MCQ Test Construction Tutorial
“What’s in Your MCQ?”

Boston University School of Medicine
Office of Medical Education
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The purpose of this Tutorial is to provide the necessary content and skills for the Medical School Faculty to construct MCQ items that are fair, clear, concise and measure their course learning objectives.

This is a self-learning tutorial. Please proceed at a convenient pace for you. You can stop and return to any slide as you wish. Yellow task slides are provided for practicing your MCQ skills.
Learning Objectives

By the end of this tutorial on MCQ Test Construction, you will be able to:

- Define assessment needs
- Recognize the MCQ format
- Evaluate for MCQ flaws
- Provide student feedback strategies
Tutorial Modules

1. Planning
2. Construction
3. Test Evaluation
4. Feedback to Students
Planning: Design the MCQ Items

Define assessment needs

- **Step 1**: Review course learning objectives
- **Step 2**: Consider learner characteristics
- **Step 3**: Determine cognitive level
- **Step 4**: Differentiate content for Basic Sciences and Clinical MCQ items
Learning Objectives and MCQs

Clear and concise learning objectives potentially deliver

Learning Objective
Predicts student performance

→ MCQ
Assesses student performance

Clear and concise multiple choice questions
Step 1. Review Learning Objectives

A Learning Objective is a clear, concise and specific statement of observable student behaviors that can be evaluated at the conclusion of the learning activities.

\[ A + B + C + D = \text{Learning Objective} \]

- **Audience** = BUSM-1
- **Behavior** = action verb + content
- **Condition** = from lecture notes and syllabus material
- **Degree** = 100% correctly
From the Lecture and Syllabus notes on the Gene and Genome Organization Unit, the BUSM-1 students will correctly be able to:

- **Describe** the processes of **mitosis and meiosis**
- **Identify** the roles of different parts of genes
- **Explain** Mendelian Laws of segregation and of independent assortment
- **Recall** the epigenetic relationship between chromatin structure and gene expression
Tip #1:
If your learning objectives are NOT clear and concise, then STOP and rewrite the learning objectives now before proceeding to write multiple-choice questions.

Taking the time now to have focused learning objectives will ease the writing of your MCQ items later.

For further assistance see the tutorial on writing learning objectives.
Tutorial Task 1

In a new window or on a piece of paper, write a learning objective by defining the:

- Audience
- Action verb* + content
- Condition
- Degree

*If you are using verbs such as “understand, be familiar with, or appreciate”, then these are NOT considered action verbs upon which to base assessment items and must be revised.
Step 2. Consider Learner Characteristics

Students encode, store and retrieve information by:

- **Learning style**
  - Convergence
  - Divergence
  - Assimilation
  - Accommodation

- **Learning experience**
  - Interpreting the content through their previous academic, cultural and social knowledge
  - Motivating their preferred interests to attend to the content

Students retrieve information to answer MCQs using their learner characteristics
How Do Learning Styles Alter MCQ Test Results?

Convergers (think & do) and Assimilators (think & watch) score better because the MCQ test requires a single best answer. *

Tip #2:
How do you accommodate for different learning styles in a MCQ exam?

By providing a variety of types of MCQ items, the exam will not be repetitive with just recall items and will appeal to a multiple of learning styles.

Alternative types of MCQs using verbal and nonverbal channels will motivate your students to respond and challenge them to use different intelligences to answer questions.

For further assistance refer to learning styles discussed as VAK, Kolb’s Learning Style Inventory, and/or Howard Gardner’s Multiple Intelligences.
Step 3. Determine A Cognitive Level*

1. **Knowledge**
   - To itemize information

2. **Comprehension**
   - To classify information

3. **Application**
   - To relate two or more concepts

4. **Analysis**
   - To apply principles and predict outcomes

5. **Synthesis**
   - To organize concepts

6. **Evaluation**
   - To assess concepts

Testing Item Content Levels

1. **Recall** – testing knowledge of isolated facts
2. **Interpret*** – asking to review and reach some conclusion
3. **Problem solve*** – asking to take some action after reading a situation

*Higher order thinking skills.
Writing for Different Cognitive Levels

• **Recall**
  – *Which of the following is the process of mitosis?*

• **Interpret**
  – *Which of the following can be classified as a meiosis error?*

• **Problem-solving**
  – *A maternal blood sample revealed decreased levels of AFP and estriol and elevated hCG. What would be the next logical test to perform?*
Tutorial Task 2

Select one of your learning objectives and write 3 different questions to:

2. Test factual learning -- knowledge
3. Test conceptual learning -- application
4. Test problem solving -- evaluation
Tip #3:
It is a good idea to sequence the cognitive level in a group of MCQ items by beginning with a recall item to jog the student’s memory on a topic.

After the initial recall item, the cognitive level can build in subsequent items until reaching the desired cognitive level for the learning objective.

6. Evaluation (test)
5. Synthesis (categorize)
4. Analysis (discriminate)
3. Application (classify)
2. Comprehension (explain)
1. Knowledge (recall)
# Step 4. Write for Basic Sciences & Clinical Content

**NBME recommends:**

<table>
<thead>
<tr>
<th>Basic Sciences Items</th>
<th>Clinical Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Test application of knowledge</td>
<td>• Test application of knowledge</td>
</tr>
<tr>
<td>• Use experimental and clinical vignettes</td>
<td>• Use clinical vignettes to decide on patient care</td>
</tr>
<tr>
<td>• Target essential key concepts and principles</td>
<td>• Target common problems &amp; decision-making tasks</td>
</tr>
<tr>
<td>• Select content relevant to clinical clerkships &amp; post graduate education</td>
<td>• Avoid clinical situations reserved for subspecialists</td>
</tr>
</tbody>
</table>
Module 2. Construction: Write the MCQ items

Use the NBME Recommended MCQ Format

Step 1. Select the MCQ Format
Step 2. Write the MCQ stem
Step 3. Draft the Lead-in
Step 4. Compose the Options
Step 5. Edit to avoid MCQ flaws
A Multiple Choice Question (MCQ) has the following components:

**Stem** – the information for the question

**Lead-in** – the question and how to answer

**Answer options:**

1. **Key** – the correct answer
2. **Distracters** -- the incorrect answers (4)*

*4-5 options reduces the chance of guessing the item is correct
Item Shape

Long Stem: A MCQ item stem should contain all the relevant facts and be relatively long with short options.

Lead-in: Asks the question

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td>Short Option</td>
</tr>
<tr>
<td>B.</td>
<td>Short Option</td>
</tr>
<tr>
<td>C.</td>
<td>Short Option</td>
</tr>
<tr>
<td>D.</td>
<td>Short Option</td>
</tr>
<tr>
<td>E.</td>
<td>Short Option</td>
</tr>
</tbody>
</table>
The extended matching has these components:

- Theme
- List of options (with multiple keys)
- Lead-in
- At least 2 item stems
Case Clusters

Another format for the clinical vignette is case clusters. The components are:

One patient presentation as a stem

A Lead - in
  • Key
  • Distracters

Another Lead - in
  • Key
  • Distracters
Tip #4:
Be careful in using case clusters that you do not give away answers to other cluster questions (known as “cueing.”)

Also, avoid “hinging” where the student uses one stem to select the best answer in a first item and based on that answer selects the best answer in a second item.
Clinical Vignettes MCQs

Basic Sciences MCQ

Stem At a banquet, the menu included fried chicken, home-fried potatoes, peas, chocolate eclairs, and coffee. Within 2 hours, most of the diners became violently ill, with nausea, vomiting and abdominal pain.

Lead-in Analysis of the contaminated food is most likely to yield large numbers of which of the following organisms?

Options
- A. Escherichia coli
- B. Proteus mirabilis
- C. Salmonella typhimurium
- D. Staphylococcus aureus*
- E. Streptococcus faecalis

Clinical Vignette MCQ

Stem A previously healthy 15-year-old boy has cramping periumbilical pain; after several hours, the pain shifts to the right lower quadrant and becomes constant. He vomits several times and is brought to the emergency department. The abdomen is tender on deep palpation of the right lower quadrant. Findings on the chest and abdominal x-ray films are normal. Leukocyte count is 15,000/mm³. Urinalysis shows 3 leukocytes/hpf.

Lead-in Which of the following is the most appropriate initial management?

Options
- A. Supportive treatment at home
- B. Barium enema
- C. CT scan of the abdomen
- D. Intravenous pyelography and cystography
- E. Surgical exploration of the abdomen*
The 10 Golden Rules for Writing MCQ Test Items

1. Examine only the important facts
2. Use simple language
3. Make questions brief and clear
4. Form the questions correctly
5. Take into consideration the independence of questions
6. Offer uniform answers
7. Do not use negative questions
8. Avoid using absolutes ("always, never, all, none")
9. Differentiate distracters significantly from the key
10. Provide at least four distracters
Step 2. Write the Stem

The Stem gives the essential information.

- Provide only relevant information
- Use clear and concise language
- Give bare details and do not summarize
- Avoid using negatives (e.g., not, never, only)
Possible Stems

• **Premise-consequence** - give a circumstance
• **Analogy** -- give two contexts to relate
• **Case Study** -- give a lab or patient vignette
• **Incomplete scenario** -- describe a series of events
• **Problem/Solution Evaluation** -- present a problem and proposed solution
Tutorial task #3 Write Your MCQ Stem

From your selected learning objective:
• Give the bare facts
• Stimulate higher-order thinking (e.g., synthesis)
• Write your MCQ stem clearly
Step 3. Draft a Lead-in

- Write a question for the one-best-answer
- Do NOT use incomplete statements or opinions
- Be specific
- Confirm answer to lead-in can be found from stem
- Avoid frequency terms (usually, often)
Sample Lead-ins

• Which of the following is
  – abnormal?
  – most likely?
  – the most likely cause?
  – Defective/ deficient/ nonfunctioning?

• Which of the following should be administered?

• Given the pedigree, what is the likelihood that the next child (specify gender) will have the disease?
Tutorial Task #4 Write the Lead-in

Read over the bare facts in your stem and write a lead-in that asks the question and describes how to select the best option.
Tip #5:
To test if the lead-in actually asks what you want to question, give the stem and the lead-in to a colleague without the options and see if the colleague answers are similar to your options.
Step 4. Compose the Options

• Write the key (the one best answer) first
• Provide only plausible & significantly different distracters
• Use common student errors
• Avoid obvious wrong options
• Keep option length the same
A good distracter is a **plausible** answer:

- **CM** = common student mistakes, a recurrent misconception about topic
- **TG** = too general option, that is too broad to answer the question
- **TS** = too specific option, option focuses on one detail in stem
- **OT** = off topic, option misses the answer completely
Avoid “Bad” Distractors”

- Same information is repeated in all the options
- Negative options (not, never, none, only)
- Same information in stem is repeated in one option
- Unparallel structure in options
- Tedious text copied incorrectly from text that seems familiar, but is wrong
- “All or none” of the above
Tutorial Task #5 Write the Options

There must be one “right” or “best” answer and at least four distracters. Write the best answer first and then four plausible distracters.
Step 5. Edit for MCQ Flaws

Testwiseness

Student answers based on test-taking skills

- Grammatical cues
- Logical cues
- Absolute terms
- Long correct answer
- Repeating word
- Convergence strategy
Avoiding MCQs Flaws

Irrelevant Difficulty

Student has difficulty answering due to

• Long, tricky and complicated stems
• Inconsistent data
• Unparallel language in options
• Illogical order of options
• “None of the Above” option
• Answer hinged to another item
• Imprecise terms
Tutorial Task #6 Find the Flaws

Review some of your MCQs from previous exams and see if you can find these flaws:

• Testwiseness
• Irrelevant Difficulty
Module 3. Evaluate MCQ Items

Item Analysis
Step 1. Estimate MCQ Item Difficulty
Step 2. Determine Item Discrimination Index
Step 3. Strive for Validity and Reliability
Step 4. Interpret LXR Report
Step 5. Provide feedback to test developer
Evaluate Your MCQs

What is a “bad” MCQ?

If students do not answer the question correctly because it is:

- too difficult or
- too easy or
- unclear,

then the question is not good and should be edited or deleted from the test.
Step 1. Estimate MCQ Item Difficulty

MCQ item difficulty can be calculated using this formula:

$$P = \frac{\# \text{ of correct answers}}{\# \text{ each question}}$$

Acceptable difficulty level is 0.3 - 0.7

Easiness = $\frac{\text{total \# correct answers}}{\# \text{ of students who took test}}$

Too easy $>0.7$

Difficulty = 1 - easiness

Too difficult $<0.3$
Step 3. Item Discrimination Value Index

After the test, you can calculate the difference in performance between the top and bottom performers on each item with this formula:

$$\text{Discrimination Value Index} = 2(B-L)x$$

- $B$ is the Better group or top 27%
- $L$ is the Lower group or lower 27%
- $X$ is the # of students
Item Discrimination Value Index

The bigger the discrimination # the better

Excellent:  > 0.35
Good:  0.35 - 0.25
Acceptable:  0.25 - 0.15
Deleted:  < 0.1
Step 3. Strive for Validity & Reliability

- **Validity** = Exam assesses what it is designed to measure

- **Reliability** = Exam repeatedly yields the same or similar results

Estimate reliability using test-retest, alternative forms, and/or split the test group in half.
Step 4. Interpret the LXR Report

Scanning the answer sheets with a software called LXR Test 6.0 (used by the Educational Media Center) will provide:

• Item Statistics Report -- gives item difficulty, item discrimination value index and validity

• Test Statistics Report -- charts students and scores + median, mean, standard deviation, test reliability and standard error of measurement

• Individual Scores Report -- identifies an individual student’s response by item
Step 5. Provide Feedback to Test Developer

Communicating with Test Developers:

- Be positive, constructive and confident
- Use test language
- Show good and bad MCQ examples from NBME Manual
- Use item analysis from LXR report
Module 4. Feedback to Students

Why and how you tested certain content

- Step 1. Communicate and collaborate
- Step 2. Recognize student complaints
- Step 3. Prepare feedback strategies
- Step 4. Redirect feedback actions
Step 1. Communicate and Collaborate

- Be an active listener
- Be respectful & understanding
- Foster collaboration
- Use LXR data
- Provide a solution
Step 2. Recognize Student Complaints

- Information gap
- Retention gap
- Misinterpretation of information
- Synthesis gap
- Vocabulary gap
- Inability to decipher
- Jumping to conclusions
- Rushed
- Miskeying…
Step 3. Prepare Feedback Strategies

- Provide an answer feedback sheet where each question is answered correctly and your supporting information.
  - This reinforces those who got it right and redirects those who got it wrong.
  - If you want to recycle MCQs and do not want to release answers, then prepare this sheet for your reference when talking with students
- Offer MCQ test-taking strategies
- Feedback should be appropriate, helpful and encouraging
Step 4. Redirect Feedback Actions

- Direct to another resource
- Admit any mistakes
- Find a solution
Tips for Writing MCQs

1. Do not write test items in one day
2. Write test items as you write the learning objectives
3. Prepare feedback (how and why) on each item as you write
4. Ask a colleague to answer an item
5. Collect good items in a question bank
For Assistance

1. National Board of Medical Examiners guidelines at http://www.nbme.org/about/itemwriting.asp

2. Sign up for an in-depth MCQ experience by attending the next “What’s in your MCQ? Multiple-Choice-Question Test Construction Workshop

3. Contact Gail March, Manager of Faculty Development, Office of Medical Education, at gmarch@bu.edu or 617-414-744