Writing cognitive educational objectives and multiple-choice test questions

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Abstract: Guidelines for writing cognitive objectives and multiple-choice test questions for pharmacy educational programs are suggested. Cognitive educational objectives relate to intellectual skills and can usually be tested with multiple-choice questions. Pharmacy educators writing cognitive objectives should focus on the major, not minor, knowledge or skills that participants in an educational program are expected to acquire; ensure that the objectives are supported by instruction; define the desired performance of the learners; ensure that the objectives are observable and measurable; and define the learning level for each objective (i.e., knowledge, comprehension, application, analysis, synthesis, or evaluation). Each multiple-choice test question should be written with a view to assessing the learner’s achievement of one of the stated objectives. Educators should write test questions that are clear and concise, are in the form of complete sentences, include one clearly correct or best response, are phrased positively rather than negatively, and give no clues as to the correct answer. The learning level of each question should match that of the objective the question is designed to test. Educators should weight tests fairly by including the same number of questions for each objective. It may be necessary to include some higher-level questions to ensure assessment of the competence level at which the program is aimed.

Cognitive educational objectives should be observable and measurable; multiple-choice test questions should correspond to specific objectives and be based on the appropriate learning level.

Index terms: Education, pharmaceutical; Educators; Examinations; Guidelines; Writing


Educational objectives

Well-written educational objectives and test questions that assess the achievement of those objectives are essential to the success of pharmacy educational programs, whether courses, workshops, laboratories, or other formats. Although objectives and test questions vary, this article will focus on cognitive (intellectual) objectives because these are the most common in pharmacy education. Multiple-choice test questions will be discussed as well because of their appropriateness for assessing cognitive objectives and their widespread use. It is important to remember that some pharmacy education objectives cannot and should not be tested by multiple-choice questions. Direct observation or other forms of assessment are therefore necessary to ensure that some types of objectives are met. Readers are referred to the cited references for information that goes beyond the scope of this article.1-7

Educational objectives

An educational objective is what you the educator want learners to be able to do as a result of participating in an educational program. Objectives may be in one of three learning domains: cognitive, affective, and psychomotor.

Cognitive. The cognitive domain of learning involves intellectual skills. Examples of cognitive objectives are to be able to define appropriate pharmacotherapeutic goals for a patient and to be able to design a patient’s drug therapy regimen and monitoring plan. Cognitive skills can usually be tested with multiple-choice questions.

Affective. The affective domain of learning concerns values, attitudes, and beliefs. Examples are the capacity to value the concept of pharmaceutical care and the capacity to respect cultural diversity among
The Primer section covers basic information in various fields of knowledge of interest to pharmacists who practice in health systems. Within the scope of the section are reviews of fundamental concepts in, for example, pharmacy, pharmaceutics, pharmacology, physiology, therapeutics, and health care technology. Also covered are topics somewhat out of the mainstream of pharmacy (e.g., advances in non-drug health technology) but nevertheless of interest to practitioners.

patients. Evaluation of affective objectives is complex and is beyond the scope of this article; interested readers are referred elsewhere.3,6

**Psychomotor.** The psychomotor domain of learning includes the performance of physical movements, such as applying a blood pressure cuff and taking a patient’s pulse or temperature. Attainment of objectives in this domain needs to be assessed by direct observation.

**Guidelines for writing educational objectives**

**Aim for the important.** Objectives should define knowledge or skills that are important for participants in an educational program to acquire. Focus on what you want the learners to be able to do after they complete the program. The objectives should define major, not minor, knowledge or skills.

**Ensure that objectives are supported by instruction.** Objectives should be supported by the instruction provided through the educational program. If something is not taught, do not write an objective for it.

**Define expected learner behavior.** Objectives should define the desired performance of the learners as a result of their participation in an educational activity (e.g., reading an article). Do not describe what the program will teach.

Wrong: The objective of this article is to teach how to write effective cognitive educational objectives and multiple-choice test questions.

Right: After reading this article, readers will be able to explain guidelines for writing effective cognitive educational objectives and multiple-choice test questions.

**Write observable, measurable objectives.** Observable, measurable objectives enable you to accurately assess whether the learner has achieved an objective. For example, you cannot measure or observe whether a learner “knows” or “understands” information. You can measure or observe whether the learner can accurately explain information or identify correct information.

<table>
<thead>
<tr>
<th>Measurable</th>
<th>Not measurable</th>
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<tbody>
<tr>
<td>State</td>
<td>Know</td>
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<td>Explain</td>
<td>Understand</td>
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<td>List</td>
<td>Learn</td>
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<td>Identify</td>
<td>Grasp the significance of</td>
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<tr>
<td>Compare</td>
<td>Become familiar with</td>
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</table>

**Define the learning level for each educational objective.** Most objectives related to pharmacy education programs are on one of six levels of cognitive learning. To determine which level is appropriate for each objective, ask yourself which of the following you want the learner to be able to do.

1. Recall information (knowledge level),
2. Explain information or skills (comprehension level),
3. Use information or skills (application level),
4. Have an in-depth understanding of the information and its components and organization (analysis level),
5. Create something new with the information or skills (synthesis level), or
6. Evaluate something by using the information or skills (evaluation level).

Examples of objectives on each level follow.

Knowledge. Knowledge-level objectives relate to the ability to recall previously learned information (memorization):

- List the categories of information to be included in a patient-specific database.
- Compare and contrast processes for organizing information in a patient-specific database.
- Application. Application involves using new information, rules, methods, concepts, principles, laws, and theories. To meet a comprehension-level objective, learners would need only to be able to explain a rule; at the application level, they would need to be able to apply the rule:
  - Use a systematic procedure for recording information in a patient-specific database.
- Analysis. Analysis requires more in-depth comprehension involving the ability to break down material into parts, detect relationships among the parts, and understand the way the parts are organized:
  - Identify the information required by a pharmacist to make appropriate recommendations for a particular patient’s medication therapy.
- Synthesis. Synthesis is the process of using acquired information in new and unique ways (e.g., the creation of a proposal, a drug therapy regimen, or a report):
  - Design a drug therapy regimen.
- Evaluation. Evaluation requires the ability to perform assessments or make judgments by using a set of criteria:
  - Determine the adequacy of the rationale provided for an evaluative study or a descriptive report.

**Guidelines for writing multiple-choice test questions**

**Test the objectives.** Write each test question with a view to assessing the learner’s achievement of one of the stated objectives.

**Decide on the number of questions.** There are
different methods for determining the number of questions to include in a test. The main issue is to ensure that each objective is tested fairly. The general policy at ASHP is to include the same number of test questions (usually three) for each objective. This ensures that the test is weighted fairly. Each test includes a minimum of 15 items. If there are fewer than five objectives, more items per objective are included. For a more in-depth discussion of how to determine an appropriate number of questions, readers are referred elsewhere.2

**Write effective multiple-choice test questions.**

Use complete sentences or questions in the stem.

Right: You are asked to review literature about the long-term effects of a drug used to treat a chronic disease. Which type of medical literature is most likely to have this information? (Note the complete sentence.)

A. A descriptive report.
B. A pharmaceutical research report.
C. An observational report.
D. Practice guidelines.

Wrong: You are asked to review literature about the long-term effects of a drug used to treat a chronic disease. The medical literature most likely to have this information is (Note the incomplete sentence.)

A. A descriptive report.
B. A pharmaceutical research report.
C. An observational report.
D. Practice guidelines.

Write one clearly correct or best response and three "distracters" or incorrect responses that, while clearly incorrect, would be plausible to the uninformed.

Be clear and concise.

Ensure that the length of the responses is not a clue to the correct answer. For example, correct responses should not be consistently longer than incorrect responses.

Do not use “All of the above” as a response option. Research demonstrates that the use of “All of the above” decreases the validity of test questions. Use “None of the above” only if there is no other possibility for a response option.

Avoid the use of negatives when possible. If negatives are used, highlight them by using bold type or capital letters.

**Match the learning level of each test question with the relevant learning objective.** A test question should test at the same level of learning as the objective it is designed to assess. The following are examples of test questions at each level.

**Knowledge.** Questions that assess at the knowledge level ask the learner to recall memorized information but not to explain or apply it.

Objective: Name the components of a pharmacist’s care plan.

Test question: Which of the following is a component of a pharmacist’s care plan?

A. A patient-specific database.
B. A drug therapy problem list.
C. Demographic information about the patient.
D. A pharmacotherapeutic regimen.

To successfully complete this item, a learner need only recall the list of components and does not need to show understanding of the components.

**Comprehension.** Comprehension-level test questions assess understanding and recall.

Objective: Compare the strengths and weaknesses of three types of drug information sources.

Test question: Which of the following statements best summarizes the strengths and weaknesses of primary information sources?

A. They are the most current but the most difficult to efficiently search for specific information.
B. They are easily accessible and have multiple experts contributing to them, which enriches their application and interpretation, but they may be less current than other information sources.
C. They are the most current and easily accessible information source but may be biased by author interpretation.
D. They allow efficient access to multiple information sources but may be expensive or complex and require training before use.

**Application.** At the application level, learners must demonstrate an ability to use (not just explain) new information, applying rules, methods, concepts, principles, laws, or theories.

Objective: Calculate the absorption rate constant ($K_a$) of a drug product.

Test question: A single oral dose (500 mg) of sustained-release procainamide hydrochloride was given, and the following serum concentrations were determined.

<table>
<thead>
<tr>
<th>Time after Dose (hr)</th>
<th>Serum Concentration (µg/mL)</th>
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<tbody>
<tr>
<td>0</td>
<td>0</td>
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<tr>
<td>0.1</td>
<td>0.60</td>
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<tr>
<td>0.25</td>
<td>1.35</td>
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<tr>
<td>0.5</td>
<td>2.34</td>
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<tr>
<td>0.75</td>
<td>3.05</td>
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<tr>
<td>1.0</td>
<td>3.55</td>
</tr>
<tr>
<td>2.0</td>
<td>4.33</td>
</tr>
<tr>
<td>4.0</td>
<td>3.89</td>
</tr>
<tr>
<td>8.0</td>
<td>2.41</td>
</tr>
<tr>
<td>12.0</td>
<td>1.49</td>
</tr>
</tbody>
</table>

What is $K_a$ for this formulation?

A. 1.20 hr$^{-1}$
B. 2.00 hr
C. 1.10 hr$^{-1}$
D. 0.50 hr

**Analysis.** Analysis-level questions test a learner’s understanding of a concept’s components and their relationships to each other.

Objective: Identify the types of information the pharmacist needs for a patient database in order to make informed drug therapy decisions.

Test question: Mrs. Finney is a 47-year-old patient returning to the clinic after discharge from the hospital
one week ago. During hospitalization she was treated for deep vein thrombosis in her right leg with heparin and warfarin. Her medical history also includes asthma and seasonal allergies. Her medications upon discharge were warfarin sodium 5 mg daily, conjugated estrogens 0.625 mg daily, and cromolyn and albuterol inhalers. Her husband drove her home from the hospital. Today, she reports that she developed symptoms of a urinary tract infection (UTI) three days ago and began taking trimethoprim–sulfamethoxazole tablets from an old supply she had at home. She is worried because she plans to visit her sister in California next week and has had two nosebleeds in the past two days. Her blood pressure today is 130/62 mm Hg, her pulse is 80 beats/min, her oral temperature is 98.6 °F, and her respiratory rate is 22 breaths/min. On physical examination it is noted that the patient’s right leg is neither tender nor erythematous. The lung examination shows no wheezes or rhonchi on auscultation. Laboratory analysis of a blood sample reveals sodium 142 meq/L, potassium 4.2 meq/L, chloride 98 meq/L, bicarbonate 28 meq/L, blood urea nitrogen 10 mg/dL, creatinine 0.9 mg/dL, and glucose 115 mg/dL. Which of the following new pieces of information obtained in the follow-up visit needs to be recorded in the pharmacist’s database?

A. History of asthma.
B. Blood glucose concentration.
C. History of UTI.
D. Temperature.

The learner must analyze the given information in order to correctly respond to the question.

Synthesis. Learning at the synthesis level cannot be directly assessed by a multiple-choice test because synthesis involves creating something new. Evaluation-level test items can be used; these require the learner to assess the results of the synthesis process.

Objective: Design a drug therapy plan for achieving desired pharmacotherapeutic goals.

Test question: (Based on information on the hypothetical patient Mrs. Gaskill.) Which of the following is an appropriate part of Mrs. Gaskill’s drug therapy plan?

A. Add an antacid to Mrs. Gaskill’s therapeutic regimen to treat her stomach pain.
B. Review Mrs. Gaskill’s medical history, and discuss possible osteoporosis treatment with her.
C. Recommend the addition of conjugated estrogens 0.625 mg daily to Mrs. Gaskill’s drug regimen.
D. Discontinue combination therapy with amiloride hydrochloride and hydrochlorothiazide.

Evaluation. An evaluation-level test question requires the learner to assess adequacy on the basis of specific criteria.

Objective: Determine the adequacy of the rationale provided for an evaluative study or a descriptive report.

Test question: A statement of rationale for a study is to “determine the safety and efficacy of clindamycin in the treatment of infections.” Which of the following statements best describes the rationale for this study?

A. The rationale is inappropriate because it does not list the types of infections.
B. The rationale is well stated because it is short, is descriptive enough to enable a good methodology to be developed, and lays the foundation for a good evaluation.
C. The rationale is inappropriate because it shows the study does not need to be conducted.
D. The rationale meets all the criteria for an ideal statement.

Use higher-level test questions. Knowledge- and comprehension-level test questions are sometimes used to test objectives that define higher levels of learning. Many educational programs are aimed at enabling learners to do more than recall facts or talk about content. Rather, the programs are designed to enable learners to use or apply knowledge or skills. Developing questions at a sufficiently high level ensures that you are assessing the competence that the program was designed to impart.

The following example illustrates the use of a low-level test question to assess the achievement of a high-level objective. A more appropriate test question is then presented.

Objective: Determine the adequacy of the literature review in the introduction to a report on an evaluative study or a descriptive report.

Wrong: Which of the following are characteristics of a well-written literature review in an introduction to a report on an evaluative study or a descriptive report?

A. It is thorough, balanced, and accurate.
B. It is brief.
C. It includes all literature on the subject of the report.
D. The bibliography includes mostly tertiary literature.

This question requires learners only to recall a list of characteristics of a good literature review. Although the objective corresponds to the highest level of learning (evaluation), this question tests at the lowest level (knowledge). A correct answer to this question does not indicate whether the learner possesses the skill defined in the objective.

Right: Which statement best describes the literature review in the introduction of the report? (Learners are given a specific report to read as part of the test.)

A. The reference section contains an inadequate number of references applicable to dosage guidelines and serum sampling methods.
B. Only tertiary sources are listed in the bibliography.
C. The citations are inapplicable or irrelevant to the study.
D. The references cited are adequate, even though they are mostly older, classic references.

This question is on the same level of learning as the objective (evaluation). It simulates a real-life situation in which the learner would be required to apply the skill defined in the objective. To answer the question correctly, the learner must actually evaluate a literature review and come to a correct conclusion about its adequacy. If learners can consistently answer such questions correctly, they can reasonably be assumed to have met this objective.
Conclusion

When educational objectives are written, important objectives should be defined and should be supported by instruction within the educational program. Objectives should define behavior for the learner, not the teacher, and should include terms that are observable and measurable. The person writing the objectives should determine whether the corresponding cognitive learning level for each objective is knowledge, comprehension, application, analysis, synthesis, or evaluation and should write each objective accordingly. Each test question should correspond to a specific objective and match the learning level of that objective. The test should be weighted fairly by including the same number of test questions for each objective. The use of low-level test questions to assess high-level objectives should be avoided.

References