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MULTIPLE-CHOICE TESTS CAN SUPPORT DEEP LEARNING!

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Abstract

This session presented a perspective for the use of multiple-choice tests beyond that of basic knowledge recall and summative assessment. We discuss here how intentionally designed multiple-choice questions can be used to both foster and assess deep learning in higher education. With a focus on creating rich learning opportunities, we illustrate with examples how we have expanded our use of multiple-choice to develop students' knowledge base, skills, and attributes to prepare them for future work. Recognizing that creating deep learning multiple-choice items is challenging, we share our guiding practices to show teachers how it might be possible for them to design and incorporate such multiple-choice tests in their teaching.

Keywords

assessment; deep learning; multiple-choice items; higher-order thinking; collaborative learning

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Report

Multiple-choice tests are often a challenge to design. Instead of encouraging students to develop deeply understood, richly-interconnected, applicable, and lasting knowledge and skills, educational contexts featuring multiple-choice tests often encourage students to adopt “surface-learning” strategies aimed to help them memorize and then recognize (often without really understanding) correct responses. Most often, teachers view multiple-choice tests not as a way to help students learn, but as a means to evaluate student learning.

In our experience teaching university level courses, including higher-order thinking multiple-choice tests in our assessment approach has allowed us to effectively integrate formative and summative assessment of students’ learning. Well-designed multiple-choice tests become a powerful tool to foster deep learning while concurrently providing both the students and the teacher with rich information regarding the depth, breadth, and accuracy of their knowledge and understanding. In addition to creating test items that pique students’ curiosity, challenge their assumptions, and activate their prior knowledge, we often administer the test in a collaborative setting. Allowing students the time and the opportunity to confer with peers during the test encourages them to share meaningfully, reason thoughtfully, and communicate effectively.

Deep learning is demonstrated by the student’s ability to manipulate and apply information in contexts different from that in which they have acquired the information. Although there is a need to be able to recall information from a strong knowledge base, deep learning requires students to use higher-order cognitive processes to integrate information into their existing knowledge and apply its use with varying skills. Multiple-choice tests that support deep learning, therefore, must have questions that provide students with an opportunity to recall information and apply skills such as critical thinking, analytical reasoning, problem-solving, and decision-making. Creating such deep learning multiple-choice questions can be a challenge.

The Revised Bloom’s Taxonomy (Anderson, Krathwohl, and Bloom, 2001) offers a framework and a language that can support teachers in the design of multiple-choice questions that promote deep-learning. The Bloom’s Taxonomy framework can be used to help teachers identify the type of higher-order thinking and skills that best align with their learning goals. With a clear sense of purpose, the framework offers learning verbs that can be used to create multiple-choice questions that work to develop the intended knowledge base, skills, and attributes.

Multiple-choice questions that support deep learning will focus on fostering students’ abilities to comprehend information, apply information in different ways and contexts, analyze information for a specific purpose, or compare and evaluate information to make a judgement. To guide the development of items for the tests, we use the learning verbs of the framework in each of these ability categories. For example, recall questions typically ask students to define, describe, list, label, or identify, whereas questions that ask students to justify, appraise, evaluate, or compare target their judgement. Items that involve the interpretation of a graphical display require analysis and comprehension, and items that involve the interpretation of results require application and comparison. To demonstrate some of these ideas, here are examples of items in each of our areas of research and teaching.

In educational mathematics, school teachers are expected to provide accurate, rich learning classroom experiences and to assess their students' understanding of mathematical concepts and procedures. This requires educators to develop a deep understanding of the mathematics they teach in conjunction with solid pedagogical approaches and strong collaborative skills. To create meaningful learning experiences, Genevieve designs multiple-choice tests that are open book, open access, and open to discussion with peers. Many of the items on her tests ask students to select one or more of the provided options, with wrong answers incurring a penalty. Not knowing how many of the options are correct encourages her students to consult their peers and to think more critically about what they are learning. Genevieve reports that her students find this feature of the tests quite challenging at first, but grow to appreciate its significant impact on their learning. For example, foundational concepts of rational numbers constitute the largest component in the elementary school mathematics curriculum. It is therefore imperative that teachers understand the nature and purpose of these numbers. Unfortunately, students' first introduction to these numbers is with fractions of a pizza. While the pizza context may appear relevant, it does not provide the need for a ratio and thus is not a true rational number situation. In light of this disconnect, one question Genevieve has developed regarding fractions has her students engaged in many conversations, not only with their peers in the course, but with peers at work, and even with family members:

In which of these situations are fractions suitable?

(a) Determining the chances of winning an electronic reader in the school-wide draw
(b) Describing a box of chocolates in which some are white, some are milk, and some are dark
(c) Estimating the time needed to arrive at a destination
(d) Reading music
(e) Giving a child a piece of cake

Not all items on Genevieve's tests require students to choose multiple responses. Since it is important for teachers to reflect on their pedagogical choices and how these affect student learning, Genevieve develops questions that focus on best practices. For example, another large component of the elementary mathematics curriculum is the teaching and learning of arithmetical algorithms.

All too often, elementary student work is simply marked as correct or incorrect and the teacher repeats the explanation whenever the classroom results indicate low performance. Analyzing student errors and responding appropriately requires teachers to explore alternative algorithms, to know when to "instruct" and when to "guide," and to be able to choose a targeted intervention when needed. Here is a question that illustrates how Genevieve achieves this on a multiple-choice item:

After teaching multiplication, some of your students are committing the following error:

248 x 3 184	279 x 3 277	437 x 7 499

Choose the intervention that would be most effective:

(a) Instruct the students to place a line between the multiplicand and the regrouped number to separate the two numbers.
(b) Ask the students to use the explicit algorithm to solve the problems.
(c) Ask the students to use the base-ten blocks to solve the problems.
(d) Ask the students to use the multiplication chart to solve the problems.

In biology, Leigh-Ann's students are working to integrate and apply a robust knowledge base of facts, concepts, and theories to design and interpret laboratory experiments. With limited access to laboratory space and materials, Leigh-Ann uses application and analysis based multiple-choice questions, together with visual processing and immediate feedback to provide frequent, low risk opportunities to build the cognitive skills traditionally fostered in a laboratory learning experience. To create this learning opportunity, Leigh-Ann employs a learning process centered around multiple-choice questions that present laboratory scenarios based on a molecular mechanism, processes, and/or technique. In this process, her students are required to independently create a visual of the underlying mechanism, process, or technique. This visual is then used to support student analysis to determine the answer to the multiple-choice question. Students receive immediate peer feedback as they engage in a small group discussion sharing their answer and reasoning. Concluding with the correct answer, Leigh-Ann challenges students with reflective questions to prompt a metacognitive response aimed to help them self-diagnose the cause of any errors.

Consider the following example. In class, students explore the molecular mechanism of retinoblastoma and how dysregulation of this mechanism can impact cell cycle progression to contribute to the development of cancer. Due to laboratory limitations, Leigh-Ann is not able to conduct cell cycle progression experiments. However, she uses the following multiple-choice question to offer a learning opportunity that simulates the cognitive processes that would be employed while conducting a laboratory cell cycle progression experiment.

> The following two images (not shown) show immunohistochemical staining of two different tumors, A and B, using an antibody that specifically recognizes hyperphosphorylated retinoblastoma protein. Both tumors have been treated with an antiproliferative cancer drug. Testing indicates that tumor A is responding positively to the drug treatment. Illustrate the molecular mechanism of retinoblastoma to support your analytical reasoning. Based on your knowledge of the molecular mechanism of retinoblastoma and the evidence provided, which of the following is the mostly likely mechanism of action for this drug?
>
> (a) The drug decreases cyclin E levels.
> (b) The drug increases CDK4 activity.
> (c) The drug increases cyclin D levels.
> (d) The drug accelerates an RB protein conformational change.
> (e) The drug activates histone acetylase.

Following peer sharing and determination of the correct answer, students reflect on the following questions:

- How did you analyze the immunohistochemistry to gather information about cell cycle progression?
- What did you identify as being different between tumor A and tumor B?
- How did your molecular mechanism illustration help you interpret the immunohistochemistry?
- What strategy from class did you use to reason the drug mechanism?

Using this approach, both Leigh-Ann and her students gain valuable information regarding their ability to: read for comprehension; select relevant information; determine of the scope of the question; create an accurate visual for analysis; apply analytical thinking; problem solve; explain logical reasoning; build interpersonal skills; demonstrate critical reflection; and work to self-assess errors.

In our experience, we have been able to use multiple-choice questions to provide our students with a rich learning opportunity that supports deep learning. To use multiple-choice questions effectively, we design and select a set of multiple-choice questions that align with an identified learning goal that supports the development of specific knowledge, skills and/or attributes. We work to ensure that multiple-choice questions present relevant details in full sentences, with meaningful and higher-order learning verbs used where possible. The use of negative phrasing is limited to specific purpose and skill development. We strive to present answer options that are clear, concise, plausible, logical in order, and homogeneous in content. Special consideration is taken for the use of inclusive and complex answer options.

The literature abounds with articles and books about assessment of learning and assessment for learning. We aimed to create an assessment tool that integrates the two. Higher-order thinking multiple-choice tests that involve collaboration, feedback, and reflection achieve this goal.

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