Short communication

Want an easy way to write test questions? Use concept theory

Marion Slack, PhD[*], Jill Augustine, PharmD, MPH, Terri Warholak, PhD, RPh

Department of Pharmacy Practice and Science, University of Arizona College of Pharmacy, Tucson, AZ

Abstract

Objectives: To review concept theory and to describe a model for using concept theory so as to develop multiple-choice questions that can test more advanced cognitive skills in the area of study design.
Theory: Concepts are abstract categories containing information about objects, symbols, or events that share specific characteristics. Concepts serve as tools for identifying and categorizing objects, events, or situations, for instance, types of study designs, as examples or non-examples of a category.
Application: The process for developing questions to test concept learning in study design can be summarized as follows: (1) identify the learning objectives that require concept classification (e.g., use verbs such as identify, differentiate, or compare); (2) identify new case examples (cases not previously encountered by students) of the target concepts (e.g., an abstract for a randomized controlled trial); and (3) use information from the case examples to write multiple-choice questions. The questions use concept names (e.g., independent variable) and specific examples from the case (e.g., blood pressure) in the question stem or as response options.
Conclusions: By using concepts or specific examples from the case, multiple-choice questions that test concept skills critical to using the literature in clinical practice were developed. Use of a case example new to students assures answers cannot be memorized, and use of coordinate concepts as response options assures all options are viable choices. An advantage of using concept theory is that some questions can be reused with new case examples.
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Introduction

Imagine that two pharmacy students, Anne and Zach, are on an advanced pharmacy practice rotation and they have been asked to respond to a query about using Drug A. The prescriber wants to use Drug A as an adjunct therapy for a 35-year-old female who has not responded to several trials of different medications for her depression. Drug A is relatively new and is not approved by the Federal Drug Administration (FDA) for the treatment of depression. Anne

* Corresponding author: Marion Slack, PhD, Department of Pharmacy Practice and Science, University of Arizona College of Pharmacy, 1295 N. Martin Ave., PO Box 210202, Tucson, AZ 85721-0202.

E-mail: slack@pharmacy.arizona.edu

and Zach quickly locate a half dozen studies, three showing a substantial impact of Drug A as an adjunct therapy for depression and three showing no impact. Anne and Zach immediately recognize that they need to consider how the studies were designed before they can make a judgment about which studies to accept and which to reject. Anne and Zach know that randomized controlled trials (RCTs) provide the best evidence so they will need to be able to identify the RCTs in the group of studies, as well as identify other study designs and consider the potential for bias in those studies.

In the language of concept theory, Anne and Zach must be able to categorize a reported study as, e.g., an RCT, a pre-test/post-test design, crossover design, or retrospective cohort design. Categorization requires concept classification skill using concepts that are fundamental to professional and

scientific expertise in pharmacy; in the example, the skill to classify a reported study based on the study design. Study design concepts are tools that enable pharmacists to recognize clinical implications and to make appropriate recommendations for improving drug theory.

The issue for pharmacy educators is to provide instruction in a manner that facilitates concept learning followed by an exam that accurately assesses students' ability to use concepts, ideally those concepts that are required for their professional practice and research competence. Development of valid assessments is particularly problematic with exams using multiple choice or similar formats. The purpose of this article is to briefly review concept theory then to describe a model for using concept theory to develop multiple-choice questions that can test more advanced cognitive skills in the area of research design.

Theory

Concepts are abstract categories containing organized information about a group of objects, symbols, or events that share specific characteristics; individual concepts are referenced by specific names.[1–4] Concepts serve as tools for identifying and categorizing objects, events, or situations as examples or non-examples of a category, for instance, a person with cardiovascular disease could be categorized and labeled as having hypertension, heart failure, or myocardial infarction. Information on the characteristics that differentiate hypertension from heart failure or myocardial infarction is associated with the concept. When individuals are presented with a situation, they use information on characteristics associated with the relevant concept and the characteristics of the situation to determine if the patient has hypertension, that is, they classify the situation as an example or a non-example of the category, hypertension.

A number of verbs used to designate cognitive skills are considered to represent categorization of concepts. For example, the verbs recognize, classify, categorize, identify, compare, contrast, differentiate, judge, and diagnose can denote concept categorization. The implication is that concept classification skill is demonstrated whenever an object, symbol, event, or situation is identified as belonging to a specific category rather than to other possible categories. Note that concept classification skills are tied to examples; the skill cannot be demonstrated in the absence of newly encountered examples. Concept classification skill can require substantial knowledge, that is, knowing the specific characteristics of category members or the relationships between concept categories. However, research has shown that being able to recall category characteristics does not mean that a person can correctly categorize new examples of the concept, although being able to categorize new examples facilitates recall of category characteristics.[2]

A concept category may be described by its relationship to other concept categories, that is, whether it is a superordinate category, subordinate category, or coordinate category[2] (Fig. 1). The category, study design, is considered a superordinate category relative to examples of study designs that have a coordinate relationship to one another. Examples of study designs that are subordinate to the concept, study design, are considered superordinate to examples of statistical tests that, again, have a coordinate relationship to one another. The characteristics of the example study design are used to differentiate it from other study designs and to classify newly encountered examples. For instance, random assignment to study groups differentiates an RCT from other study designs.

Concept theory as used by Merrill and Tennyson[2] represents cognitive skills somewhat differently than they are represented in Bloom's taxonomy.[5] Bloom's is a general, overarching taxonomy described on two dimensions: knowledge and cognitive processes. Conceptual knowledge is one of four types of knowledge (factual knowledge, conceptual, procedural, and meta-cognitive) that could involve six types of cognitive skills (remember, understand, apply, analyze, evaluate, and create). This two-dimensional approach results in concepts being included in multiple knowledge categories that involve multiple types of cognitive skill. Concepts as represented by Merrill and Tennyson[2] are based on examples and the primary cognitive skill requires use of a mental representation of previously encountered examples to classify new examples which results in a more integrated approach to concept learning, instruction, and testing. For instance, recognize, is considered to be in the lowest level of knowledge, factual knowledge, and to use the lowest level of cognitive skill, remember, in Bloom's taxonomy. In the concept theory of Merrill and Tennyson,[2] recognize is considered a skill related to concepts and could be very difficult and presumably involve more advanced cognitive skill (concept theory in general does not use the terminology of lower vs. higher-level skills) if it was associated with a difficult example. Although there are many similarities between Bloom's taxonomy[5] and concept theory as used by Merrill and Tennyson,[2] there is not a direct correspondence making it difficult to translate one into the other.

The most effective way for students to learn concepts is through exposure to examples and non-examples (examples from related categories) of the concept. Learning is facilitated if category characteristics are explicitly identified and if a range of examples, including typical examples and non-examples, are presented. Additionally, students need practice using concept classification skills either through in-class examples or through homework assignments. To test students' ability to correctly classify examples, they are presented with new examples and non-examples of a category.

A variety of question forms can be used for testing concept learning including true/false, matching, short answer, multiple choice, and short essay[2]; however, the question must be asked in the context of new examples. In the case of a true/false question, the student can be