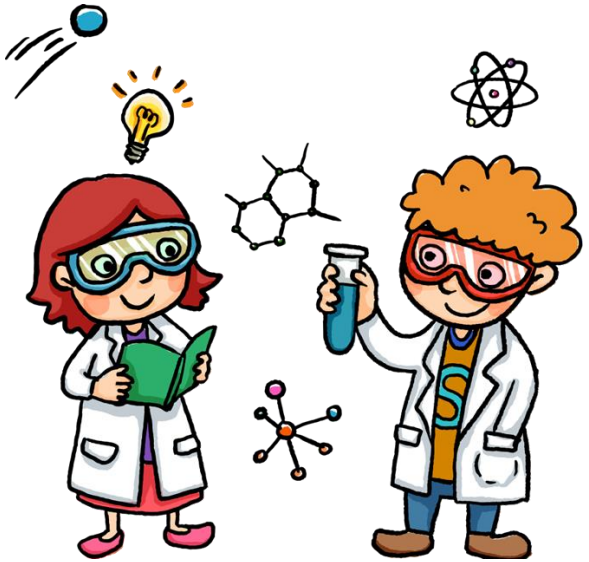
Designing a Quality Question as an Effective Teaching Tool to Promote Students' high order thinking skills in Classroom



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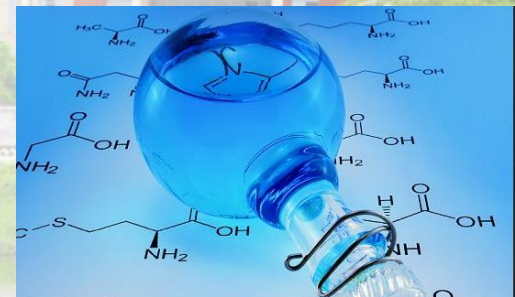
From the Title, I highlight three keywords:

Quality question

High order thinking skills

Effective teaching tool



Why is the question important in classroom?

- One of human nature is to have a curiosity to response their surrounding environment that is manifested through questions
- The higher the quality of the question asked, the higher the quality of knowledge students want to know or construct
- Questioning means thinking or the manifestation of thinking.
- As thinking, asking question is not develop automatically.
- Low quality question do not help students think at a high level

So, Teachers' role in helping students to ask question and to think at a high level is essential in classroom

QUESTIONS LEVELS

Prediction, Analysis, Evaluation, Inference — Q4

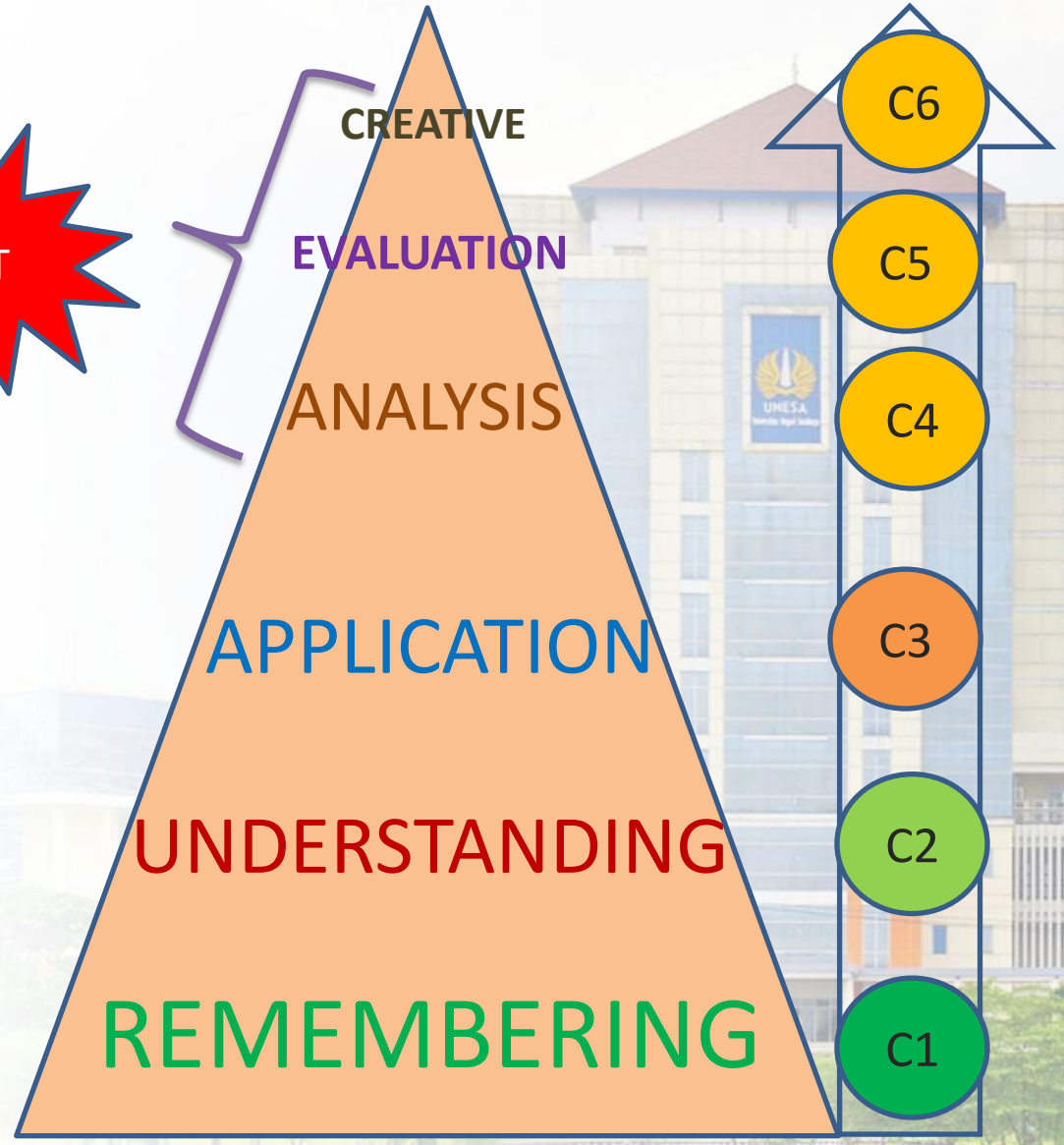
Application — Q3

Understand — Q2

Memorize — Q1

HOT

COGNITIVE PROCESS LEVELS



As human nature, someone will ask if…

Question

1 Interesting

- Something interesting (object or event)
- Something relevant to their experience

2 Need to know

- Something needed and is relevant to the experience
- Something according to his thinking ability
- Received question

3 Discrepant event

- Students face new situation or new challenge
- Fact is different from students' expectation
- Students face dilemma and uncertainty situation

Example: Some interesting events

How soap cleans

Water pollution

Baking soda make foods rise

To ignite fire requires a certain temperature for activation energy

The Nature of Facts, Situation, Problems, and questions to foster high order thinking skills

1. The starting point is not clear
2. Contain many variables
3. Contain many solutions
4. Problem solving strategies are not specific
5. Requires creative problem solving
6. Requires the ability to manipulate information or ideas
7. More than one solution
8. Requires cognitive processes C4 – C6 (Bloom Taxonomy)

Which of the following questions in open, closed, or investigative?

1. A sample of methane, sometimes referred to as swamp gas, is found to contain 12.0 grams of carbon and 4.03 grams of hydrogen. If a second sample of methane is found to contain 30.0 grams of carbon, how many grams of hydrogen does it contain?
2. What is the minimum concentration of Ag^+ ion needed to precipitate AgCl (*Ksp* AgCl = 2×10^{-10}) in 0.1M NaCl?

3. What should be done so that the tools iron at home is not easy to rust?

Which of the following questions requires an answer or more than one answer?

1. What is the solubility of $Mg(OH)_2$ in grams per 100 mL of solution? (*Ksp* $Mg(OH)_2 = 1.8 \times 10^{-11}$)

2. What should be done to increase the solubility of $Mg(OH)_2$ in water?

Please choose: Question 1 or 2!

Connection

In many cases, teachers asking question…

1. to get a correct answer (unfortunately, most students do not believe that their answer that is the correct answer)

2. to foster students' thinking processes (however, it is just to repeat teachers' idea and is not to create their own ideas)

3. to train students to do practice questions (procedural knowledge)

Who asking question?

During Learning
Student ask question

Before and after learning
Teacher ask question

Strategy: Inquiry, Discovery, Group Investigation, PBL

Experiment/ Observation

New knowledge

Solving problem

Evaluation and Diagnostic tools

Achievement
Learning outcomes

Learning Difficulties
Misconception
Pre conception

Cognitive, Skills, Attitudes

Competences

How to Facilitate students to ask questions?

1. The teacher determines the competencies that students will achieve after learning.
2. The teacher determines indicators of competency achievement
3. The teacher determines the strategy for achieving competency, especially students-centered learning.
4. Teacher presents the object of observation to orient students on the problem that the answer matches to the competence or indicator
5. Encourage students to ask question based on the result of their observation.
6. Scaffold the students (if they have trouble asking) by showing the focus of observation, than back to number 5.
7. Guide students to answer their questions through experimentation or observation or meeting experts.

Crusial & essential

Example

Competence : Analysis solution properties
Knowledge : Electrolyte and non electrolyte solution
Skills : Scientific thinking skill
Indicator : Explain the electricity of solution

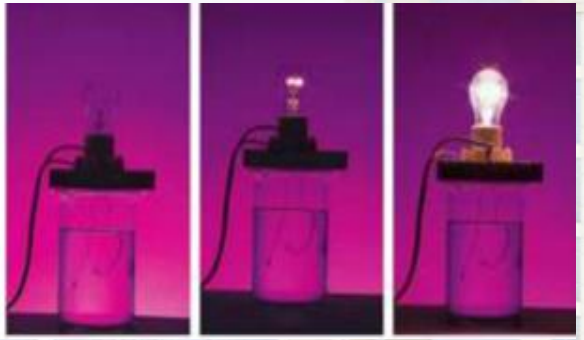
Question

Why lamp 3 brighter than lamp 2 and lamp 1 turns off? (Analysis question)

Cognitive conflict

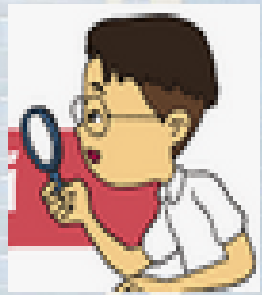
Student hopes all lamps turn on or turn off with the same bright

Scaffolding: Engage student observe the three lamps, whether all three lights are the same?



1 2 3

Observation object



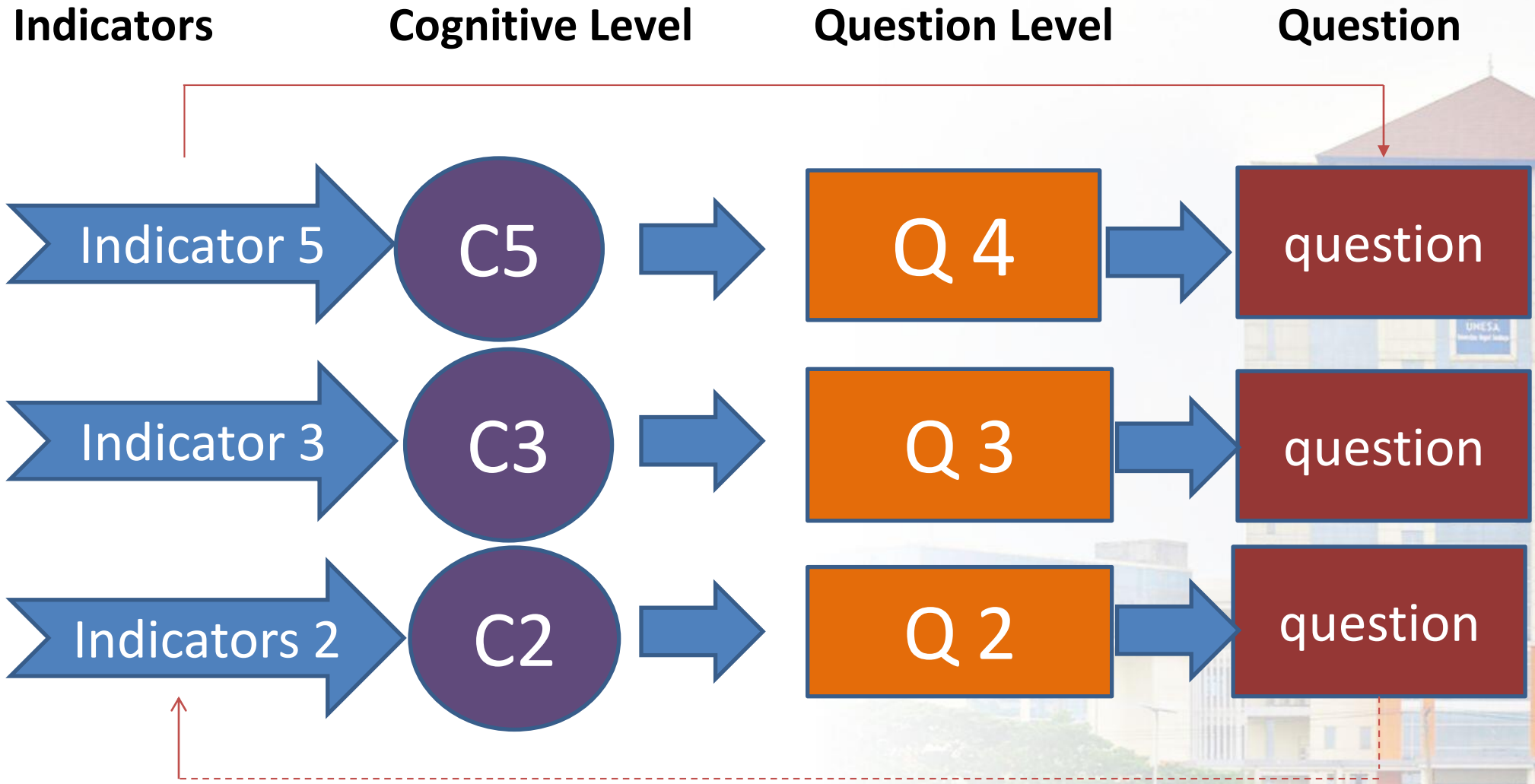
When the teachers is able to make quality question?

- Teachers who use student-centered strategies
- Teachers who are able to operate high-level thinking skills including scientific thinking skills
- Teachers who involve higher-order thinking skills in classroom

How to Design Question as an evaluation tool

1. Curriculum analysis to address the competences
2. Designing indicators of the competence
3. Designing question for each indicator
6. Question can be in the form multiple choice or essay
7. Determine question quality
    a. validity (by expert or peer)
    b. reliability (Cronbach alpha)
    c. difficulty index (fix to students' capacity)
    d. distinguishing power

Point 1 to 3 must be in line


Indicators
Cognitive Level
Question Level
Question
Indicator 5
C5
Q 4
question
Indicator 3
C3
Q 3
question
Indicators 2
C2
Q 2
question

Hots Question Template

Analysis

1. Look at the table / graph / diagram / picture ..., make an analysis of ...
2. What causes….
3. Classify ... based on ...
4. Draw a diagram for ...
5. What is the meaning of the symbol ...

Inference

1. Make a hypothesis, what will happen if ...
2. Predict what will happen if ...
3. What is the conclusion of the experiment ...
4. Based on the information you get, what can you conclude ...
5. Based on the facts that you get what your advice for ...

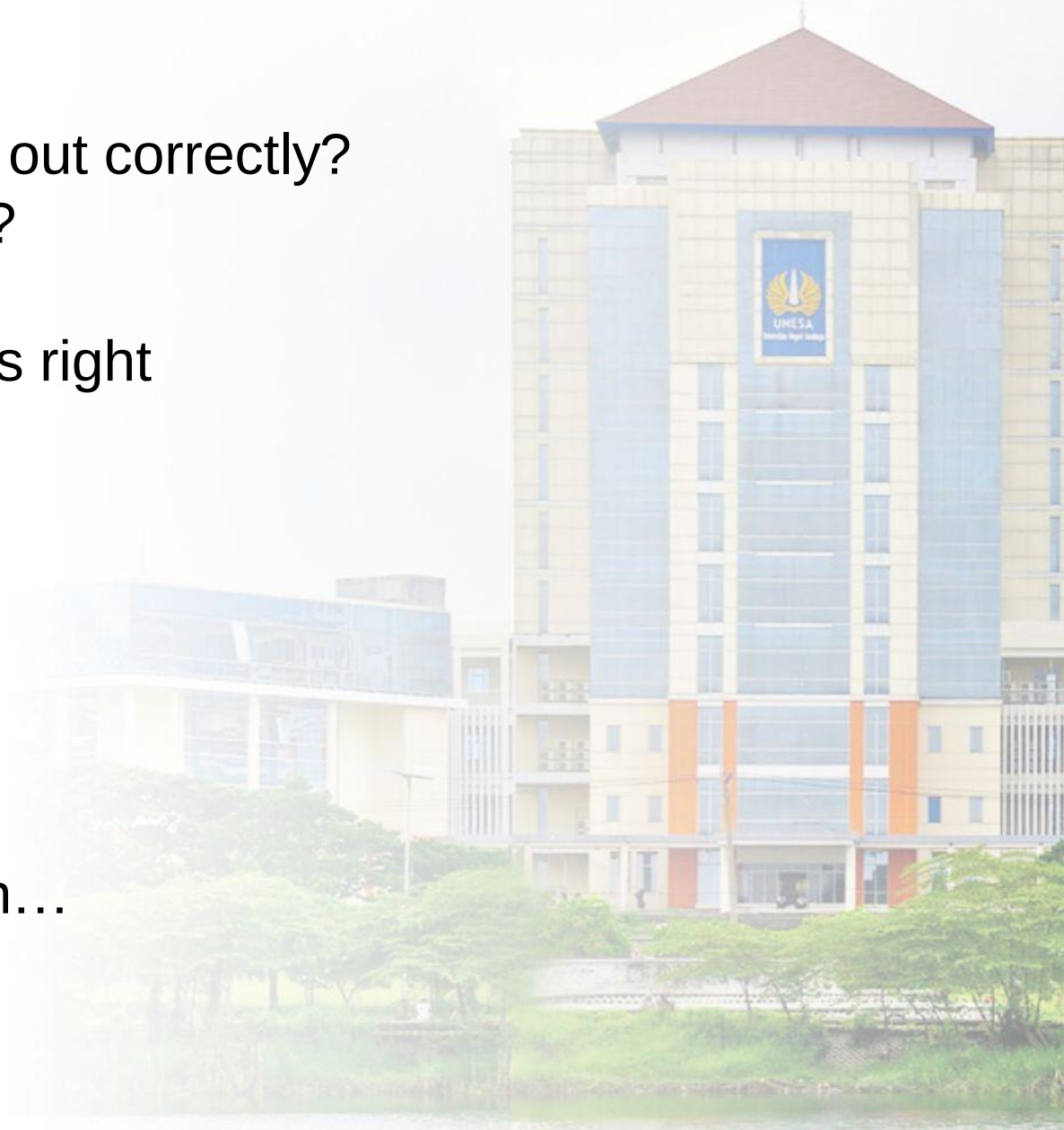
Hots Question Template

Evaluation

1. Has the experiment about ... been carried out correctly?
2. What decision should be taken? And why?
3. Which one is better for us ... or this one ...
4. Whether the decision taken to prevent ... is right
5. What are the benefits of using ...

Creation

1. Create an experimental design ...
2. What must be done to prevent ...
3. What is the best way to prevent ...
4. What should be done to solve the problem…



Question Q2

Indicator: Students understand Ions or uncharged substances

Problem

Ions are especially important in the human body, where they play a central role in maintaining the balance of electric charge in living cells. A nerve impulse in part consists of an exchange of ions across cell walls. Which of the following is the ion?

a. K^+ b. SO_4^{2-} c. SO3 d. O_2 e. SF_6

Question Q3

Indicator: Student can apply the law of conservation of mass
Problem
Magnesium is a light metal that when reacted with oxygen forms an extremely adherent high-melting layer of magnesium oxide. Magnesium is used in metal alloys that need to be structurally strong but lightweight-like those in aircraft bodies, car engines, cameras, and luggage, A piece of magnesium weighing 2.30 grams reacts with oxygen to form 3.81 grams of magnesium oxide.
How much oxygen reacted with the magnesium?

a. 2.30 grams b. 3.81 grams c. 1.51 grams d. 6.11 grams e. 0.00 grams

Question Q4 (Essay)

Indicator: Students can explain ways to prevent corrosion in metal tools

Problem/question

In the Figure 1, it appears that equipment made mainly of iron is very easy to rust so it becomes damaged and cannot be used. What should you do to prevent the metal tools (iron) from rusting easily?

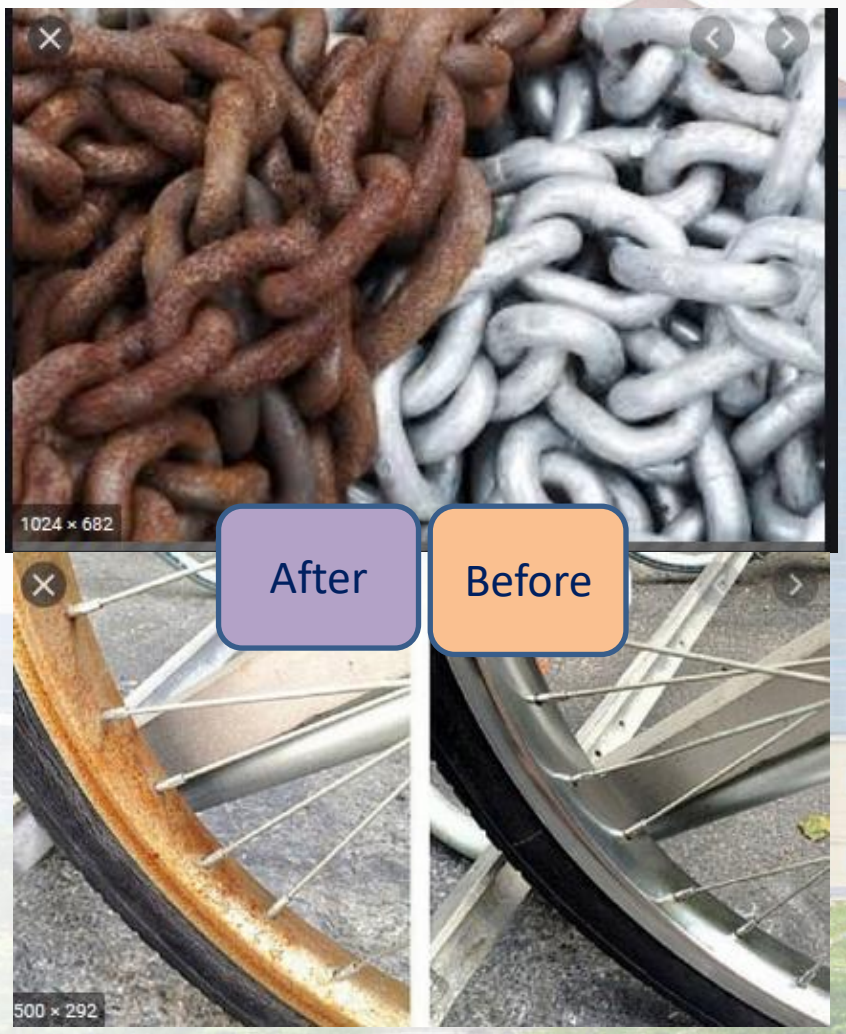


Figure 1

In a closed room, substances will evaporate until the room is saturated or a dynamic equilibrium is reached between the liquid or solid with saturated steam. The amount of vapor pressure depends on the type of substance and temperature. Substance with the large pull force between particles are difficult to evaporate. The greater the temperature the saturated vapor pressure of a substance will be even greater.

Table 1 The decrease in saturated vapor pressure (P) various types of solution in water at 20°C

Solute	Mole fraction of solute	The saturated vapor pressure of the solution (mmHg)	Decrease in the saturated vapor pressure of the solution (mmHg)
Pure water	--	17.54	--
Glycol	0.01	17.36	0.18
Glycol	0.02	17.18	0.36
Urea	0.01	17.36	0.18
Urea	0.02	17.18	0.36

Based on the data in Table 1, what conclusions can be drawn about the decrease in saturated vapor pressure of the solution?

a. A decrease in the vapor pressure of a saturated solution can occur at a constant temperature
b. The vapor pressure of a saturated solution is not affected by the type of solvent even at different temperatures
c. The decrease in saturated vapor pressure of the solution depends on the concentration of the solute and does not depend on the type of solute at a constant temperature.
d. The decrease in saturated vapor pressure of the solution depends on the type of solute at a constant temperature
e. The reduction in the type of vapor pressure of the solution depends on the type of solvent at a constant temperature.

Validity of question

1. Theoretical validity (Content and construct validities) by three experts or peer validators or Focus group discussion to address
   - content, including substance or concept of the question,
   - construct of the question, and
   - language aspect (the question' mean is clear and not ambiguous)

(most common in science/chemical educational research)

1. Empirical validity (try out)

The Simple Form of Validation (just for example)

Question	Answer of question	Review			Score (1, 2, 3, 4)	Suggestion for revision
		content	construction	language		
Question 1	Answer 1	yes/no	yes/no	Yes/no		
Question 2	Answer 2	yes/no	yes/no	Yes/no		
Question 3	Answer 3	yes/no	yes/no	Yes/no		

Score 1: if content, construction, and language need to revise

Score 2: if construction dan language need to revise

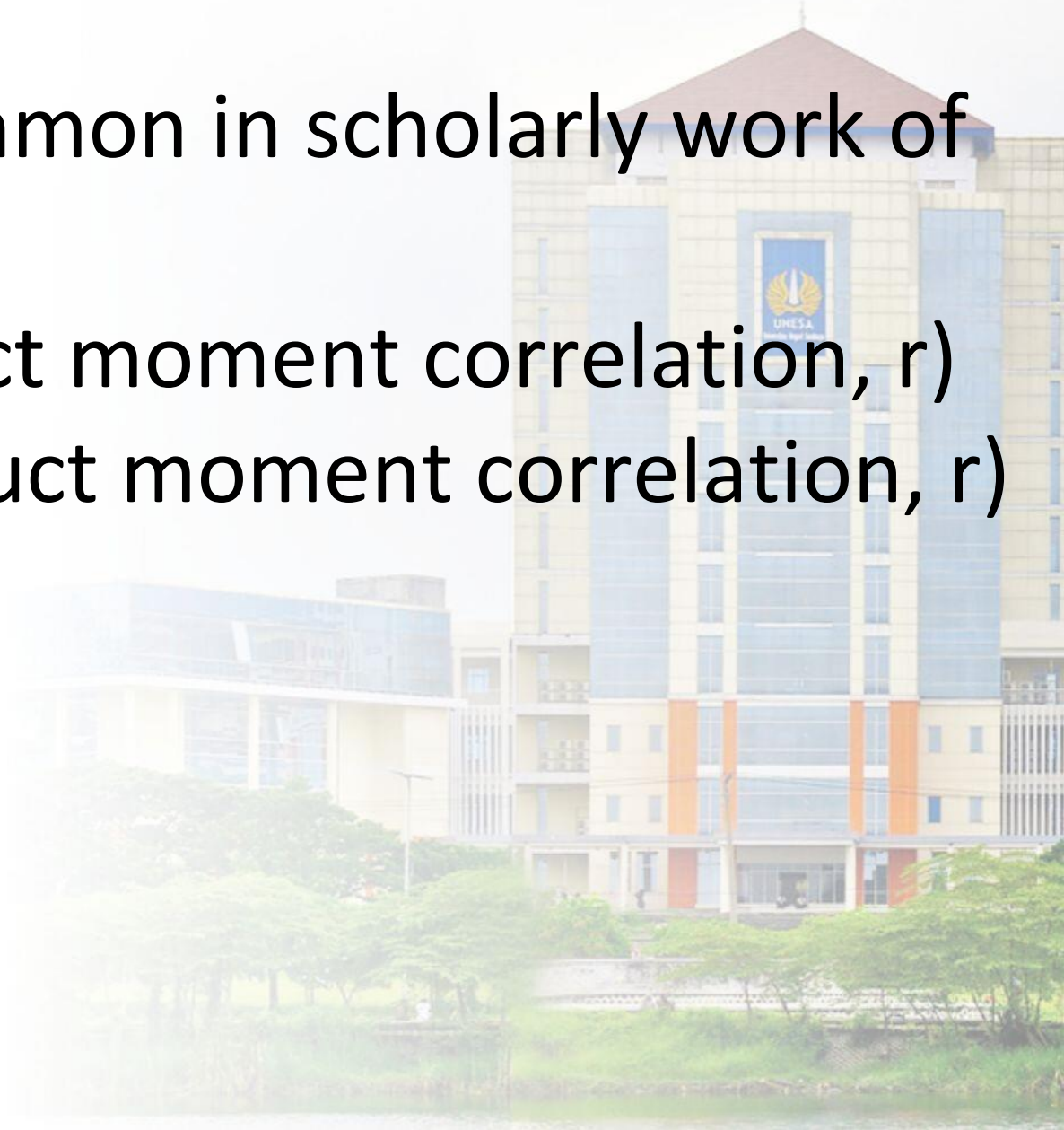
Score 3: if only language needs to revise

Score 4: no revise

Criteria: Question is stated valid if the validation score modus minimal 3

Reliability

1. Cronbach Alpha (most common in scholarly work of educational research)
2. Split half, (calculate product moment correlation, r)
3. Test retest (calculate product moment correlation, r)



Difficulty Index (DI)

DI is determined through the following steps:

- Determine the number of students who answered right
- Calculate the total number of students
- Calculate the proportion of students who answered right (SRA) by dividing the number of students who answered right (SRA) by the total number of students involved (T)
- Calculate DI

$$DP = \frac{SRA}{T}$$

DP	Interpretation
0.00 – 0.30	difficult
0.30 – 0.70	medium
0.70 – 1.00	easy

Distinguishing Power (DP)

DP is determined through the following steps:

- Determine the number of upper groups (SG) and lower groups (NSG)
- Calculate the number of SG and NSG that answer the question correctly
- Calculate the proportion of SG (PSG) by dividing the number of SG that answered correctly (RSG) by the total amount of SG (TSG)
- Calculate the proportion of NSG (PNSG) by dividing the number of NSGs that answered correctly (RNSG) by the total number of NSGs (TNSGs)
- Calculate DP by reducing the proportion of SG to NSG

$$DP = PSG - PNSG$$

DP	Interpretation
0.00 – 0.20	Not good
0.20 – 0.40	Enough
0.40 – 0.70	Good
0.70 – 1.00	Very good

Thank You

Terima Kasih

Semoga Bermanfaat

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