

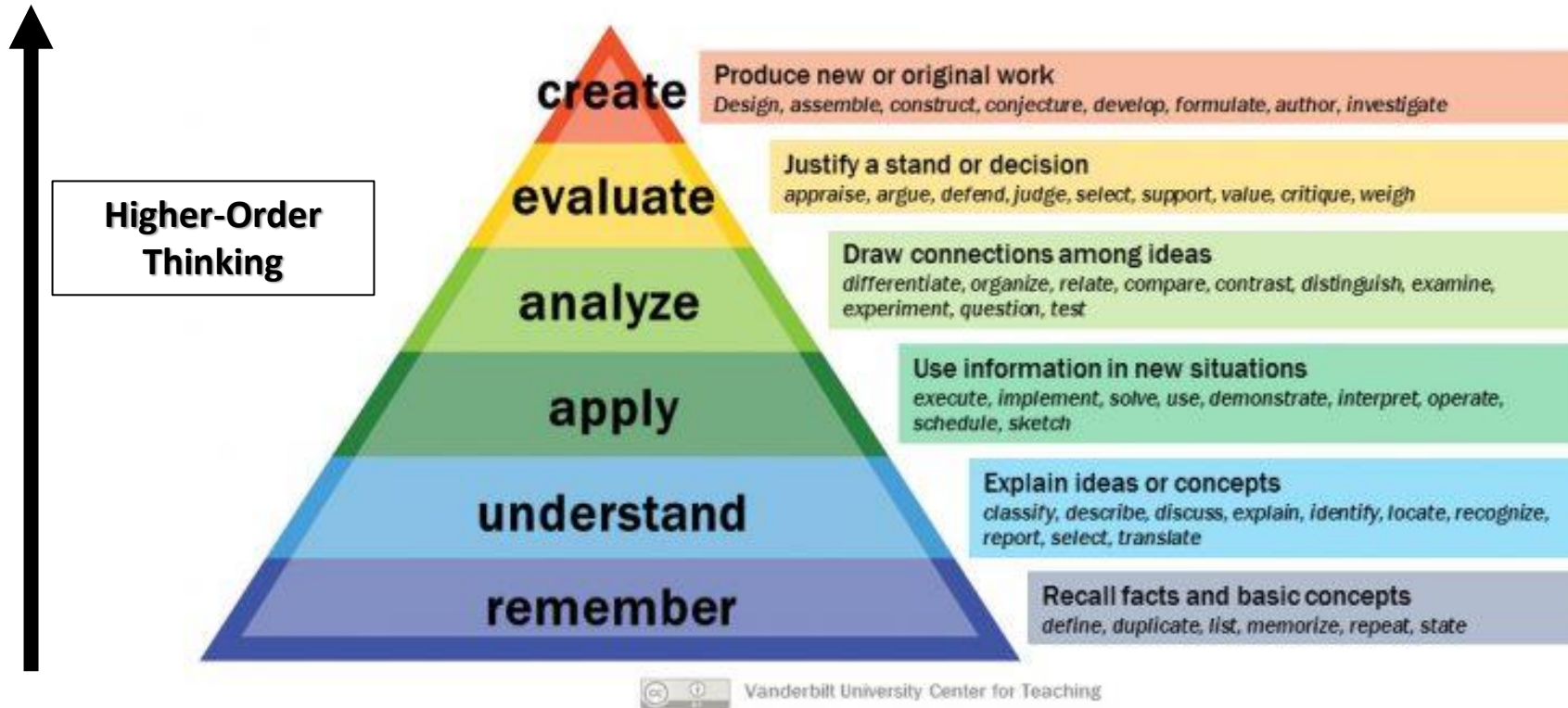
Understanding the Components of Multiple-Choice Question Writing within the “Higher-Order” Thinking / Bloom's Taxonomy Rubric and Writing Better Questions: A Preliminary Report

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Objectives

- 1. Discuss Bloom's Taxonomy in Graduate Medical Education**
 1. Initial Purpose in education
 2. Use within the context of multiple-choice questions
 3. Previous successes and challenges in the Boyer lab
- 2. Illustrate the use of Bloom's Taxonomy in developing high-level multiple-choice questions (MCQs)**
 1. Applications in question construction
 2. Applications in previous assessment analysis

Bloom's Taxonomy



- Developed in 1956 by Benjamin Bloom and colleagues to help in the development of educational objectives¹
- Revised in 2001 to reflect the *actions* that learners undertake when using each level of the pyramid¹
- Originally intended for learning and later adopted for assessment and development of multiple-choice questions

(Armstrong, P. (2010). Bloom's Taxonomy. Vanderbilt University Center for Teaching.)

Assessment: Formative vs. Summative

Low- or No-
Stakes
/ Point Value

Formative

Forms part of the instructional process. It helps teachers modify teaching methods and future lessons based on needs, to improve lessons.

Examples

- Turning Point Questions
- Review Questions
- Quizzes

Both

Are ways to assess pupils
Must evaluate pupils effectively
Are used for student feedback
Assist in future lesson planning

Summative

Determines what students know at a particular point in time / end of learning segment. Improves overall school performance.

Examples

- Course Examinations
- NBME Shelf Examinations
- Step 1, 2 (CK), 3


High-Stakes
/ Point Value

Assessment: Multiple-Choice Questions

- Multiple-choice questions are a standard mechanism of assessment in medical education
 - Machine graded
 - Optimize over time and use from year-to-year
- In previous generations, **“fact-based” questions** were commonly deployed.
- The urgency for faculty to develop assessment question writing knowledge and skills which allow for the incorporation of **“higher-order” thinking** as an element of questions is underscored by the extensive use of such questions within **United States Medical Licensing Examination (USMLE) Step** examinations.

Bloom's Taxonomy in MCQs: Histology Tool

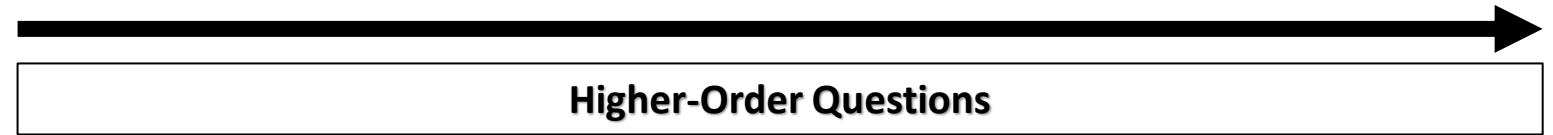
- University of Michigan faculty found potential for adoption of Bloom's taxonomy to create a subject-specific scoring tool for histology multiple-choice questions²
- Emphasis on previously established Bloom's Taxonomy levels as well as revised key skills
- Addition of Characteristics of MCQ format and types of domain-specific information



Higher-Order Questions					
Bloom's Taxonomy Histology Tool Score:	1	2	3	4	5
Key skills assessed:	Recall	Explain, identify	Apply, connect	Analyze, classify	Predict, judge, critique, decide
Types of histological information assessed:	Basic definitions, facts, and terms.	Basic understanding of architectural organization of histological features and concepts (connective tissue, muscle tissue, neural tissue, etc.). Interpretation and organization of organs or cell types from novel images confined to single cell type/structure.	Visual identification in new situations by applying acquired knowledge. Additional functional or structural knowledge about the cell/tissue is also required.	Visual identification and analysis of comprehensive additional knowledge. Connection between structure and function confined to single cell type/structure.	Interactions between different cell types/tissues to predict relationships; judge and critique knowledge of multiple cell types/tissues at same time in new situations. Potential to use clinical judgment to make decisions.
Characteristics of multiple-choice questions:	Only requires recall. Students may memorize answer without understanding the process. Knowing the "what," but not understanding the "why."	Requires recall and comprehension of facts. Image questions asking to identify a structure/cell type without requiring a full understanding of the relationship of all parts. The process of identification requires student to evaluate internal or external contextual clues without requiring knowledge of functional aspects.	Two-step questions that require image-based identification as well as the application of knowledge (e.g., identify structure and know function/purpose).	Students must call upon multiple independent facts and properly join them together. May be required to correctly analyze accuracy of multiple statements in order to elucidate the correct answer (e.g., generally answer choices with "I & II" or "I & II & III"). Also evaluate all options/ understand all steps and can't rely on simple recall.	Use information in a new context with the possibility for a clinical judgment. Students are required to go through multiple steps and apply those connections to a situation, e.g., predicting an outcome or diagnosis or critiquing a suggested plan.
Equivalent level of Bloom's taxonomy:	Knowledge	Comprehension	Application	Analysis	Synthesis/Evaluate

Bloom's Taxonomy Pathology Tool (BTPT)

- Adoption of Bloom's Taxonomy of graduate level pathology class
- Similarities to BTHT
 - 5 Levels reflecting combination of Bloom's Taxonomy
 - Relevant Domain-specific information as well as characteristics of the relevant MCQs
- Differences
 - theoretical challenge of developing types of pathological knowledge assessed



Score	1	2	3	4	5
Bloom's Skills Assessed	Knowledge	Comprehension	Application	Analysis	Synthesis/Evaluate
Type of Information	Recall, Memorized Facts	Understanding of pathophysiology	Applying knowledge of pathophysiology to make a diagnosis	Requires students to be able to make a diagnosis and apply outside information to further analyze a scenario.	Requires students to analyze information and come to a conclusion on what the appropriate diagnostic measure may be, or how the issue may be resolved
Multiple Choice Question Characteristics	Pure memorization, may involve identification of media, or regurgitation of factual information	Requires students to understand basic pathophysiology, may ask to explain a process or purpose of a step in a process. In cases of media, may require ability to explain the function of a displayed item	Requires ability to practically apply information in a vignette. Student must be able to make a diagnosis based on pt symptoms. Or with media, come to a conclusion to the causing pathophysiology. Will often require assumptions or "most likely" diagnosis	Student must be able to make a diagnosis and be able to apply outside knowledge to correctly analyze associated risks factors, symptoms, or exacerbating factors	Student must be able to properly make a diagnosis and determine the next step to take to confirm diagnosis or how to prevent pathology from worsening.
Focus of Question	What is this?	What causes this?	Patient has these symptoms: what is this disease process?	Patient has these symptoms: What else is he/she at risk for? What associated symptoms may be seen? How can diagnosis be confirmed?	Patient has these symptoms: How could this be prevented? How could side effects be prevented? How can the disease be treated?

Practical Challenge

- Popular question banks and board questions often involve 2nd or 3rd order questions that involve answering multiple intermediary questions and may or may not be overall high order
- Ex) Question Components
 - Application of given knowledge
 - Integration of basic remembered knowledge of which ions flow out of a cell

Molecular biologists perform a series of experiments to characterize the electrophysiologic properties of human muscle cells. The resting membrane potential for an isolated muscle cell is determined to be -70 mV. The equilibrium potentials for important ions under normal physiologic conditions are as follows:

$$E_{\text{Na}} = + 60 \text{ mV}$$

$$E_{\text{K}} = - 90 \text{ mV}$$

$$E_{\text{Cl}} = - 75 \text{ mV}$$

$$E_{\text{Ca}} = + 125 \text{ mV}$$

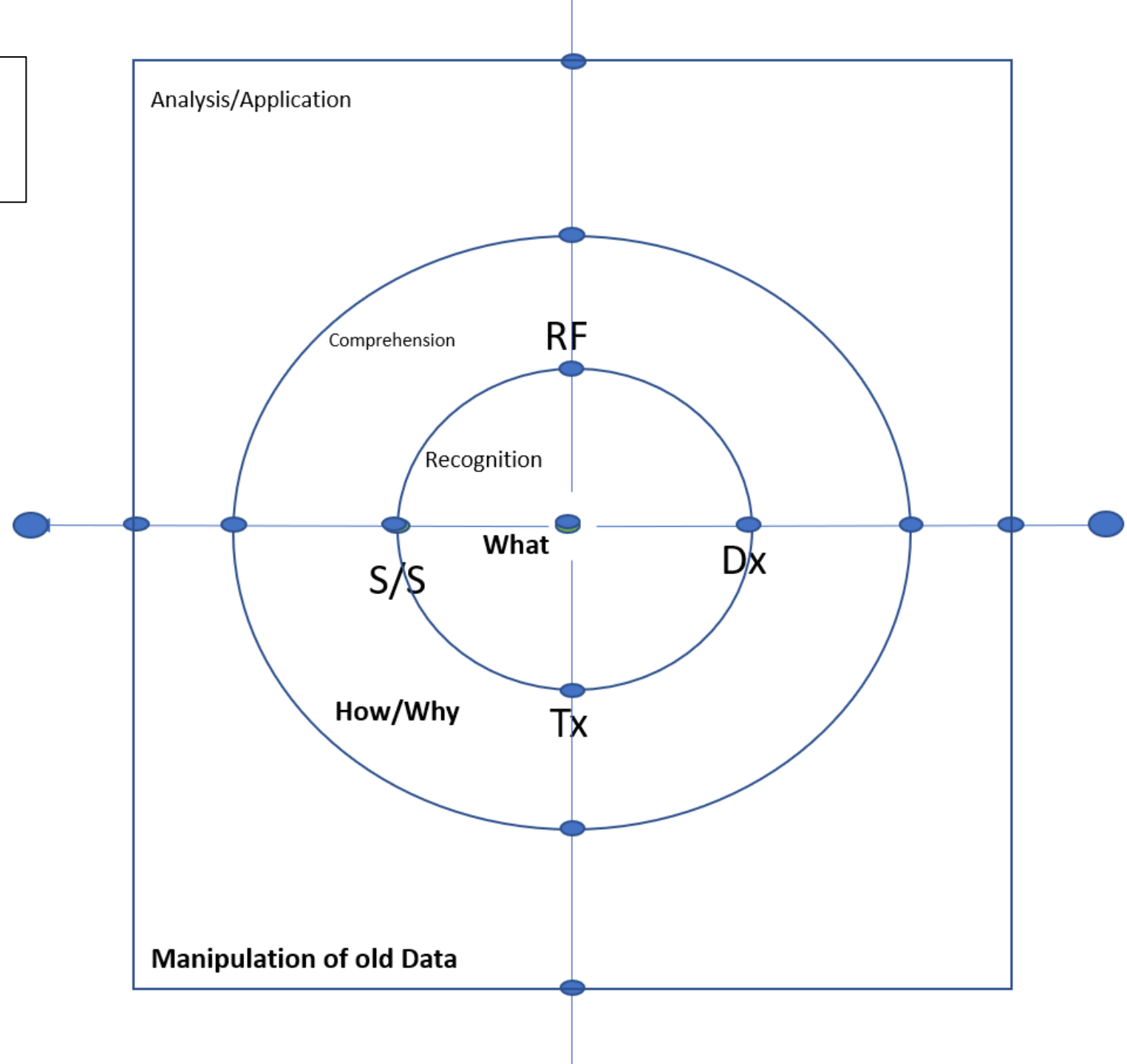
$$E_{\text{Mg}} = 0 \text{ mV}$$

If physiologic conditions are maintained, which of the following ions would most likely flow out of the cell after opening of their respective ion channels?

- A. Magnesium and calcium [1%]
- B. Magnesium and chloride [1%]
- C. Potassium and chloride [42%]
- D. Potassium only [42%]
- E. Sodium and calcium [12%]

Radial Grid

- **Breadth** = the extent to which relevant teaching has been retained
 - Tied to the number of cognitive jumps a question may require
- **Depth** = the strength of the test taker at manipulating that knowledge.
 - Tied to question stem and the incorporation of Bloom's Taxonomy
- **Grid Design**
 - Concentric circles represent layers of bloom's taxonomy, largely tied to question stems and knowledge depth
 - Linear axes represent commonly tested pieces of information and knowledge breadth



MCQ Development: Example: Diabetes

1 "step" MCQ

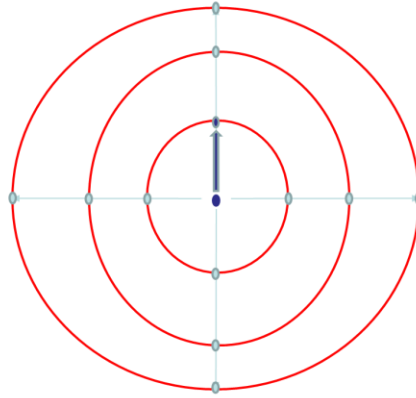


Figure 1: Given disease name, what are the risk factors? (1 step)

Ex) What are the risk factors for diabetes?

2 "step" MCQ

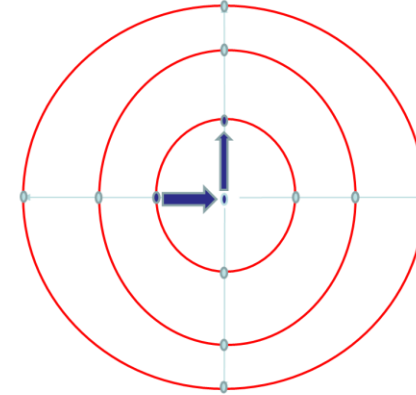


Figure 2: Given symptoms of a disease, what are the risk factors? (two steps)

Ex) A 27M presents with frequent urination at night, what are the risk factors for his condition?

3 "step" MCQ

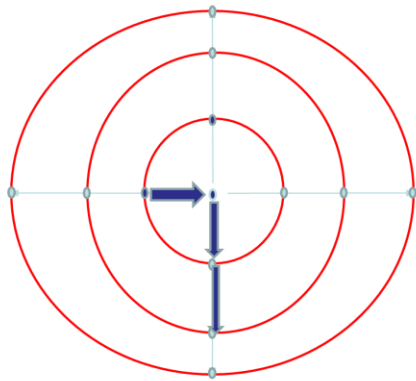


Figure 3: Given symptoms of a disease, how does the first line treatment work? (three steps)

Ex) A 27M presents with frequent urination and fatigue, how does the first line treatment work?

4 "step" MCQ

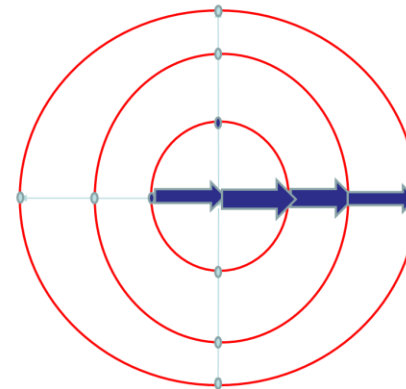


Figure 4: Given symptoms of a disease, would this new diagnostic test (with mechanism of action) be appropriate to diagnosis him (three steps)

Ex) A patient with fatigue and polyuria is tested using a new diagnostic test. When could this test report a false negative diagnosis?

Analysis of MS2 Pathology Endocrine Quiz 2

- MCQs with >1 cognitive step compared to counterparts
 - **increased** difficulty (lower proportion correct)
 - **increased** discrimination index
 - **increased** avg completion time

- MCQs in Bloom's 2nd Order compared to 1st order counterparts
 - **increased** question difficulty
 - **increased** discrimination index
 - **decreased** average completion time

Question Category Subtypes	Proportion Correct	Discrimination Index	Time (s)
1 Cognitive "Step"	0.83	0.39	80
2 Cognitive "Steps"	0.73	0.45	92
Bloom's 1 st Order (Recognition)	0.85	0.37	84
Bloom's 2 nd Order (Comprehension)	0.35	0.75	80

Conclusions / Next Steps

- **Conclusions**

- Our conceptual model allows us to understand the components of a multiple-choice question to optimally write “lower-order” to “higher-order” assessment questions.
- Allows for generation of questions as we develop
 - Formative assessments
 - Summative assessments
- Preliminary results are encouraging in the use of dividing analysis between question breadth and depth.
- Future research will include evaluation of questions based on their ability to stratify students within the upper, median, and lower quartiles of the class.
- Limitations in sample size prevent stronger conclusions from being drawn.

- **Next Steps**

- Expand analysis to additional endocrine assessments, and later other organ system blocks
- Institute changes to endocrine assessment materials with goal of increasing discrimination index
- Evaluate inclusion of irrelevant information into the model and explore how this inclusion affects discrimination index

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Brody School of Medicine**



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Questions?

