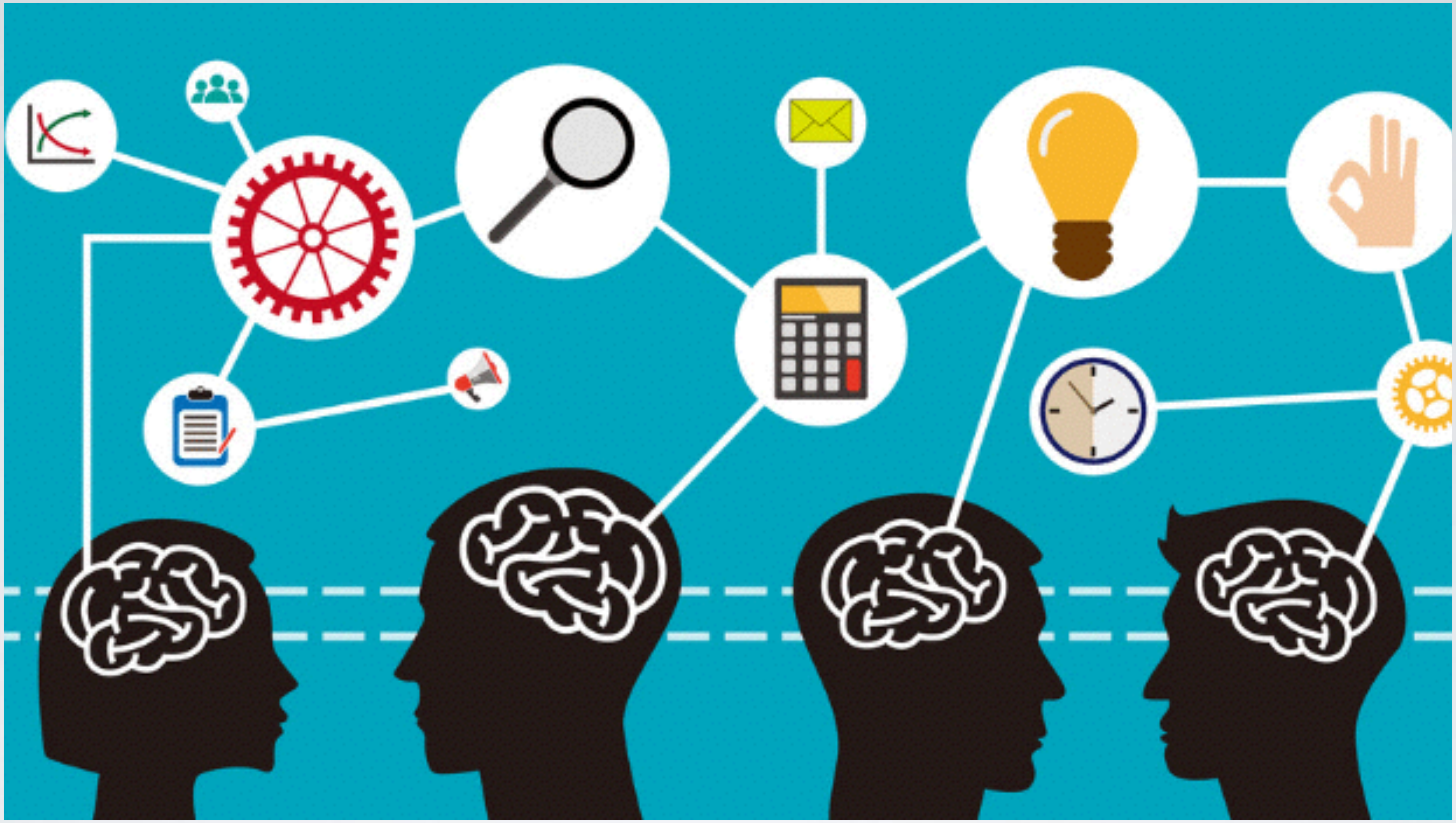
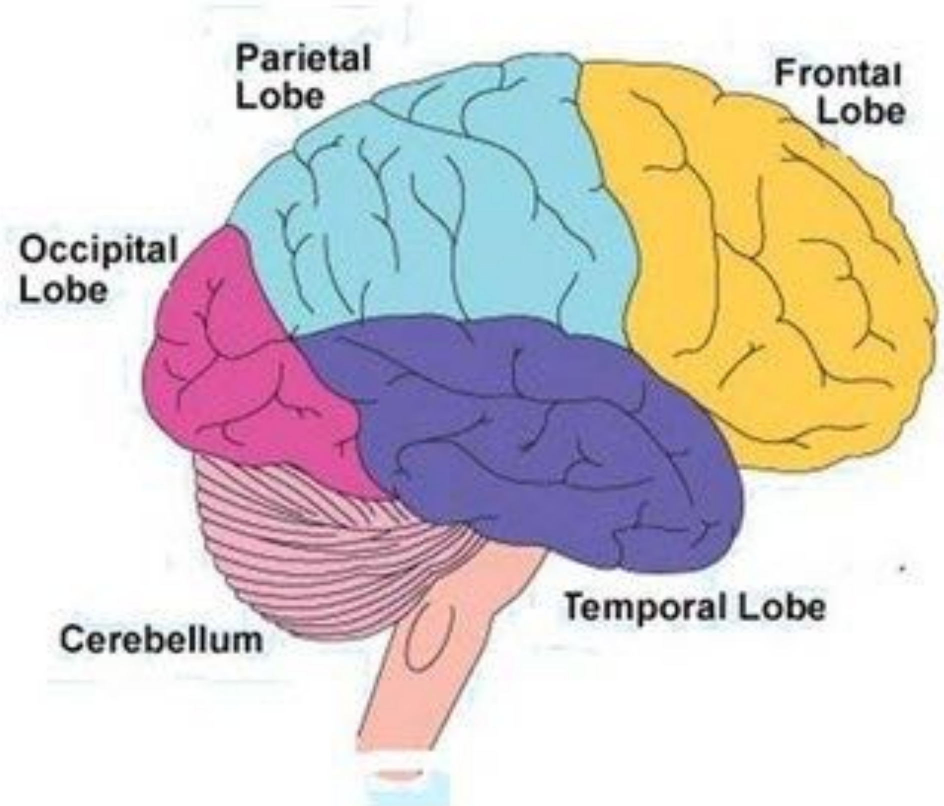


HIGHER ORDER THINKING SKILLS (HOTS)

Dr. Mohd Nor Syahrir Abdullah
syahrir@recsam.edu.my

Executive Functioning



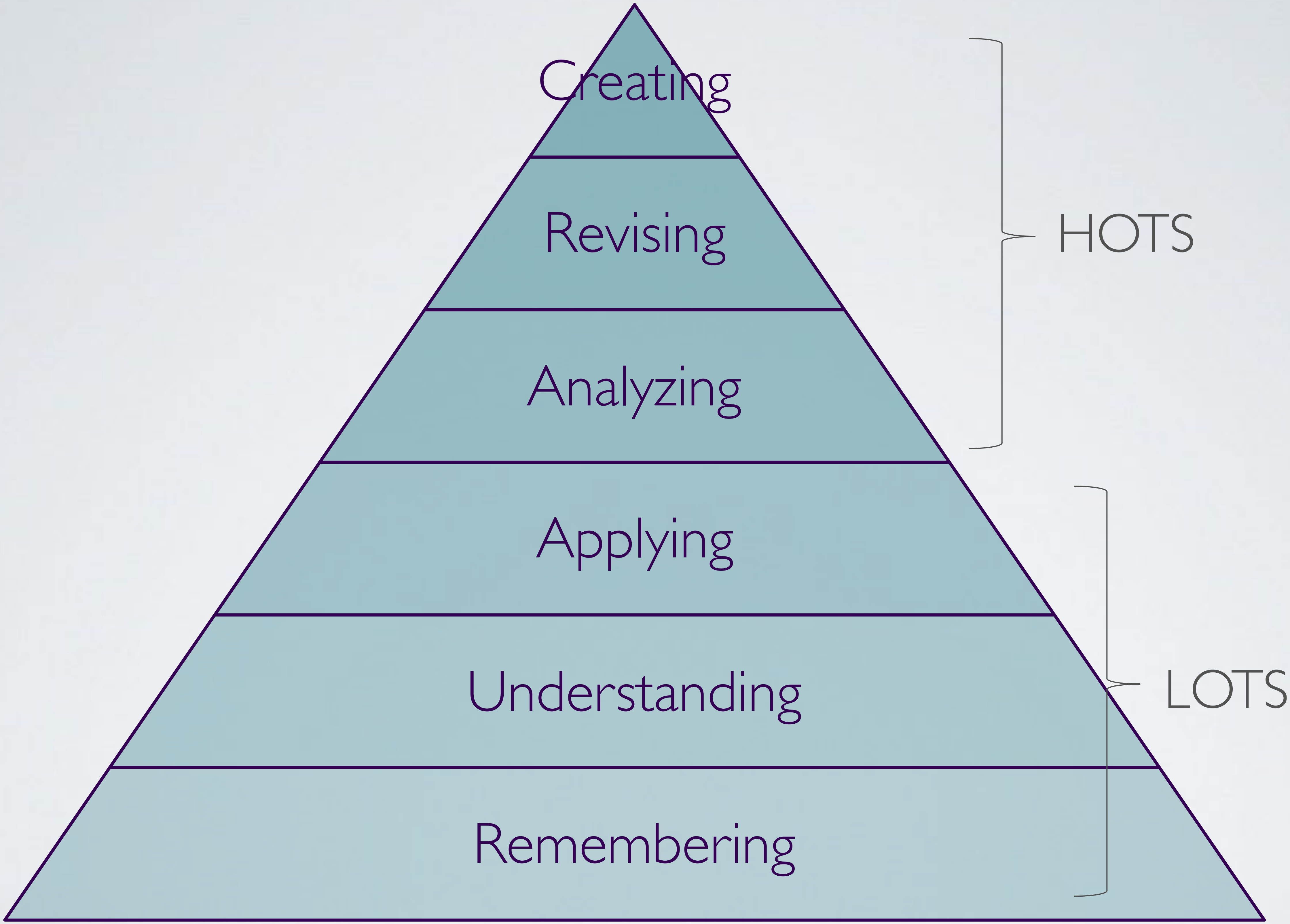
Frontal lobe is responsible for much of the executive functioning of the brain.

These functions include:

- Attention
- Working memory
- Planning, organizing
- Forethought
- Impulse control

Thinking is…

- goal-directed to achieve a specific purpose
- intentional …to solve problems
- Non-automated
- Reflective and constructive



Bloom's Taxonomy (Revised) (Krathwohl, 2002).

Lower Order Thinking Skills (LOTS)

- Remembering
- Understanding
- Applying – routine context/situation

Higher Order Thinking Skills (HOTS)

- Analysis
  - Use own judgement.
  - Able to distinguish between fact and opinion.
  - Compare & contrast.
- Revising
  - Infer relationship among sources.
  - What alternative would you suggest for_____?
  - What changes would you make to revise____?
  - What could you invent to solve____?
- Creating
  - Making judgement about the values, ideas, items, and materials.

Components of HOTS

- Higher Order Thinking Skills
  - Reasoning Skills
  - Argumentation Skills
  - Problem Solving & Critical Thinking
  - Meta-cognition

Reasoning Skills

Deductive Reasoning	Inductive Reasoning
Uses facts, claims, or evidence to support a conclusion	A verifiable conclusion is generalized to a new case.
e.g., Susan is a physicist and All the physicist are well-educated, Then Susan is well educated	e.g., All human have five fingers, Ali has five fingers Minah has five fingers
Specific -> General	General -> specific
Important to allow us to use one's evidence to draw conclusion	Allow us to make credible inferences about the unknown based on what we do know to be true or assumed to be true.

Argument Skills

- Helps individuals to make assertations, gather and evaluate evidence, and integrate multiple sources of evidence to support a claim, or counterargue a claim (Andrews, 2005, 2007).

Problem Solving & Critical Thinking

- 5-stage strategy in Problem solving

(1) Identifying the problem

(2) Representing the problem

(3) Selecting an appropriate strategy

(4) Implementing the strategy

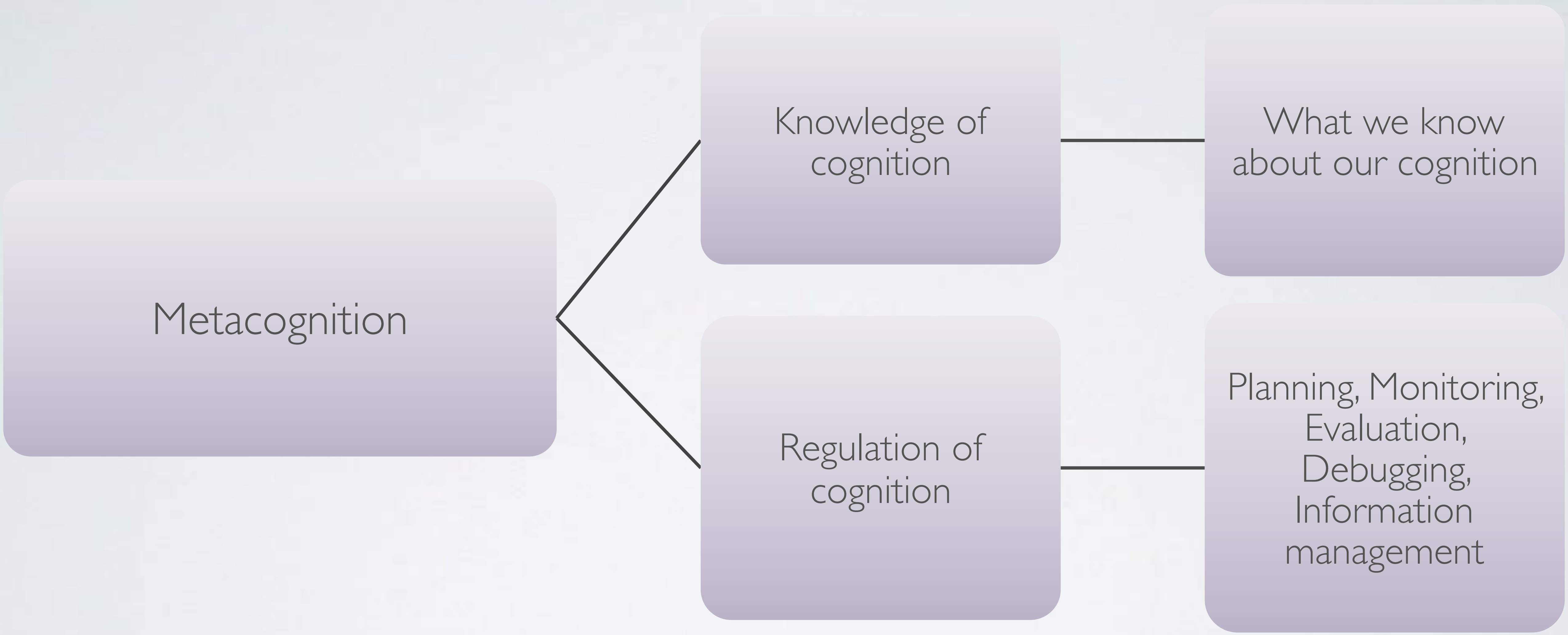
(5) Evaluating solutions

Problem Solving & Critical Thinking

- Critical thinking

- Reflective thinking focused on deciding what to believe or do (Ennis, 1987)
- Open-mindedness
- Sensitivity to other's beliefs, feeling and knowledge
- Focusing on the questions,
- Analysing arguments, and
- evaluating evidences

Metacognition



Metacognition

- Knowledge and cognition about cognitive phenomena (Flavell, 1979).
- "thinking about thinking" (Bogdanovic, Obadovic, Cvjeticanin, Segedinac, & Budic, 2015).
- Two components of metacognition (Schraw & Moshman, 1995):
    - Knowledge of cognition: what individuals know about their own cognition.
    - Regulation of cognition: regulations of metacognitive activities that help control one's thinking or learning

Metacognition

- Number of researches done to identify variables that influence metacognition ability.
- Gender:
  - Sulaiman et al. (2006): female students possesses better ability and skill
  - Downing, Kwong, and Lam (2008): females significantly higher levels of self-regulation and a more positive attitude to academic study.
- Academic achievement:
  - Dunning (1999): students with good metacognition ability demonstrated good academic performance.
  - Koch (2001): taught how to think metacognitively.
  - Rahman, Jumani, Chaudry, and Abbasi (2010): students with high metacognitive awareness performed well in their chemistry test.

Teaching Strategies That Enhance HOTS

- Encourage questioning
- Connect concept
- Teach students to infer
- Use Graphic Organizers
- Teach problem-solving strategies
- Encourage creative thinking
- Teach students to elaborate their answers

Teaching Strategies That Enhance HOTS

- Thoughtful Questioning
  - Aware of our questioning as we teach – paying attention of what we are saying, slowing down and pausing before and after questions.
  - Discussion – students clarify their thinking & hearing other's points of view.

Teaching Strategies That Enhance HOTS

- Thoughtful Questioning – don't do:
  - Questions designed to embarrass or humiliate the learner – asking question to 'test' whether someone is listening is unnecessary.
  - Questions that answer themselves - "So, can you see the way adding these three numbers makes it easier to solve the problem?"
  - Over-use of closed questions or those with yes/no answers: "So, who can tell me the name of this part of the world?"
  - Rhetorical questions: "Are we ready to begin?"
  - Disjointed questions that fail to follow through a line of thought….(and therefore keep the conversation at the shallow end!).
  - Lack of 'wait time' before and after a question is asked
  - Asking a limited range of questions that mainly focus on recall rather than deeper analysis and reflection.
  - Opting for whole class discussions rather than the more effective small group or one to one discussions where questioning can be more personalized.
  - Asking all the questions – rather than encouraging students to question each other.
  - Poor listening to students' responses – not making eye contact with the student who is talking. Inauthentic listening.
  - Marginalising certain students (often unconsciously) - e.g. asking questions only of students whom we know will be able to answer
  - Praising 'correct' responses in a way that decreases student risk taking or sharing alternative viewpoints.
  - Waiting until the end of an instructional period to ask questions rather than asking before and during.
  - Negative or judgmental feedback to what are deemed poor or incorrect responses rather than seeking more information or constructively challenging and probing to scaffold thinking.

Teaching Strategies That Enhance HOTS

- Thoughtful Questioning
  - Eliminating hands up from discussion - When students can only speak if their hand is raised:
    - it's often the same students every time
    - those who don't get 'chosen' switch off and stop listening
    - the conversation is often stilted and superficial as those with hands up are selected in turn
    - the teacher controls the conversation
    - in an effort to be heard, students will fling their hands up before they have given adequate thought to the question
    - students who take TIME to think are not chosen because their hand is not raised in time
    - those with their hands up are often focused more on getting your attention than really listening to the other contributions.
  - What are the alternatives?
    - Tell students you will be having a conversation with them but you will not be using the 'hands up' technique.
    - Circle formation - students sit in a circle rather than a group all facing you. Only one person speaks at a time and that they need to wait until there is a pause before they speak.
    - Talk tokens – small groups. Give students two 'talk tokens' – when they wish to say something. They must try to use both tokens in the conversation but once spent, they can no longer contribute. This is a good strategy to raise awareness about how to share talk time in a conversation.

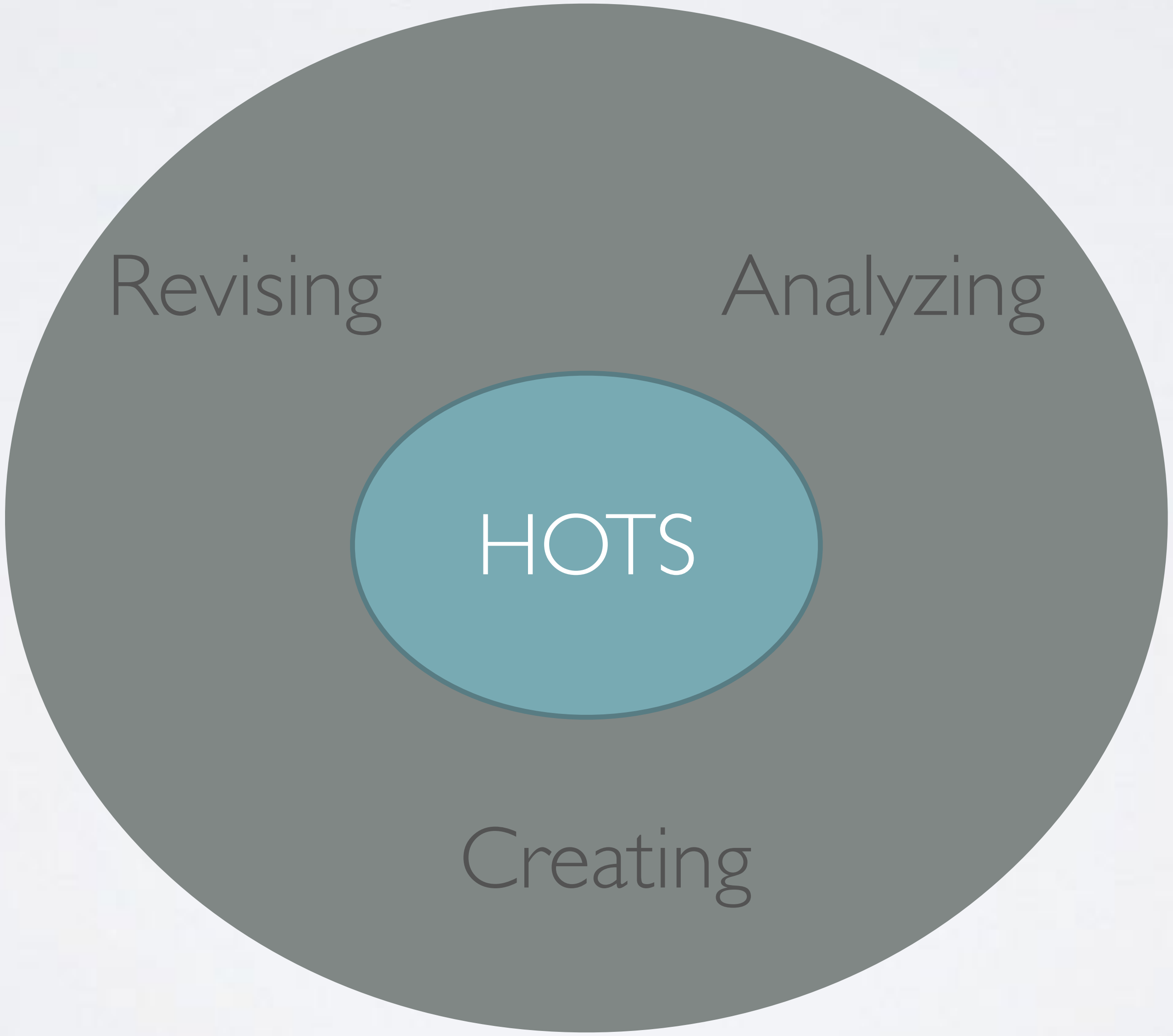
Teaching Strategies That Enhance HOTS

- To engage students' interest/intrigue/curiosity
- To ascertain students' understanding of something (and, therefore, inform our teaching)
- To help students 'dig deeper' and take an idea further
- To help students critique and analyse something
- To promote divergent, creative thinking – to help students think beyond the obvious
- To help students make connections between ideas and establish patterns/ relationships
- To scaffold students' planning or problem solving – to help them figure something out for themselves
- To promote reflection and encourage the student to evaluate, self assess and goal set.

Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

1. Circle Map – for brainstorming or defining in context.



Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

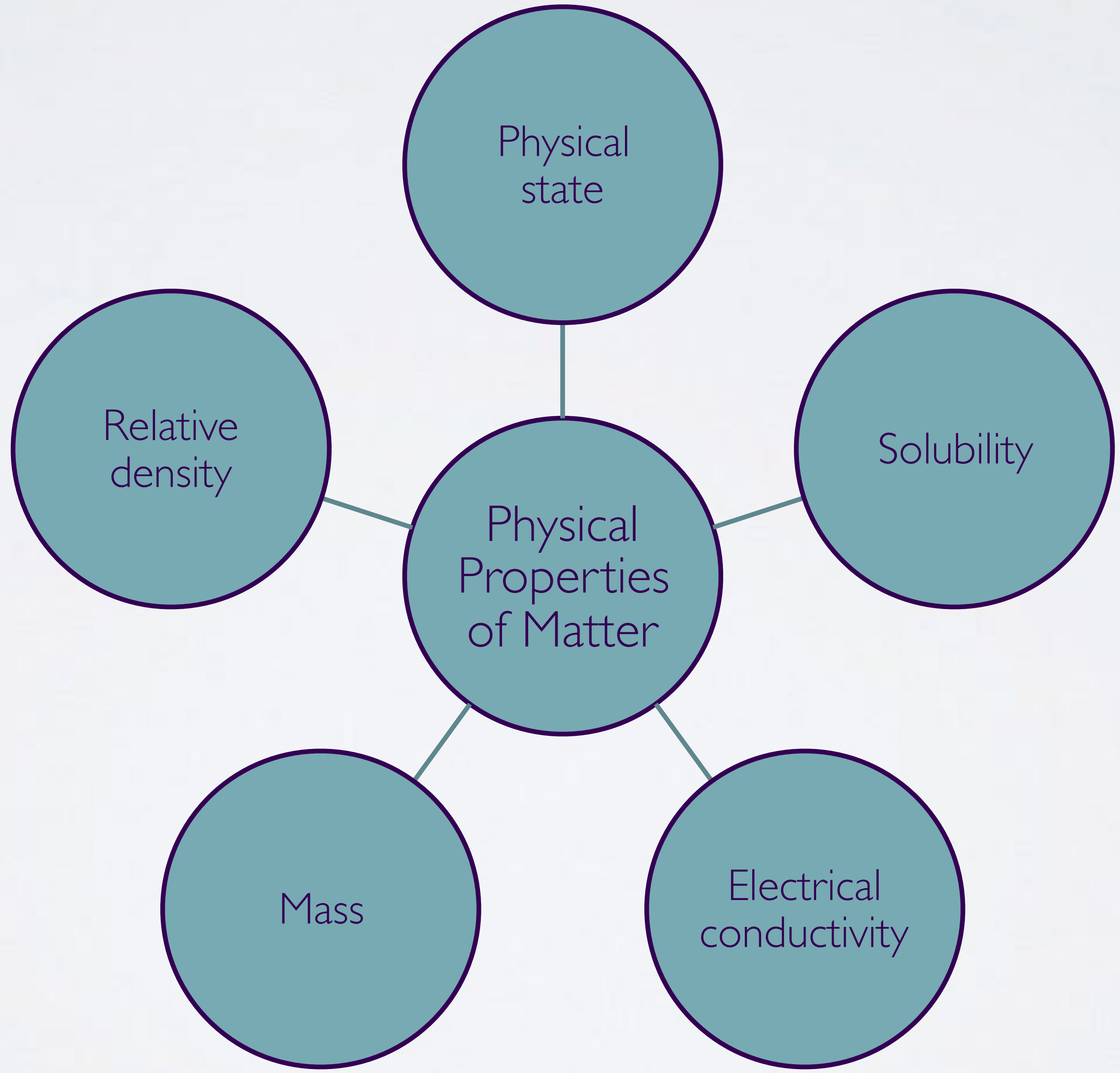
2. Flow Map - Sequence of Events or for anything that has a Step-by-Step Process.

seed → Seed sprouted and developed roots → The seedling grew some leaves → The root grew and developed a bulb

Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

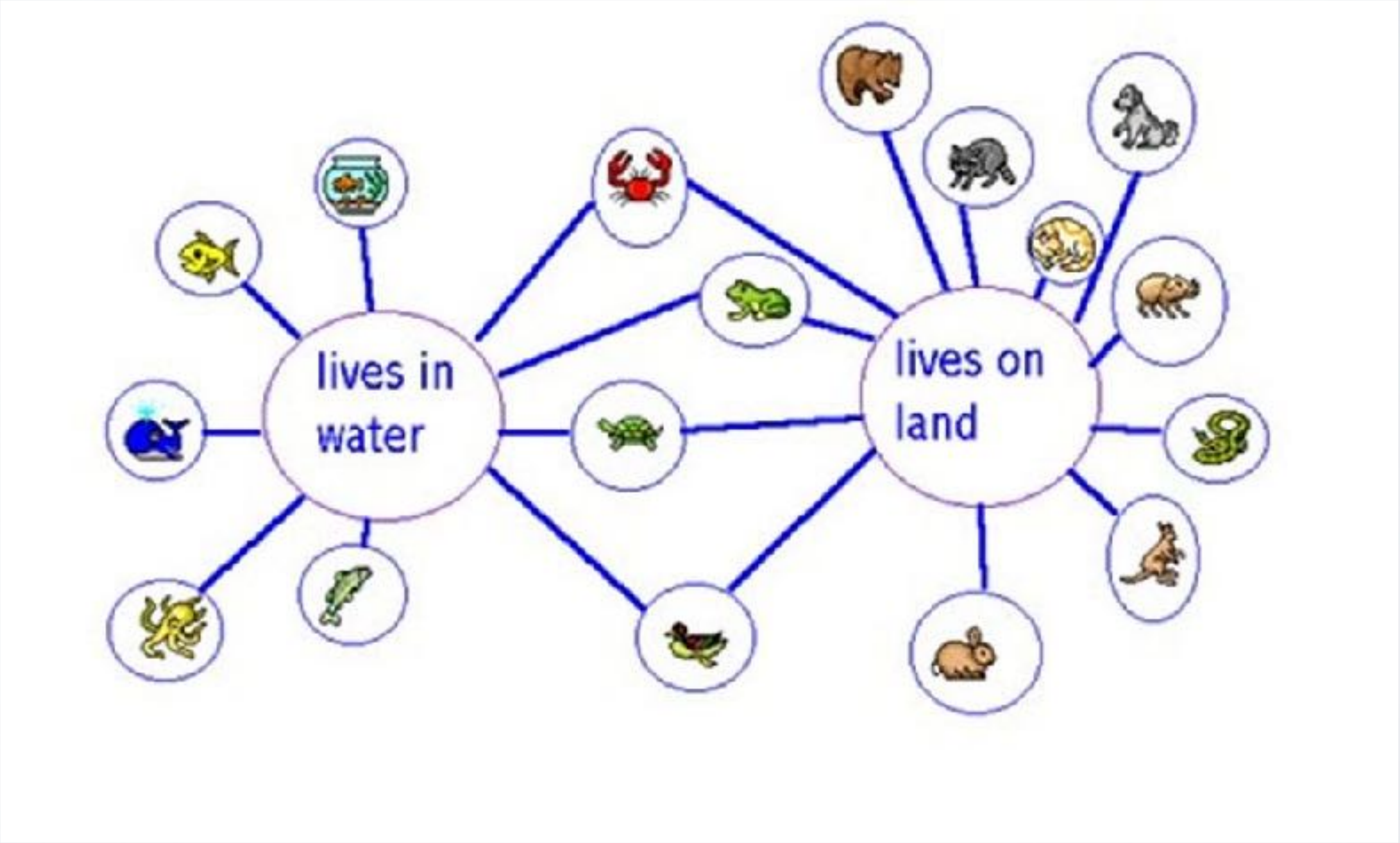
3. Bubble Map - Describing (use adjectives or adjective phrases)



Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

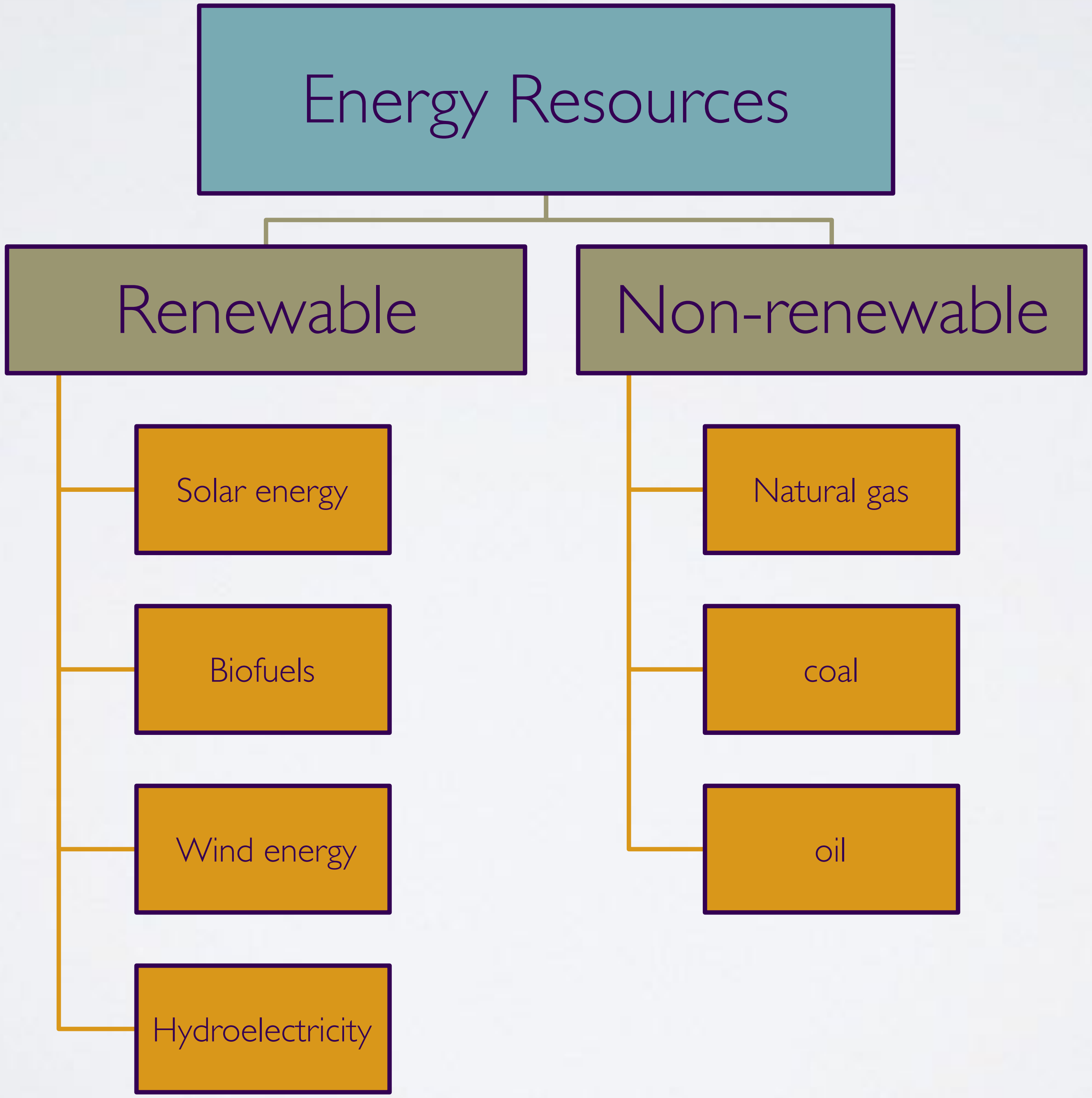
4. Double Bubble Map - Comparing and Contrasting (Similarities & Differences)



Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

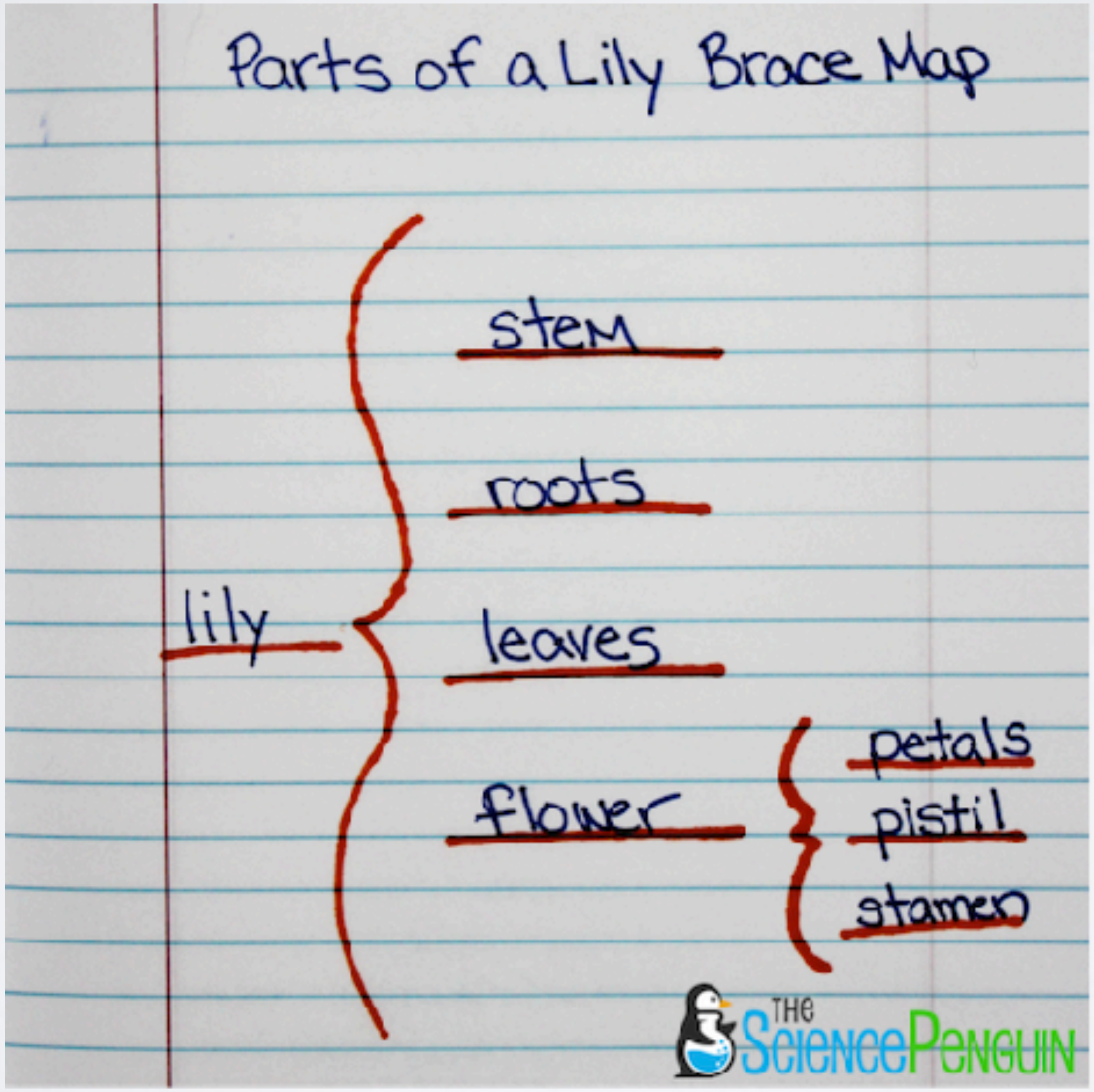
5. Tree Map - Classifying or Categorizing



Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

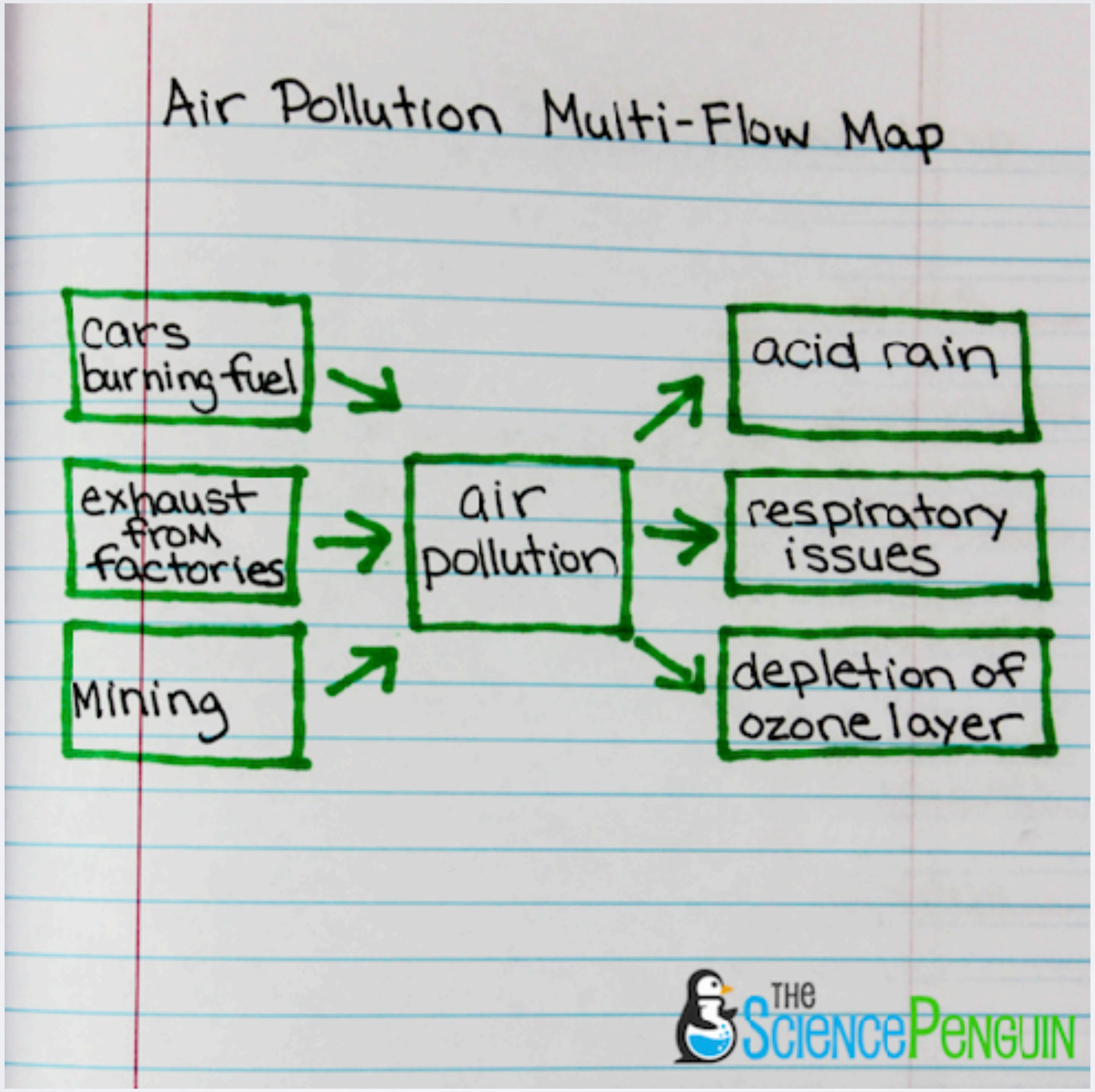
6. Brace Map - The Whole and all its Parts



Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

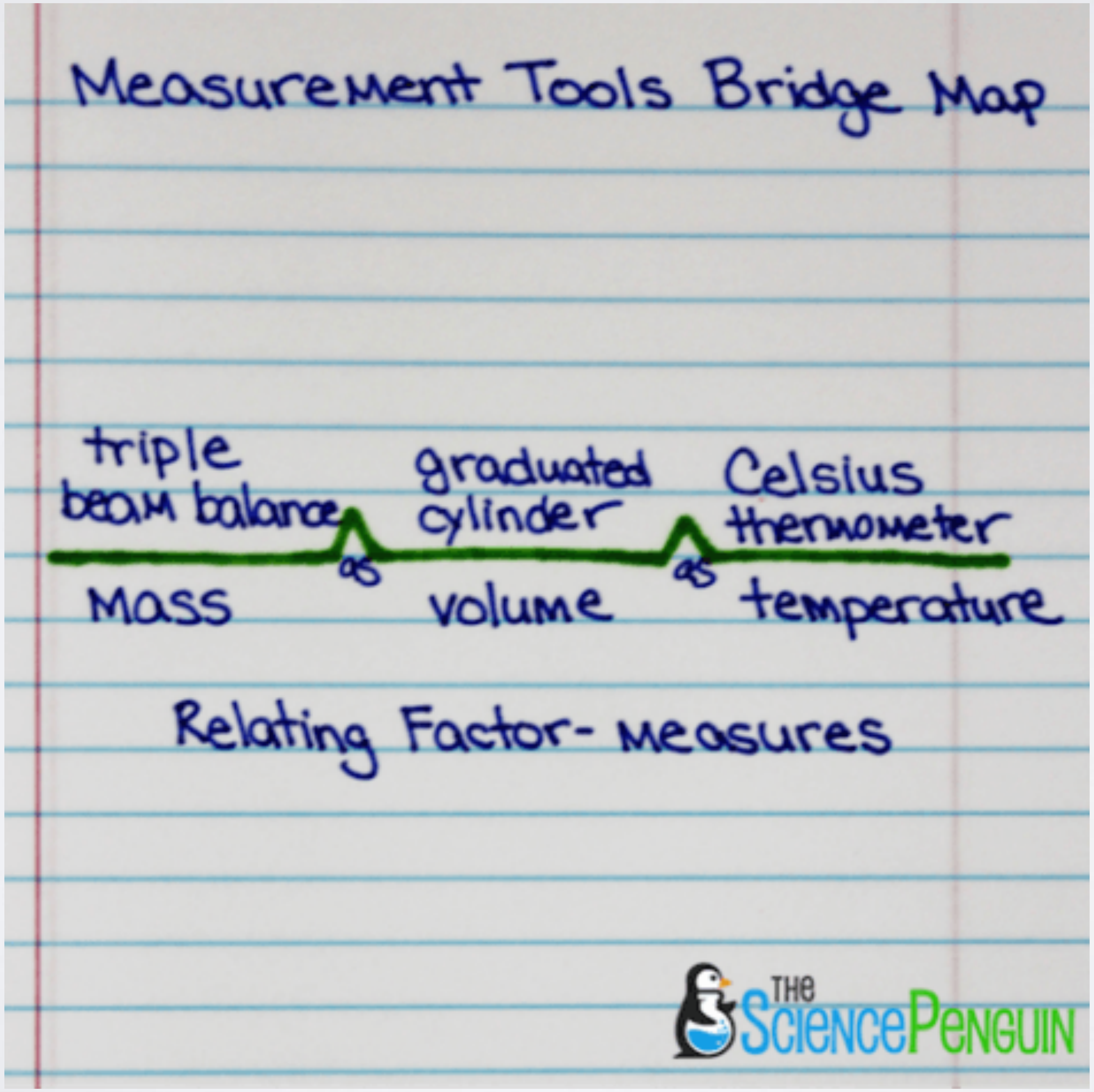
7. Multi-Flow Map - showing Cause & Effect



Teaching Strategies That Enhance HOTS

- Use Graphic Organizer – iThink:

8. Bridge Map - Show Analogies (and their relating factor)



Sharing session

- Group 1 – circle map & bridge map
- Group 2 – flow map & multi-flow map
- Group 3 – bubble map & brace map
- Group 4 – double bubble map & tree map

1. Choose 2 concepts/topics (Science Primary School).
2. Present the concepts/topic using iThink map that your group assigned for.
3. Design HOTS questions you will ask your students.

Teaching Strategies That Enhance HOTS

- **Structured Problem Solving.**
  - help the students to enhance their HOTS - introducing new concepts.
  - give the students the chances to create the ideas to solve the problems.
  - Step 1: Identify the problems:
    - students read carefully the problems. understand the problems. teacher asks questions to help the students.
  - Step 2: Generate solutions through brainstorming:
    - individual, pair or small group.
    - teachers play important role - move around, make sure the students focus on discussion, facilitate the students, give comments and feedbacks on students responses.
  - Step 3: Evaluate the solutions:
    - present the ideas with others - organise the ideas (graph, charts or mind map)
    - identify and consider the pros and cons of the solution - compare.

Teaching Strategies That Enhance HOTS

- **Structured Problem Solving.**
  - Step 4: Summarise
    - students summarise and make conclusion what have been learned.
    - choose the best solutions.
    - teachers assist the students to make reflections - what are the strategies to solve the problems?
  - Step 5: Evaluation
    - evaluate what they have learned.
    - how far they understand the concepts learned.
    - what are the strategies to improve their understanding.
    - apply the knowledge they learned by answering the questions.
    - write reflective journal.

Teaching Strategies That Enhance HOTS

- **Inquiry Learning.**
  - Student-centered approach.
  - Focus more on questions & problem-solving.
  - learn through reasoning and doing, through asking questions, carrying out experiments, weighing up evidence and considering alternative hypotheses.
  - Learn about the facts rather than received the fact from teacher.

Levels of Inquiry

- **Confirmation**
  - traditional ‘recipe style’ laboratory activities.
  - Students are given step-by-step guidance to confirm already-known principle.
- **Structured inquiry**
  - Teachers provide questions to be explored, equipment and instructions.
  - Students do not know the result/solution.
- **Guided inquiry**
  - Teachers only provide problem/question.
  - Students design/choose the methods to collect & analyse data.
- **Open inquiry**
  - Teachers provide a general topic.
  - Students generate their own scientific question to investigate.
  - Students have complete autonomy in designing and conducting the investigation.

Information provided by teachers while engage in ’structured’, ‘guided’ or ‘open’ inquiry activities.

Structured

- the question or issue to examine.
- the resources needed.
- instructions presented to students in a step-by-step format.

Guided

- the question or issue to examine.
- the resources needed.

Open

- None provided – learner makes all the decisions about:
- what to investigate
- how to conduct the investigation
- why to research this particular question

Questions learners might ask themselves when engage in ’structured’, ‘guided’ or ‘open’ inquiry activities.

Structured

- What observation do I need to make and record?
- How should I record my observations?
- Can I explain what the observations mean?

Guided

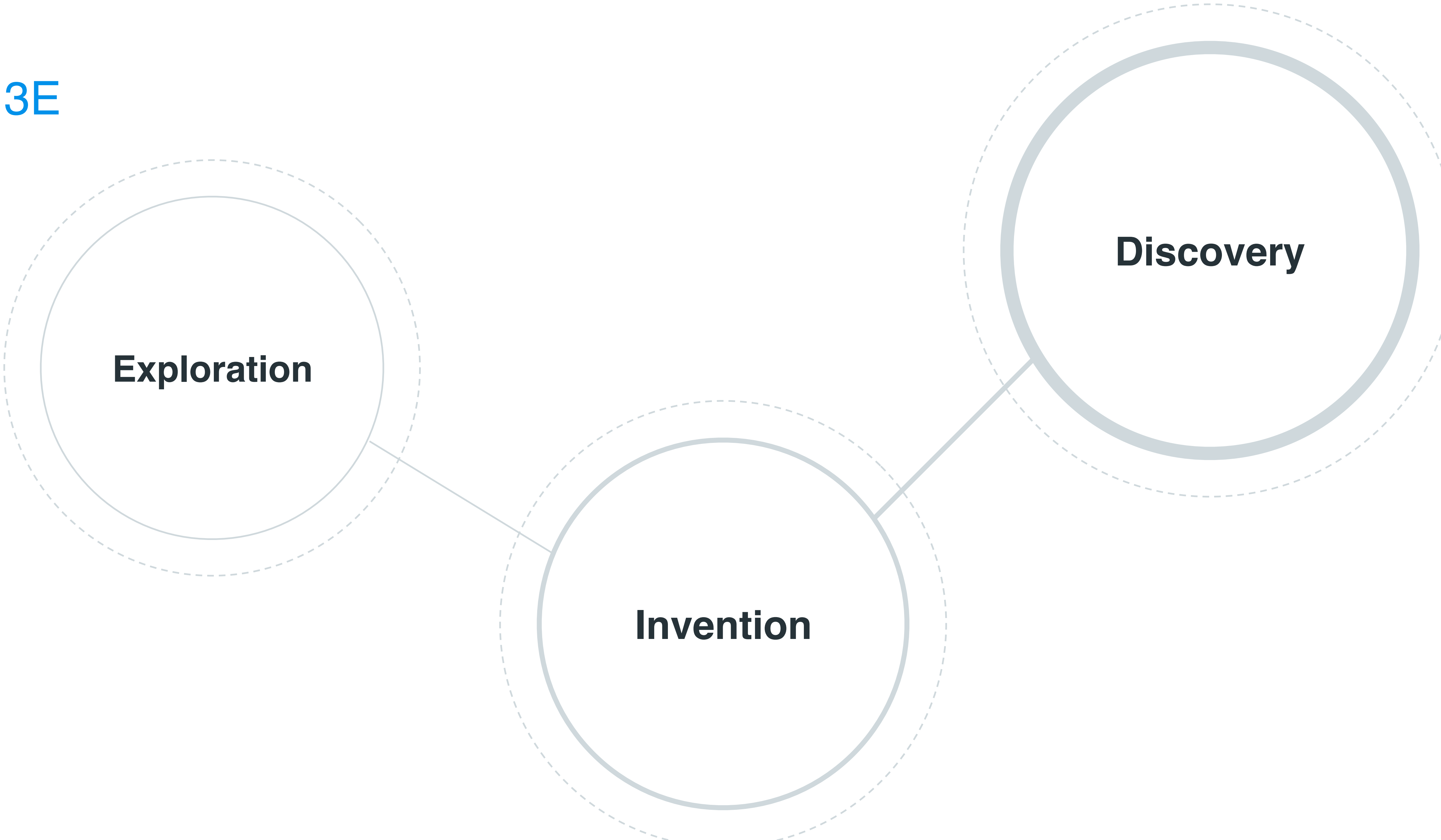
- How can I go about answering the questions?
- What procedure(s) or method(s) can I devise/ think up that will enable me to answer the question?
- What observations do I need to make and record?
- How should I record my observations?
- Can I find out how other people have gone about answering the question?

Open

- What questions should I decide to investigate?
- How should I phrase the question?
- What background research will I need to conduct before proceeding?
- How should I go about investigating this question?
- What procedure(s) or method(s) can I devise/think up that will enable me to answer the question?
- How should I record my observations?
- How can I best present my findings?

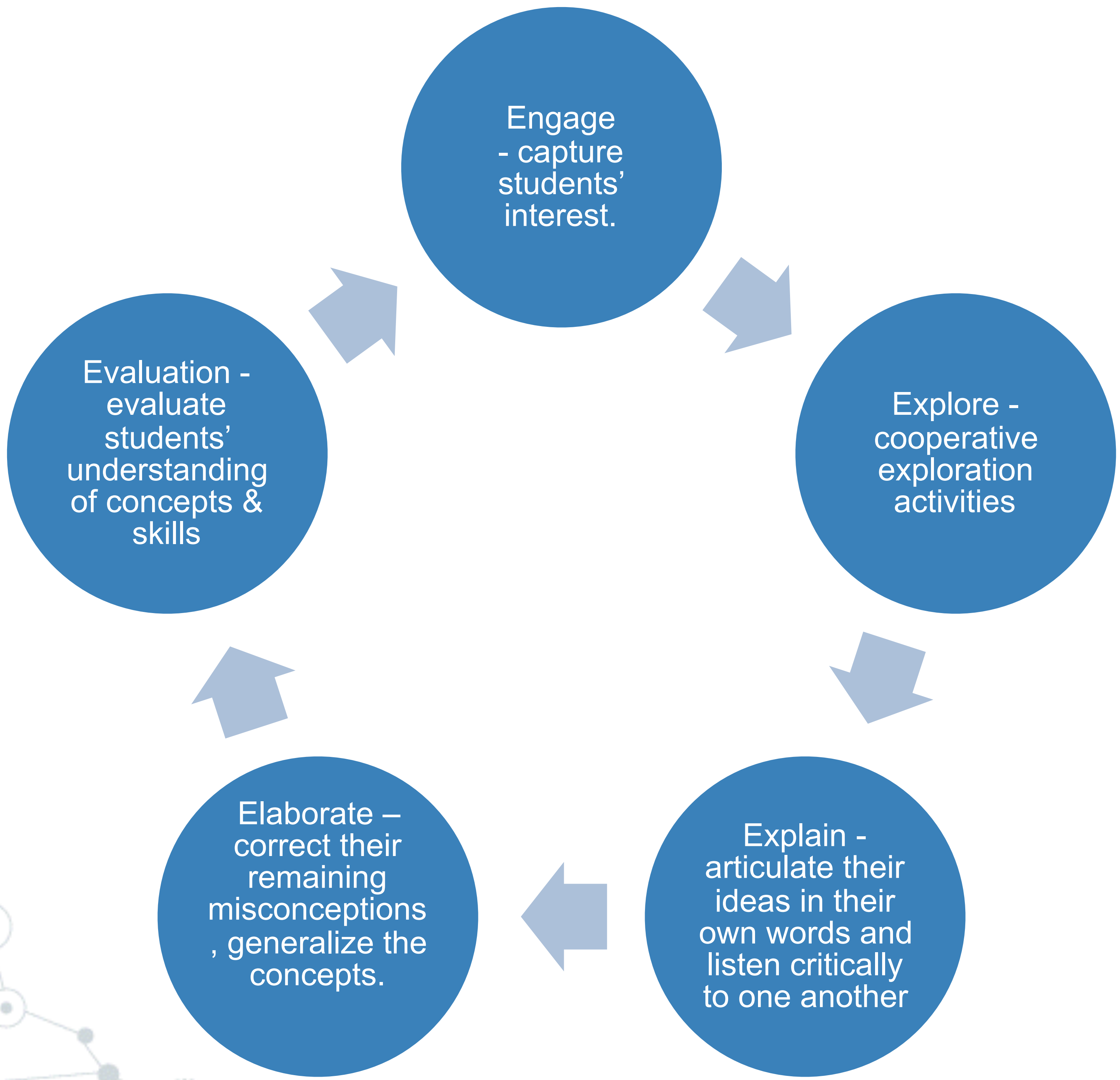
Instructional Model

3E



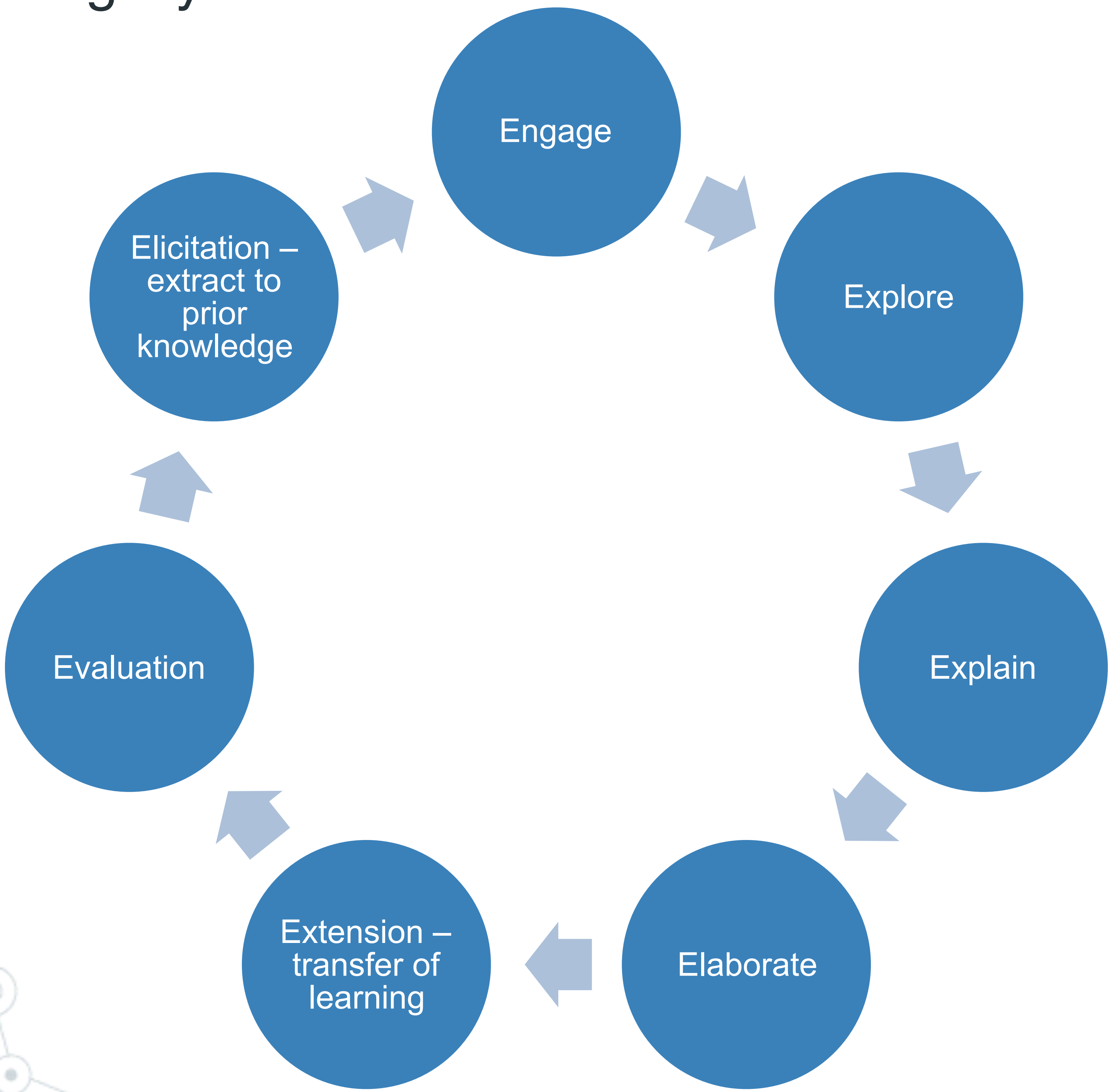
Instructional Model

- 5E Learning Cycle



Instructional Model

- 7E Learning Cycle



Teachers' Roles

- Motivator
- diagnostician
- guide
- innovator
- experimenter
- researcher
- mentor
- collaborator
- learner
- active collaborator
- leader
- apprentice
- teacher
- planner

Assessment of higher order thinking skills

- **Assessment *for* learning** is more commonly known as formative assessments.

- Assessment *for* learning is the use of a task or an activity for the purpose of determining student progress during a unit or block of instruction.

- Teachers are now afforded the chance to adjust classroom instruction based upon the needs of the students. Similarly, students are provided valuable feedback on their own learning.

ASSESSMENT *OF* LEARNING

- **Assessment *of* learning** is the use of a task or an activity to measure, record and report on a student's level of achievement in regards to specific learning expectations.
- These are often known as summative assessments.

ASSESSMENT AS LEARNING

- **Assessment as learning** is the use of a task or an activity to allow students the opportunity to use assessment to further their own learning.

- Self and peer assessments allow students to reflect on their own learning and identify areas of strength and need.

- These tasks offer students the chance to set their own personal goals and advocate for their own learning.

CHALLENGES

- The measurement of higher order thinking has eluded teachers and test developers for years (Stiggins, Griswold, & Wikelund, 1989).

"…*the heart of this problem is our failure to define such terms as critical thinking, problem solving, metacognition, reasoning and abstract thinking. Without adequate definitions and training, teachers lack the knowledge and skills to teach and test for these desirable but elusive human qualities*…"

BASIC ASSESSMENT PRINCIPLES (NITKO & BROOKHART, 2011)

(1) Begin by specifying clearly and exactly the kind of thinking, about what content, for which you wish to see evidence for.

(2) Design performance tasks or test items that require students to use this kind of thinking and content knowledge.

(3) Decide what you will take as evidence that the student has, in fact, exhibited this kind of thinking about the appropriate content, and design a scheme for scoring or interpreting performance.

ADDITIONAL PRINCIPLES FOR ASSESSING HIGHER-ORDER THINKING

(1) Present something for those who are assessed to think about, in the form of introductory text, visuals, scenarios, problems or choices of some sort,

(2) make sure the material you present is novel materials, not already familiar and thus subject to recall, and

(3) Don't confuse level of difficulty with level of thinking.

STRATEGIES FOR ASSESSING HOT

No.	Strategy	Description
1	Focus on a question	Identify the main idea and questions in a text
2	Analyse argument	Describe the structure of an argument, identify assumptions/ irrelevancies.
3	Evaluate the credibility of a source	Judge the degree of confidence one should have in the information from a particular resources.
4	Make a deductive conclusion	Reason from a principle to an instance of the principle.

STRATEGIES FOR ASSESSING HOT

No.	Strategy	Description
5	Evaluate inductive conclusions	Reason from an instance to a generalisation.
6	Identify implicit assumptions	Identify premises that must be true in order for an argument to be sound.
7	Describe multiple solution strategies	Describe several different ways to solve the same problem, and prioritise them according to appropriate criteria.
8	Model a problem	Diagram, draw or represent a problem visually.

STRATEGIES FOR ASSESSING HOT

No.	Strategy	Description
9	Reason with data	Solve a problem using data in graphs, tables or chart.
10	Use analogies	Apply a reason or principle from one situation in another, similar situation.
11	Solve a problem backward	Work backward from a desired end point.

ASSESSMENT TOOLS-ITEM FORMATS

- Multiple choice
- Performance tests

MULTIPLE CHOICE ITEMS

- Clearly worded questions
- Clearly worded appropriate correct or best answers
- Sufficiently plausible to attract those who have not mastered the knowledge or skills being measured.

CONSTRUCTED RESPONSE ITEMS

- Similar with multiple choice items, except examinees must write their own answers to the questions.

MULTIPLE CHOICE ITEMS/ CONSTRUCTED RESPONSE ITEMS

- Critical thinking (evaluating)

1. What is most effective (appropriate) for________? Which is better (worse)? What is the most effective method for____?

- Critical thinking (predicting)

2. What would happen if_____? If this happen, what should you do? Given_____, what is the primary cause?

- Problem solving (given a scenario)

3. Why do you need to solve this problem? Why _____is the possible solution?

MULTIPLE CHOICE ITEMS/ CONSTRUCTED RESPONSE ITEMS

- Problem solving (given a scenario)

3. Why do you need to solve this problem? Why ______is the possible solution?

   Then, how to design distracters that are attractive to students who have not mastered the high level of knowledge or skill being measured by the items?

PERFORMANCE TESTS (HALADYNA, 1997)

- 11 decisions

1. Should the task require responses that integrate multiple subject-matters?
2. Is process or product being evaluated?
3. What is the meaningful context for the task?
4. Are the instructions clear?
5. If materials are to be provided, what type and how many should be provided?

PERFORMANCE TESTS

6. Are there time limits?
7. What is the appropriate scope or length for the response?
8. Are the students able to consult with each other?
9. Or collaborate?
10. Is the response considered a final draft or is feedback allow?
11. Can students use computers on their task?

Strategies for Giving Feedback or Scoring Tasks Assessing HOT

- Observation
- Discussion with students
- Scoring Rubric

CRITERIA OR SCORING RUBRIC FOR GRADING RESPONSES

- Holistic rubrics
- Analytic rubrics

EXEMPLAR OF HOLISTIC RUBRIC
THE SIX LEVELS OF PROFICIENCY IN MATHEMATICS (OECD AVERAGE = 494)

Level	Lower score limit(%)	What Students can do?
6	669 (3.3%)	Conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts.
5	544 (12.6%)	Develop and work with models for complex situations, identifying constraints and specifying assumptions.
4	545 (30.8%)	Work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions.
3	482(54.5%)	Execute clearly described procedures, including those that require sequential decisions.
2	421 (77.0%)	Interpret and recognise situations in contexts that require no more than direct inference.
1	358 (92.0%)	Answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined.

ANALYTIC RUBRIC
PURPOSE OF ASSESSMENT: TO ASSESS STUDENTS' PROBLEM SOLVING SKILLS

CRITERIA	Excellent	Good	Moderate	Low
Understanding of the problem	Students understand the problem, identifies necessary data/facts for solving and creates an accurate plan to solve	Students understand the problem but can only identifies some necessary data or creates slightly incorrect plan to solve	Student understand the problem but cannot identify necessary data or plan to solve the problem	Student cannot understand the problem and cannot identify the data or create plan
Devising the Plan	Student planning is completely correct both logically and mathematically.	Student planning is mostly correct both logically and mathematically but with few error.	Student planning is correct logically but incorrect mathematically.	Student does not use appropriate plan to solve the problem
Carrying Out the Plan	Student presented correct , detailed, organized answers to the problem	Student presented correct , but not detailedand organized answers to the problem	Student presented organized but incorrect answers to the problem.	Student presented unorganized and incorrect answers to the problem.
Looking Back	Student looking back to the problem and give the correct and complete conclusion.	Student looking back to the problem and give the correct conclusion.	Student looking back to the problem and give theincorrect conclusion.	Student does not looking back to the problem and give conclusion.

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