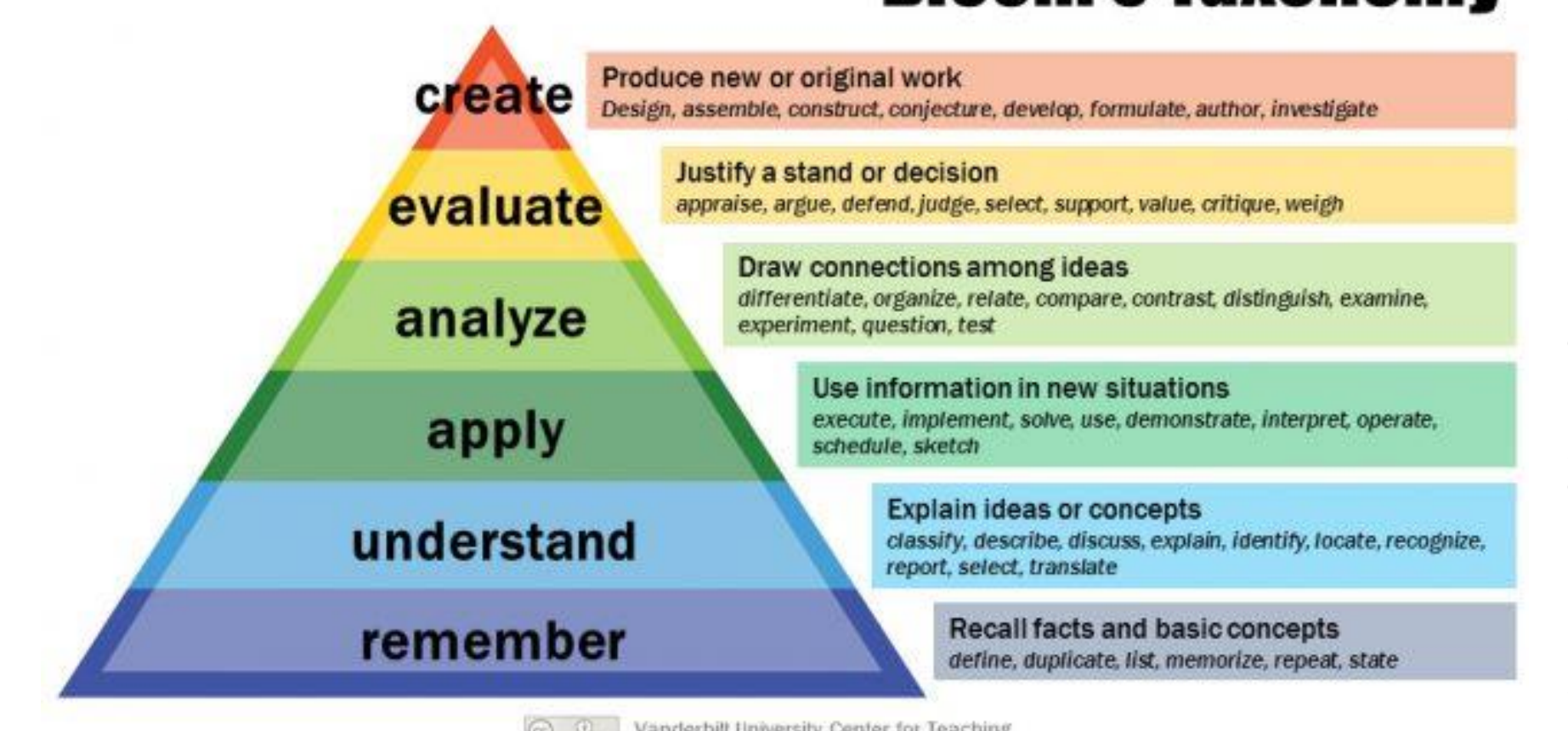


RATIONALE/NEED

- The successful completion of United States Medical Licensing Examination (USMLE) Step examination multiple choice questions requires the use of “higher-order” cognitive and critical thinking skills.
- To help students prepare to navigate such questions, it is imperative that medical educators understand how to classify multiple choice questions based on Bloom taxonomy and write questions to meet various taxonomy levels.

Bloom's Taxonomy



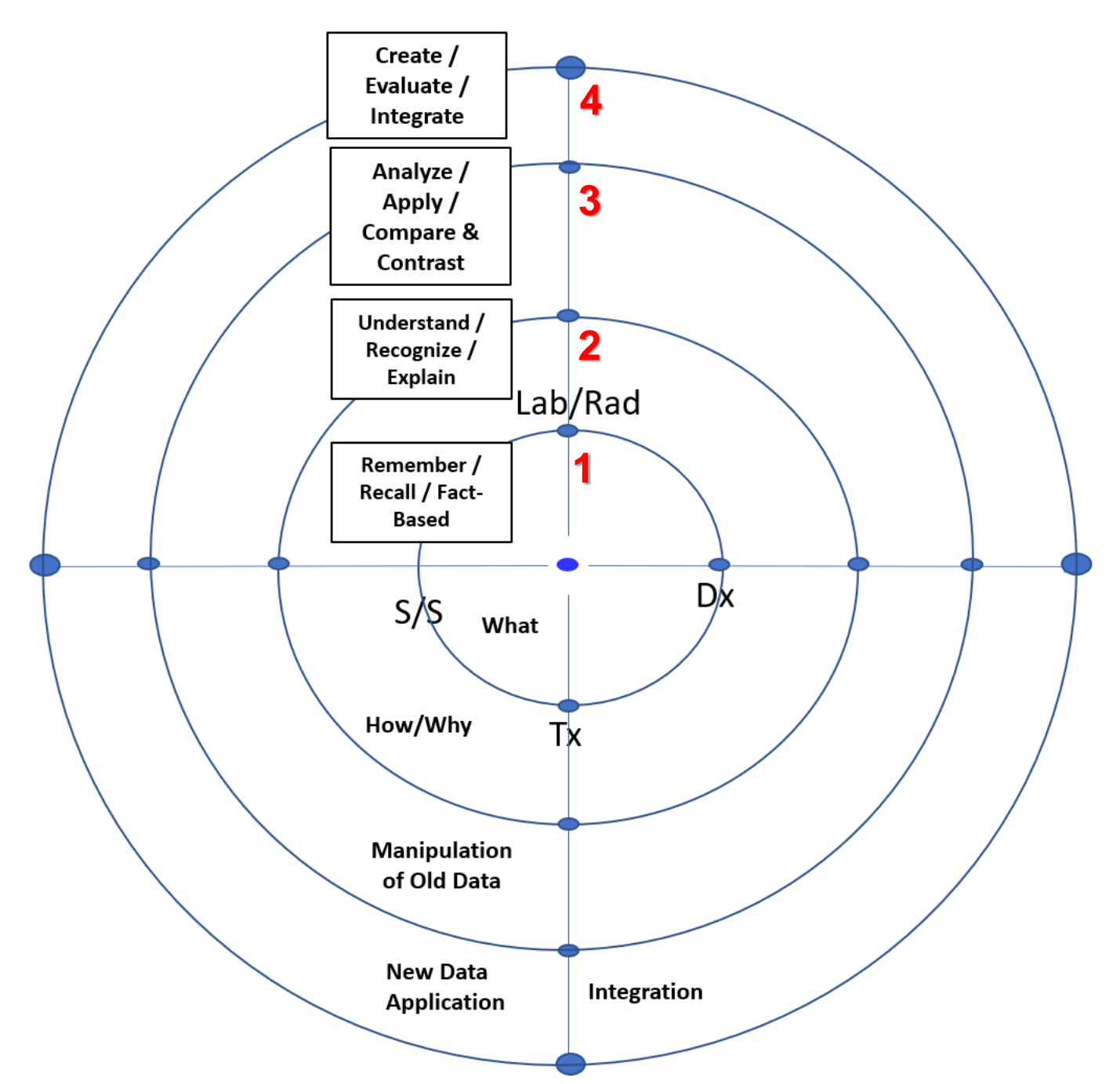
- However, the current medical literature does not provide clear and coherent guidance to the writing or dissection of the components of an undergraduate medical education multiple choice question with respect to establishing the question's Bloom level.

METHODS

- Pathology quiz and test questions from the 2019-2020 academic year were (1) analyzed using statistical data including difficulty index, discrimination index, and point biserial calculated for each question as aggregated by the assessment software (ExamSoft, examsoft.com) utilized at our medical school and (2) assigned a Bloom taxonomy level employing a conceptual model we previously developed, assigning a taxonomy level of level 1 for recall of basic concepts and recognition, Level 2 for understanding and comprehension, Level 3 for analysis, application, and manipulation of content in the question, or level 4 for integration of content.
- For the first-year Foundations of Diagnosis and disease course and for each of the six second-year organ system courses, five quiz or exam questions that were answered correctly by all or nearly all students were modified, manipulating various components of the question based on our model to raise the Bloom level and administered during the 2021-2022 academic year with subsequent data analysis.

RESULTS

Bloom Taxonomy: Working Conceptual Model



- Quiz and examination multiple choice questions from the 2019-2020 academic year ranged from Bloom level 1 to Bloom level 4, with a greater number of level 1 and 2 questions on quizzes, intended to be, in part, formative, and a greater number of level 3 and 4 questions on examinations, intended to be largely summative. The difficulty of the question was driven primarily by (1) information available, e.g. distractors (demographics, past medical and family history, physical examination data, laboratory or radiologic data), (2) the question lead-in, and (3) the answer / distracter choices.
- Raising the Bloom level on five questions for each course resulted in:
 - A lower success rate on the questions overall
 - A greater reduction in performance in students who scored in the lower quartile on all questions on the assessment
 - An increased point biserial

Question: Example #1

A 42-year-old woman is brought to the emergency department by her daughter who reports progressively erratic and atypical behavior and joint pain in her hands and feet. Physical examination revealed a rash on her face and joint swelling and tenderness to palpation in her fingers, wrists, and toes. A complete blood count identifies anemia and thrombocytopenia. A rheumatologic laboratory panel (is undertaken) / (identified evidence of antinuclear antibodies, anti-Smith antibodies, anti-double-stranded DNA antibodies, and antiphospholipid antibodies). With respect to this patient's skin changes (Photograph), which of the following is the most likely underlying mechanism of injury in the context of other findings in this case?



Which of the following is the **most likely diagnosis**?

- ✓ A. Lupus erythematosus
- B. Mixed connective tissue disease
- C. Systemic sclerosis
- D. Sarcoidosis
- E. Limited scleroderma
- F. Rheumatoid arthritis

2021:
86 / 87 Correct: 99%
Disc. Index: 0.00
Point Biserial: 0.03

2022
67/70 Correct: 96%
Disc. Index: 0.05
Point Biserial: 0.12

Which of the following is the **most specific laboratory test** which would help confirm the diagnosis?

- ✓ A. Anti-double stranded DNA antibodies
- B. Anti-nuclear antibodies
- C. Anti-smooth muscle antibodies
- D. Anti-SCL-70 antibodies
- E. Anti-cyclic citrullinated peptide antibodies
- F. Anti-immunoglobulin antibodies

2021:
Not Asked

2022
Not Asked

Which of the following is the most likely **mechanism** underlying the patient's skin changes?

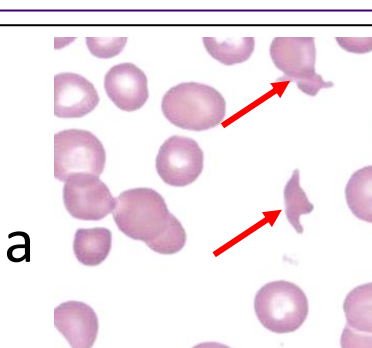
- ✓ A. Ultraviolet radiation damage
- B. Allergic reaction to food or drug
- C. Congenital vascular malformation
- D. Vasoconstriction in the setting of cold
- E. Serous effusion between the epidermis and dermis
- F. Bacterial infection

2021:
68 / 87 Correct: 78%
Disc. Index: 0.48
Point Biserial: 0.48

2022
58/70 Correct: 83%
Disc. Index: 0.32
Point Biserial: 0.20

Question: Example #2

After a meal including grilled hamburgers that were apparently undercooked, three members of a family developed abdominal cramps and pain and severe, bloody diarrhea. A 5-year-old boy required hospitalization and was found to have acute-onset renal failure with oliguria along with elevated blood urea nitrogen and creatinine concentrations. Hematuria and proteinuria were detected in his urine. Anemia and thrombocytopenia were identified on a complete blood count. Microscopic examination of a peripheral blood smear identified findings seen in the image (arrows).



Which of the following is the most likely **diagnosis** in this case?

- ✓ A. Hemolytic uremic syndrome
- B. Thrombotic thrombocytopenic purpura
- C. Dense deposit disease
- D. Sickle cell disease
- E. Disseminated intravascular coagulopathy

2020 – 2021:
Not Asked

Which of the following **laboratory findings** is most likely to be positive in this case?

- ✓ A. Escherichia coli O157:H7 in stool culture
- B. Listeria monocytogenes in stool culture
- C. C3 nephritic factor antibodies in serum
- D. Antibodies against the metalloprotease ADAMTS13
- E. Sickle cell disease on peripheral smear

2020:
77/77 Correct: 100%
Disc. Index: 0.00
Point Biserial: 0.00

Which of the following is the **mechanism** of injury in this case?

- ✓ A. Endothelial cell damage
- B. Immune complex deposits
- C. C3 nephritic factor antibodies in serum
- D. Antibodies against ADAMTS13
- E. Sickle cell disease

2021:
72/84 Correct: 86%
Disc. Index: 0.20
Point Biserial: 0.19

CONCLUSIONS

- Multiple-choice questions are a standard mechanism of assessment in medical education
 - Machine graded
 - Optimized over time and use from year-to-year
- In previous generations, “fact-based” questions were commonly deployed.
- The successful completion of United States Medical Licensing Examination (USMLE) Step examination multiple choice questions requires the use of “higher-order” cognitive and critical thinking skills.
- Our Bloom taxonomy conceptual model allowed us to:
 - Analyze the Bloom level of multiple choice questions
 - Modify questions to increase their Bloom level to test objectives in the course
 - Distinguish among higher and lower scoring students as assessed by question difficulty index, discrimination index, and point biserial metrics in both formative and summative assessments.
- This project has helped us to better understand the dynamics of multiple choice question writing for preclinical medical student assessment and allows us to generate questions ranging from Bloom level 1 to Bloom level 4 and position us to help students acquire “higher-order” cognitive and critical thinking skills necessary for successful navigation of USMLE Step examinations.

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REFERENCES

- Federation of State Medical Boards of the United States and National Board of Medical Examiners. United States Medical Licensing Examination Content Outline. <https://www.usmle.org/pdfs/usmlecontentoutline.pdf>. Accessed 03/05/2021.
- NBME Item Writing Guide, 6th Edition. Constructing Written Test Questions for the Basic and Clinical Sciences. February 2021, https://www.nbme.org/sites/default/files/2021-02/NBME_Item%20Writing%20Guide_R_6.pdf. Accessed 03/07/2021.
- Armstrong, P. (2010). Bloom's Taxonomy. Vanderbilt University Center for Teaching. Retrieved 02/20/2021 from <https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/>.
- Beckwith P. Developing higher order thinking in medical education through reflective learning and research. J Pedagogic Development 2016 6: 23-31.
- Hernandez T, Magid MS, Polydorides AD. Assessment Question Characteristics Predict Medical Student Performance in General Pathology. Arch Pathol Lab Med. 2021 Oct 1;145(10):1280-1288. doi: 10.5858/arpa.2020-0624-OA. PMID: 33450752.
- Scully D. Constructing multiple-choice items to measure higher-order thinking. Practical Assessment, Research & Evaluation. 2017 22: 1-23.
- Patil SY, Gosavi M, Bannur HB, Ratnakar A. Blueprinting in assessment: A tool to increase the validity of undergraduate written examinations in pathology. Int J Appl Basic Med Res. 2015 Aug;5(Suppl 1):S76-9.
- Phillips AW, Smith SG, Straus CM. Driving deeper learning by assessment: an adaptation of the Revised Bloom's Taxonomy for medical imaging in gross anatomy. Acad Radiol. 2013 Jun;20(6):784-9.
- Zaidi NB, Hwang C, Scott S, Stallard S, Purkiss J, Hortsch M. Climbing Bloom's taxonomy pyramid: Lessons from a graduate histology course. Anat Sci Educ. 2017 Sep;10(5):456-464.
- Zaidi NLB, Grob KL, Monrad SM, Kurtz JB, Tai A, Ahmed AZ, Gruppen LD, Santen SA. Pushing Critical Thinking Skills With Multiple-Choice Questions: Does Bloom's Taxonomy Work? Acad Med. 2018 Jun;93(6):856-859.