Effective teaching-learning strategies from Physics Education Research

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Recall Homework!

- Choose a partner.
- Choose a topic.
- 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).

Questions from yesterday.

I liked the Peer Instruction technique. It makes the class interactive. I am also convinced that students' conceptual understanding will improve. But …
They do not need to solve such problems for the exam! The exam only asks them derivations and 'write short notes on …'

Can you complete the syllabus if you do Peer Instruction and other group problem-solving activities?

What do we want our students to learn?

- Content (of course)
  not just info, but also - how does it all fit together, hierarchy of concepts
- Abilities / skills
  complex problem solving, designing experiments, making predictions, how to check solutions
- Attitudes
  where do formulae come from, what is the purpose of science, what to do if problem is difficult

How do we know if students learn this?

Via assessments - tests, viva, etc

Scenario

What teacher did?-

- I explained how to solve simultaneous linear eqns.
- I solved example problems where simultaneous linear eqns. were given and I used two different methods to solve them,

What student did?

- Students studied procedure of solving sim. linear eqns.
- Practiced solving number of problems given sim. eqns, using both methods.

What were exam questions?

A word problem involving simultaneous linear eqns was given. Students were supposed to write the two eqns and solve it.

Result

Most of the students not able to solve this problem.
Students unhappy.
Teachers unhappy.

Students' comment

The question was out of syllabus we have not done such problems in the classroom

Instructor's comment

The question is simple since students know how to solve simultaneous eqns. They just have to write the equations, apply the procedure and solve.

Both are right, but what went wrong?

From syllabus … to learning objectives

Today's class	Content from syllabus	On completion of this class, the student will be able to:
Section 2.3 from textbook	*Linear equations* Slope, y-intercept, simultaneous equations, graphs, methods of solution	Give an example of a linear equation in two variables. Interpret the meaning of m and c in y=mx+c. Solve eqns graphically Formulate and solve word problems related to sim eqn

What is a Learning Objective?

- Definition: Indicates specific measurable performance outcome of learner

- Operationally: What students should be able to do after completing a course/ lecture/ topic/ workshop …

- Requirement: **Must be measurable**
  $\Rightarrow$ *assessment and goals tightly linked*

  ✓Your goals should reflect what you value in student learning

  ✓Often, students never know what your goals are!

What is a learning objective?

Recall examples –

On completion of this class, the student will be able to:

- Give an example of a linear equation in two variables.
- Interpret the meaning of m and c in y=mx+c.
- Solve graphically the equations given by x+y=2, x-y = 4

Indicates specific measurable performance outcome of learner

Why learning objectives?

Learning objectives will help you answer the questions:

- What skills, knowledge and attitudes do you want students to develop?
- How will you structure the content of your material?
- What resources and strategies will you use?
- How will you assess the students' learning?

Learning: systematic process

Teaching: systematic process

Assessment: Clear, fair, accurate

Learning objectives of this session

- Define a learning objective.
- Explain the need for learning objectives.
- Distinguish between appropriate and inappropriate learning objectives.
- Write learning objectives in a given topic

- List the hierarchy of cognitive levels
- Create questions in various cognitive levels

Constructing learning objectives

Indicates **specific measurable performance outcome** of learner

Understand linear eqns Appreciate graphs Know simultaneous eqns Internalize a sense of confidence		
Lecture on substitution method Arrange field trips		

Are these learning objectives?

Constructing learning objectives

Indicates **specific measurable performance outcome of learner**

DON'T	Instead **DO**	Need to be
Understand linear eqns Appreciate graphs Know simultaneous eqns Internalize a sense of confidence	Formulate using "action" verbs: identify, list, describe, explain, solve, analyze, design, compare	Specific and measurable
Lecture on substitution method Arrange field trips	The student will be able to …	Concerned with learner

Pair Activity

Suppose this is the first class you are teaching in the topic of probability for BSc students.

Write two learning objectives.

Share with the pair in front /behind you.

SELF ASSESSMENT

Start with: **The student should be able to …**

Did you use **action verbs?** (avoid understand/know)

Learning objectives of this session

- Define a learning objective.
- Explain the need for learning objectives.
- Distinguish between appropriate and inappropriate learning objectives.
- Write learning objectives in a given topic

- List the hierarchy of cognitive levels
- Create questions in various cognitive levels

Are all learning objectives created equal?

Define slope

Give an example of a linear equation in two variables.

Interpret the meaning of *m* and *c* in $y=mx+c$.

Calculate the value of x in the equation: $x-3 = 5$

Solve graphically the equations given by $x+y=2$, $x-y = 4$.

Taxonomy of learning objectives

(Revised Bloom's Taxonomy)

Pair activity

1) Choose a partner

2) Choose a topic that you both teach

Hierarchy of cognitive levels

Level	Description	Action verbs
Recall	Recognize, recall facts	define, identify

Recall level questions – recognize, remember, define, list

Retrieve relevant knowledge from long term memory

Example:

- Define a linear equation.

Expected answer:

> A linear equation is an algebraic equation in which each term is either a constant or the product of a constant and the first power of a single variable.

Hierarchy of cognitive levels

Level	Description	Action verbs
Understand	Grasp meaning, explain, interpret, translate, paraphrase	describe, explain, give example
Recall	Recognize, recall facts	define, identify

Understand level questions – explain, interpret, translate, paraphrase

Construct meaning from instructional messages, including oral, written and graphic communication

Example 1:
Explain why is $y=mx+c$ called a 'linear' equation.

Example 2:
Identify the slope and the y-intercept in the linear equation
$3y = 2x - 6$

Pair activity

1) Choose a partner
2) Choose a topic that both teach

Within your chosen topic:

3) Write one question in Recall level
4) Write one question in Understand level

Hierarchy of cognitive levels

Level	Description	Action verbs
Apply	Use knowledge in a new situation. Involves rules, methods, laws, principles	Apply, calculate, solve, predict
Understand	Grasp meaning, explain, interpret, translate, paraphrase	describe, explain, give example
Recall	Recognize, recall facts	define, identify

Apply level questions - calculate, solve, compute, prepare

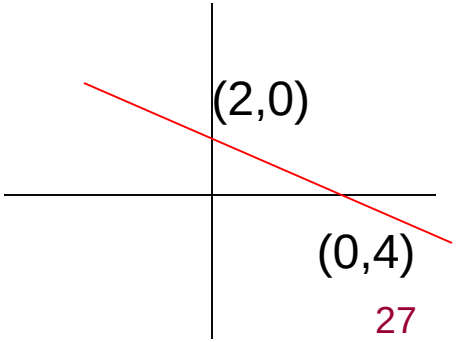
Carry out a procedure or apply knowledge in a new situation. Involves rules, methods, laws, principles

Example 1: Solve for the values of x and y which satisfy :

$$3y = 2x - 6$$

$$x^2 + y = 6$$

Example 2: Calculate the slope and y-intercept of the straight line shown below.



Hierarchy of cognitive levels

Level	Description	Action verbs
Analyze	Separate whole into parts until structure of whole and relationship between parts is clear.	analyze, infer examine, dissect ascertain,
Apply	Use knowledge in a new situation. Involves rules, methods, laws, principles	Apply, calculate, solve, predict
Understand	Grasp meaning, explain, interpret, translate, paraphrase	describe, explain, give example
Recall	Recognize, recall facts	define, identify

Analyse level questions – analyze, infer, examine, dissect, prove

Break into parts, separate whole into parts until structure of whole and relationship between parts is clear.

A multiplex sold 500 tickets in a day. Adult tickets cost Rs 200, children's cost Rs 150. A total of Rs 95000 was collected. Calculate many tickets of each kind were sold.

WHY IS THIS AN ANALYZE LEVEL QUESTION?

- Recognize that this problem can be solved using simultaneous equations.
- Then identify what they variables are (adult tkt price, child tkt price).
- Set up the simultaneous equations.
- Solve.

Pair activity

1) Choose a partner
2) Choose a topic that both teach

Within your chosen topic:

3) Write one question in Recall level
4) Write one question in Understand level

5) Write one question in Apply level
6) Write one question in Analyze level

Hierarchy of cognitive levels

Level	Description	Action verbs
Evaluate	Judge value based on criteria, decision making.	assess, conclude, contrast, evaluate
Analyze	Separate whole into parts until structure of whole and relationship between parts is clear.	analyze, infer examine, dissect ascertain,
Apply	Use knowledge in a new situation. Involves rules, methods, laws, principles	Apply, calculate, solve, predict
Understand	Grasp meaning, explain, interpret, translate, paraphrase	describe, explain, give example
Recall	Recognize, recall facts	define, identify

Evaluate level questions – contrast, compare, evaluate, decide

Judge value based on criteria, make decisions

Example:

You have learnt several methods to solve simultaneous linear equations: elimination, substitution, graphical etc. Decide which method is easier to use. Justify your choice.

Hierarchy of cognitive levels

Level	Description	Action verbs
Create	Combine parts to make (new) whole, creative behaviours, propose plans	design, combine, devise, modify
Evaluate	Judge value based on criteria, decision making.	assess, conclude, contrast, evaluate
Analyze	Separate whole into parts until structure of whole and relationship between parts is clear.	analyze, infer examine, dissect ascertain,
Apply	Use knowledge in a new situation. Involves rules, methods, laws, principles	Apply, calculate, solve, predict
Understand	Grasp meaning, explain, interpret, translate, paraphrase	describe, explain, give example
Recall	Recognize, recall facts	define, identify

Create level questions – design, plan, produce, construct, combine, modify

- *Generate new ideas, products or ways of looking at things.*
- *Put elements together to form a coherent whole*

Example:

Suppose you are given any two linear equations. Devise a rule to determine if there is a unique set of x,y values which satisfy both equations.

Pair activity

1) Choose a partner
2) Choose a topic that both teach

Within your chosen topic:

3) Write one question in Recall level
4) Write one question in Understand level

5) Write one question in Apply level
6) Write one question in Analyze level

7) Write one question in Evaluate level
8) Write one question in Create level

Reflection – 1

State one new “thing” (idea, concept, technique) you learnt from yesterday or today’s sessions.

I learnt that …

Or

I learnt to …

Reflection – 2

State one new technique from yesterday and today's sessions that *you will use in your class (at least once)*

I will use / implement / try …

Action Verbs for learning objectives

Recall- Remember previously learned material

cite, label, name, reproduce, define, list, quote, pronounce, identify, match recite, state

Apply - Use learned material in new and concrete situations

Apply, relate, solve, classify, predict compute, prepare

Create - Combine parts together to form a new whole

Combine, devise, originate, compile, expand, plan, compose, extend, synthesize, conceive, modify generalize, revise, create, integrate, design, invent, rearrange, develop

Understand- Grasp meaning

alter, explain, rephrase, substitute convert, give examples, summarize restate, translate, describe, illustrate reword, interpret, paraphrase

Analyze - break down material into its component parts to understand its organizational structure

Ascertain, diagnose, distinguish, analyze, divide, associate, examine, differentiate, reduce, discriminate, separate, dissect, infer, determine

Evaluate - judge the value of material for a given purpose

appraise, conclude, critique, judge assess, contrast, deduce, weigh Compare, criticize, evaluate