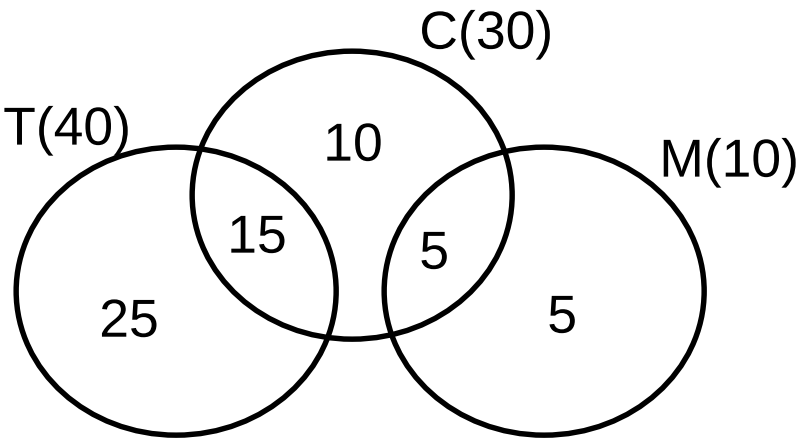

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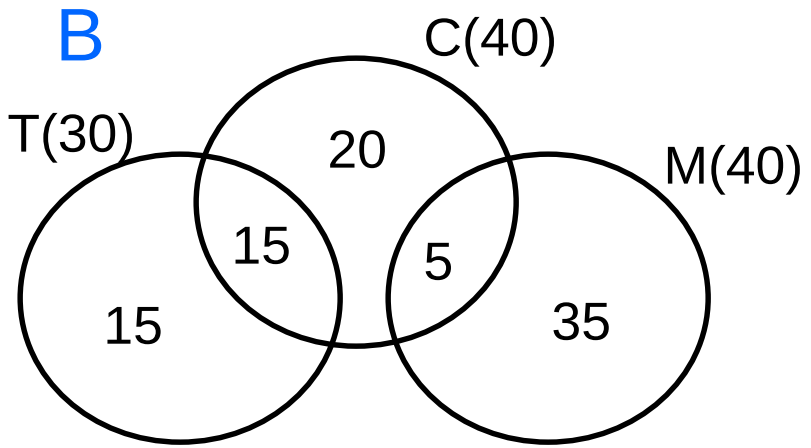


1. Only A
2. Only B
3. Both A and B
4. Neither A nor B

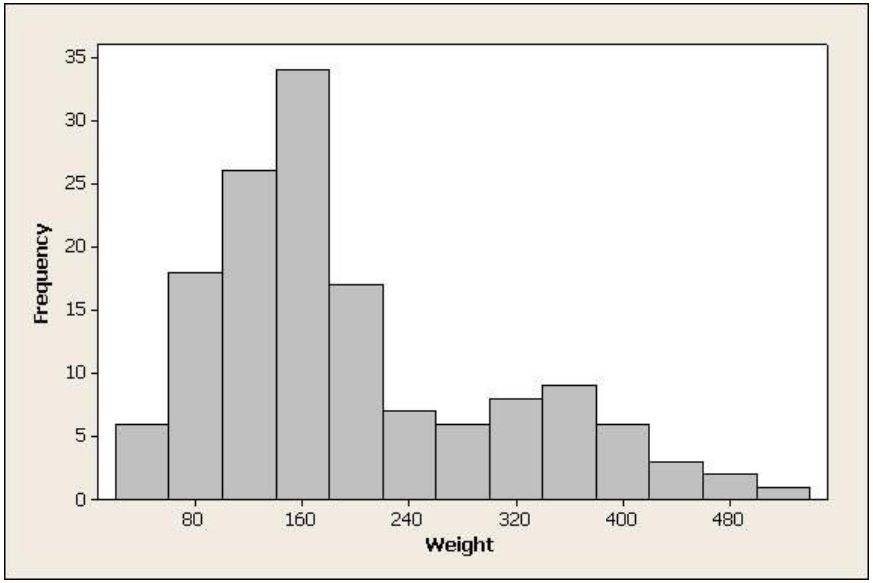
Relate different representations

Teacher

Example 5

For the data set displayed in the following histogram, which would be larger, the mean or the median?

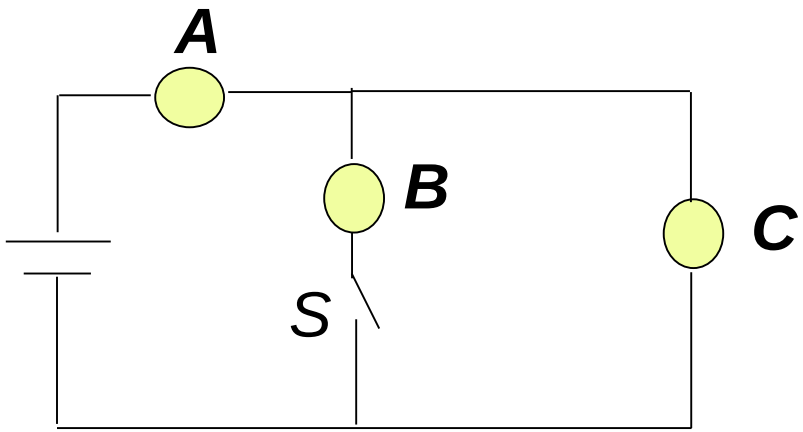
1) Mean
2) Median
3) Can't tell from given histogram



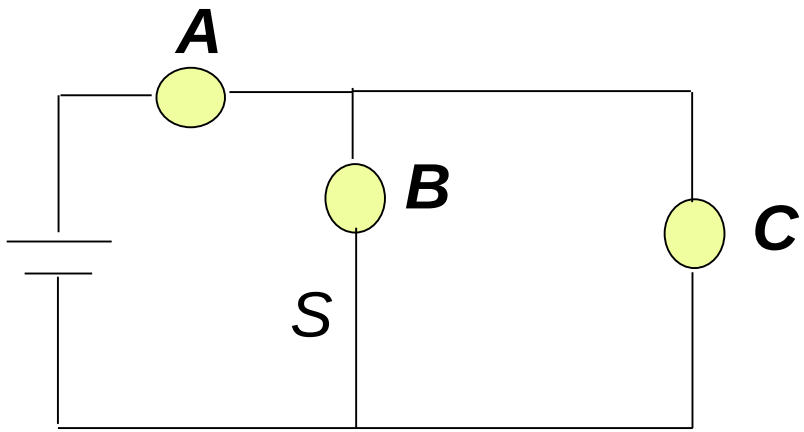
Instructional goal?

Reason using graphs, diagrams

Example 6 - Experiment



BEFORE



AFTER

What happens to brightness of bulb A *after* the switch is closed?

- Brightness of A decreases
- Brightness of A increases
- Brightness of A stays the same
- I am not sure how to answer this

Instructional goal?

Predict results of experiment

Think

In how many peer-instruction questions you saw just now, were students asked to perform numerical calculations?

(go back and see examples again, if needed)

Instructional uses of clicker questions

1. Survey students to determine background or opinions
2. Motivate students
3. Check recall of lecture point
4. Test conceptual understanding (reason logically through a problem, using words, diagrams, relationships)
5. Relate different representations
6. Predict results of lecture demo, experiment, simulation, or algorithm (describe an experiment, ask students to predict the result, then show the demo or video).

Where to find clicker questions?

Peer Instruction used > 20 years in physics.

Many Websites, papers, books, resources exist.

1) Peer Instruction: A User's Manual, Eric Mazur.

2) Guides, videos, references, how-to: http://www.cwsei.ubc.ca/resources/clickers.htm

3) Write your own!

Pair- Activity Write a clicker question

Choose a partner.

Choose a topic. (check with us)

Pair- Activity Write a clicker question

In your chosen topic:
Write a peer-instruction question for one of the goals below.

1. Survey students to determine background or opinions
2. Check recall of lecture point
3. Test conceptual understanding (reason logically through a problem, using words, diagrams, relationships)
4. Relate different representations
5. Predict results of lecture demo, experiment, simulation, or algorithm (describe an experiment, ask students to predict the result, then show the demo or video).

Which of the following statements on Multiple-Choice Questions would you most agree with ?

Vote individually – 30 seconds

1) MCQs are easy to grade but useless for learning
2) MCQs can help in deep conceptual understanding
3) MCQs are easy to grade and easy to write

Which of the following statements on Multiple-Choice Questions would you most agree with ?

Discuss with neighbour and vote again

1) MCQs are easy to grade but useless for learning
2) MCQs can help in deep conceptual understanding
3) MCQs are easy to grade and easy to write

Which of the following statements on Multiple-Choice Questions would you most agree with ?

1) MCQs are easy to grade but useless for learning

2) MCQs can help in deep conceptual understanding if written well

3) MCQs are easy to grade and easy to write

What is a “good” assessment question

Need to write good clicker questions, build a repository

What is a “good” peer-discussion question?

What does : “..if written well” mean?

THINK: (individually) Write one feature of a “good” multiple-choice question.

PAIR: Turn to your neighbour, discuss your answer, check if you agree with their answer.

SHARE: Share your responses with the rest of the class. (Write responses on board)

A “good” peer-instruction question:

- Is usually conceptual
- Elicits students’ “misconceptions”, pre-existing thinking
- Makes students apply ideas in a new context
- Makes student to think in terms of diagrams, graphs
- Asks students to predict results of an experiment, or of an algorithm

Formative assessment

Revisit – your clicker question

Does it satisfy features of a good peer instruction question?

Revisit – Principles from cognitive research

- Learning is not transfer of information. Learners actively construct their knowledge. (Constructivism)
- What people already know affects what they learn (prior knowledge)
- Effective learning happens when there is context (situated cognition)
- Learning happens effectively as social activity (social learning)

Reflection - 1

State one take-away (concept, strategy, attitude …) for **you** from this session.

Reflection - 2

Do you think you will use Peer Instruction in your class?

(at least once? more?)

1. Yes
2. No

Think-Pair-Share Strategy

What did we achieve in the previous activity?

We took a complex problem with multiple perspectives (what is a “good” MCQ) and arrived at a common consensus.

When to use Think-Pair-Share strategy

When to use this format:

- As a team (or as a class), come up with multiple ideas to solve a problem.
- Build a whole by first answering its parts

Benefits:

- Cooperative learning, give & take of ideas
- Each student gets committed
- Structure an open discussion

How to set up Think-Pair-Share activity?

Try to formulate guidelines based on the previous examples.

- Ensure that there is a clear ‘deliverable’ for each phase. This drives the action in that phase.
- Ensure that the phases are logically connected. They should use the output of one phase in next.
- Ensure that there is sufficient time for each phase. Too little → Frustration; Too much → Boredom. Move on when 80% of the class has finished