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Designing Questions for Clickers

Clickers work well for presenting multiple-choice questions, but not all multiple-choice questions are equal. Although simple recall questions have their purpose, multiple-choice questions can be used to assess deeper understanding. Multiple-choice questions that require complex analysis or evaluation can also be used to encourage class discussion and peer instruction[1]
when students are asked to explain their answers or to work together to reach a solution. (See Teaching Ideas for examples of clicker use in various subject areas.)

Clickers can also be used to ask questions for which there is no right answer, such as polling opinions or collecting data for in-class demonstrations. Note that the examples below focus on questions for assessing student learning, in which there is a correct answer.

Using clickers effectively requires choosing appropriate assessment objectives and constructing questions that satisfy them. This page provides examples of learning assessment objectives and of questions designed to evaluate varying levels of understanding.

Assessment Stages and Objectives

Clickers can be used to assess student learning at different stages in the learning process, as summarized below. (This information is adapted from materials prepared by the University of Wisconsin-Milwaukee.)

- **Pre-Assessments: At the beginning of a quarter or before a new topic**
  - What do students already know?
  - What are students' misconceptions?
- **Mid-Topic Assessments: In the middle of mini lectures or before another concept**
  - Do they understand this principle?
  - Can they connect this principle/idea to the previous one?
  - Can they apply this concept?
  - How is their thinking changing?
- **Post-Assessments: At the end of a quarter, topic, or class session**
  - What is their overall conceptual framework?
  - Can they synthesize the concepts to solve problems?
  - How had their understanding changed?

These stages and their objectives focus on varying levels of student understanding. For instance, pre-assessment may emphasize knowledge of general information, while mid-topic assessment may stress comprehension of implications or application of a technique. The next section provides examples of multiple-choice questions that assess different cognitive levels.

Sample Questions for Different Cognitive Levels

Multiple-choice questions can assess a range of understanding, from basic recall to higher-order thinking. The cognitive levels described below are based on Bloom's taxonomy. (The descriptions and example questions below are excerpts or variations from several sources on question development using Bloom's taxonomy. See the Sources section below.)

Click each cognitive level to go to explanations and sample questions.

- **Knowledge** - Remembering facts, terms, concepts, definitions, principles
- **Comprehension** - Explaining/interpreting the meaning of material
- **Application** - Using a concept or principle to solve a problem
- **Analysis**
  - Breaking material down into its component parts to see interrelationships/hierarchy of ideas
- **Synthesis** - Producing something new or original from component parts
- **Evaluation** - Making a judgment based on a pre-established set of criteria

Knowledge

Knowledge
is defined as recall of previously learned material. Questions targeting knowledge would check for basic recall of common terms, specific facts, basic concepts, principles, methods, and procedures.

Example:

Which of the following are the raw materials for photosynthesis?

A. Water, heat, sunlight
B. Carbon dioxide, sunlight, oxygen
C. Water, carbon dioxide, sunlight
D. Sunlight, oxygen, carbohydrates
E. Water, carbon dioxide, carbohydrates

Answer: *C. Water, carbon dioxide, sunlight* (Photosynthesis is the process by which plants, some bacteria, and some protistans use the energy from sunlight to convert water and carbon dioxide into sugar. Oxygen is released as by-product.)

Comprehension

Comprehension
is the ability to grasp the meaning of knowledge being learned. Questions about comprehension require students to understand facts and principles, to translate verbal material to mathematical formulas, to estimate the consequences implied in data, or to interpret verbal material, charts, and graphs.

Example:
If living cells similar to those found on earth were found on another planet where there was no molecular oxygen, which cell part would most likely be absent?

A. Cell membrane
B. Nucleus
C. Mitochondria
D. Ribosome
E. Chromosomes

Answer: *C. Mitochondria* (Mitochondria require oxygen to breakdown glucose.)

Application

Application
is the ability to use learned material in new and concrete situations. Questions assessing application would require student to apply concepts or theories to new situations or practical settings, to solve mathematical problems, to construct graphs and charts, or to demonstrate the correct usage of a method or procedure.

Example 1:
Which one of the following memory systems does a piano-tuner mainly use in his or her occupation?

A. Echoic memory
B. Short-term memory
C. Long-term memory
D. Mono-auditory memory
E. Iconic memory

Answer: *A. Echoic memory* (A piano-tuner uses echoic memory, in which auditory information is temporarily stored but not recorded in memory, to compare a note played on a piano to the correct pitch sounded by a tuning fork.)

Example 2:
Phenylketonuria (PKU) is an autosomal recessive condition. About 1 in every 50 individuals is heterozygous for the gene but shows no symptoms. If you select a symptom-free male and a symptom–free female at random, what is the probability that they would have a child with PKU?

A. (.02)(.02)(.25) = 0.0001 = 0.01%, or about 1/10,000
B. (.02)(.02) = 0.0004 = 0.04%, or about 1/2,500
C. (1)(50)(0) = 100% = all
D. (1)(50)(0) = 0 = none
E. 1/50 = 2%, or 2/100

Answer: *A. (.02)(.02)(.25) = 0.0001 = 0.01%, or about 1/10,000* (Each parent would have a 2% (1 in 50) chance of carrying the gene. If both parents did carry the gene, each of their offspring would have a 25% (1 in 4) chance of receiving the gene from both parents, which is required for presence of PKU.)

Question Legibility Tip
Writing questions that assess higher cognitive levels *and* fit on a single PowerPoint slide can be difficult. In some cases, however, it may be possible to show the question setup on one slide and the answer options on another.

Analysis

Analysis
is the ability to break down material into its component parts so that its organizational structure may be understood. At this level, questions would require students to recognize unstated assumptions and logical fallacies in reasoning, to distinguish between facts and inferences, to evaluate the relevancy of data, and to analyze the organizational structure of a work of art, music, or writing.

Example 1:
Mitochondria are called the powerhouses of the cell because they make energy available for cellular metabolism. Which of the following observations is most cogent in supporting this concept of mitochondrial function?

A. ATP occurs in the mitochondria
B. Mitochondria have a double membrane
C. The enzymes of the Krebs cycle, and molecules required for terminal respiration, are found in mitochondria
D. Mitochondria are found in almost all kinds of plant and animal cells
E. Mitochondria abound in muscle tissue

Answer: *C. The enzymes of the Krebs cycle, and molecules required for terminal respiration, are found in mitochondria* (The purpose of the Kreb's cycle, which occurs in the mitochondria, is to get as many electrons out of food as possible --these electrons drive the production of ATP, the basic fuel of cells. ATP is also produced outside the mitochondria, though far less efficiently--so option A, which also mentions ATP, is not as good an answer.)

Example 2:
[Slide 1] It is said that when organic chemist Auguste Kékulé was struggling with how the six carbon atoms of benzene linked together, he dreamt of molecules twisting and turning around like snakes. In his dream, one of the snakes swallowed its own tail and rolled around like a hoop. When Kékulé woke up, he realized that the six carbon atoms of benzene were attached to each other to form a ring. Further work showed that this was correct.

[Slide 2] Which phase of the creative process is illustrated by this example?

A. preparation
B. incubation
C. orientation
D. illumination
E. verification

Answer: *D. illumination* (In the Wallas Model for the creative process, illumination is the moment when a new idea finally emerges. It follows active preparation and a period of incubation where the subconscious is allowed to work on the problem.)

Synthesis

Synthesis
is the ability to put parts together to form a new whole. Multiple-choice questions requiring synthesis would ask students to integrate learning from different areas in order to view information in a new way.

Example:
If Homer wrote *The Iliad* today, Stanley Fish and Harold Bloom would argue, respectively, whether the work should be classified as:

A. Existential vs. romantic
B. Postmodern vs. classical
C. Modern vs. romantic
D. Postcolonial vs. modern
E. Preliterate vs. postliterate

Answer: *?*
(Response to this sample question was not provided -- if you know the answer, please contact us. However, answering would require students to know something about *The Iliad* (such as its style or when it was written) as well as to be conversant in the critical theories of Stanley Fish and Harold Bloom. Putting that information together would result in a novel (to the student) way of thinking about *The Iliad*.)

Evaluation

Evaluation
is concerned with the ability to judge the value of material for a given purpose. Questions focusing on evaluation might require students to judge the logical consistency of written material, the adequacy with which conclusions are supported by data, or the value of a work of art (either by internal criteria or external standards).

Example 1:
Consider the following answer to the question "Briefly list and explain the stages of the creative process."

[Slide 1] 5 stages of the creative process, in order, are: ORIENTATION, when a problem is identified and defined; PREPARATION, when all possible information about the problem is collected; INCUBATION, when there is no solution in sight -- the person is often busy with other tasks; ILLUMINATION, when the person gets a general idea for a solution; and finally VERIFICATION, when the person determines whether the solution works.

[Slide 2] How would you judge this answer?

A. EXCELLENT (all stages in the right order with clear, correct explanations)
B. GOOD (all stages in the right order, but explanations are not clear)
C. MEDIOCRE (1-2 stages are missing or in the wrong order OR explanations are irrelevant or not clear)
D. UNACCEPTABLE (>2 stages are missing and in the wrong order AND explanations are irrelevant or not clear)

Answer: *A. EXCELLENT (all stages in the right order with clear, correct explanations).* (All the stages are listed in the correct order. A value judgment is required on the content of the descriptions, but this example gives reasonably clear, correct explanations.)

Example 2:
Disregarding the relative feasibility of the following procedures, which of these lines of research is likely to provide us with the most valid and direct evidence as to evolutionary relations among different species?

A. Analysis of the chemistry of stored food in female gametes
B. Analysis of the form of the Krebs cycle
C. Observation of the form and arrangement of the endoplasmic reticulum
D. Comparison of details of the molecular structure of DNA
E. Determination of the total protein in the cell

Answer: *D. Comparison of details of the molecular structure of DNA* (Comparing DNA, the material that carries genetic information, would be more directly indicative of relationships among different species than comparing cellular structure and operations.)

Sources

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