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# From Questions to Answers: Teaching Evidence-Based Medicine Question Formulation and Literature Searching Skills to First-Year Medical Students

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## Abstract

**Introduction:** Medical students may arrive at medical school with some research background but not necessarily evidence-based medicine (EBM) skills. First-year preclinical medical students require foundational skills for EBM (formulating background and foreground questions, navigating information sources, and conducting database searches) before critically appraising evidence and applying it to clinical scenarios. **Methods:** We developed a flipped classroom EBM workshop for preclinical students combining prework modules and a 60-minute in-person session. After completing the online modules on foundational EBM skills, students participated in an in-person activity based on patient cases. In small groups, students formulated background and foreground questions based on a case and looked for evidence in resources assigned to each group. Small groups reported back to the whole group how they searched for information for their patient cases. A total of 105 first-year medical students were required to complete this workshop after concluding their basic sciences courses. **Results:** Because current EBM assessment tools do not assess the early steps of EBM, we developed an assessment tool for foundational EBM tools. Before the modules, students completed a pretest on formulating questions and searching for information. After the workshop, students completed a posttest. Students showed improvement in differentiating background and foreground questions ($p < .001$), formulating answerable clinical questions ($p < .001$), and developing appropriate database searches ($p < .001$ and $p = .002$). **Discussion:** This flipped classroom approach to teaching foundational EBM skills may be adapted for different contexts, but educators should consider time limitations, group size, and tools for interactivity.

**Keywords**
Evidence-Based Medicine, Flipped Classroom, Information Sources, Program Evaluation

## Educational Objectives

By the end of this activity, learners will be able to:

1. Formulate clear, answerable clinical questions based on patient scenarios.
2. List databases that can be used for background and foreground questions.
3. Develop appropriate database searches based on patient scenarios.
4. Differentiate background versus foreground questions.

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## Introduction

Evidence-based medicine (EBM) is a crucial lifelong skill for medical professionals, and medical students are required to demonstrate competence in this area by the time they enter residency.[1] With more medical school curricula operating on accelerated timelines, it is important to provide foundational EBM instruction early, reinforce it wherever possible in clinical practice, and offer structured EBM instruction materials that can be adaptable to different schedules. Librarians, who have specialized expertise in locating high-quality evidence, are well suited to teach the early foundational steps of EBM.[2] For clinical faculty who may not have these specific skills or access to librarian co-teachers, having existing materials to draw on will allow them to focus on the later, more clinically relevant steps such as critical appraisal.

This curriculum was designed for first-year preclinical medical students just starting to develop foundational clinical skills. These students may have a range of experience with research and information literacy but are likely to have less knowledge of

specific biomedical research information sources and methods.[3] They are also unlikely to have experience applying EBM skills to practice. Without necessarily having prior instruction in the early steps of EBM, such as how to approach questions requiring general background information as opposed to clinically-specific scenarios, specifying clear clinical questions, navigating disparate information resources, and developing search strategies with correct syntax for the database or search engine being used, medical students may have poor attitudes towards the content and a lack of understanding of how building these skills will support not only their EBM practice but their lifelong learning.[4] While it is important to reinforce EBM concepts during clinical training, we recommend introducing this content in the preclinical curriculum. Previous researchers have observed that when students are introduced to EBM early in the curriculum, some of the consequences are increased learner self-efficacy in practicing EBM and a higher likelihood that they will continue to practice EBM.[5]

The curriculum we have developed is unique in its combined approach to scaffolded preclinical EBM instruction and skills assessment, as well as in the integration of the workshop as a required component of the EBM curriculum at NYU Grossman School of Medicine. We will elaborate on this, specifically in the context of existing studies on preclinical EBM instruction, assessment, and critical appraisal instruction, in the Discussion section.

## Methods

### Setting

We implemented this class in the first-year NYU Grossman School of Medicine curriculum, targeting preclinical students. A total of 105 enrolled students were required to take this class at the beginning of their cardiovascular module. No prerequisite knowledge was required. There was one facilitator, the librarian who leads this curriculum (Juliana Magro). Students brought and used their own laptops for conducting searches and used their phones for the polling software.

### Educational Approach

We developed an EBM class for preclinical students using a flipped classroom model. In this model, instructional content (e-learning modules, readings, quizzes, etc.) is completed before class, freeing up in-class time for collaborative, problem-solving, hands-on work.[6] This method has been associated with improved student preparation and academic outcomes.[7] Because practice is necessary to achieve the educational objectives outlined previously, we believe this was an ideal approach for the workshop. For this class, students completed two short prework modules (Appendices A and B), followed by a 60-minute session, which included small- and large-group activities.

The prework modules were divided into two parts to mimic the two first steps of EBM: ASK and ACQUIRE. The first module (Appendix A) introduced students to EBM, including its importance, the 5-step framework, distinguishing background and foreground questions, forming clinically focused questions using the PICO framework (patient or problem, intervention or exposure, comparison or control, outcome), and types of questions. We attempted to provide alternatives to subscription-based information resources, but we recommend that educators speak to librarians at their institutions to explore available resources at no cost.

For the second prework module (Appendix B), we explored how to transform question elements into search terms, and introduced students to PubMed searching, including the use of several tools that they could continue to use throughout their studies and careers, and an explanation about Medical Subject Headings (MeSH) terms. In addition, the module introduced grey literature (such as preprints, clinical trial registries, etc.) and when it is wise to include grey literature to answer a clinical question.

Both modules contained exercises designed to keep students engaged. With this content designed as a flipped classroom, we were able to deliver important content without expositive lectures, using valued in-person class time for practice. Thus, the in-person class was geared towards developing background and foreground questions and exploring different databases that could be used to answer such questions.

Before the modules, students were asked to complete a pretest developed and peer-reviewed by the leading faculty. This pretest was created to fill a gap in assessments related to the interpretation of medical literature and the identification of study designs, types, and biases.[8] The questions were formulated based on USMLE-style questions, focusing on clinical cases to assess knowledge application rather than recall. The pretest results were not reviewed prior to the session, but educators might consider reviewing the test to calibrate the session accordingly.

This workshop is part of a larger EBM curriculum. Following this workshop, students had three classes related to critical appraisal. These classes were also 60 minutes and followed a flipped classroom model, but each session involved only a quarter of the class. The class of 105 students was divided into four sessions, and within each session, students were further divided into

groups of five to six. The themes for each class were as follows: introduction to observational studies and critical appraisal of cohort studies, critical appraisal of randomized controlled trials, and critical appraisal of systematic reviews and meta-analyses. Due to the abundance of critical appraisal publications available in *MedEdPORTAL*, we did not include the appraisal materials that are part of this curriculum in this publication. After the critical appraisal classes, students completed a posttest and a capstone assignment.

### Setup

Several days before the workshop, the facilitator worked with project coordinators to embed both prework webpages in the learning management system (LMS). We provide this content as HTML pages that can be downloaded and distributed to students (Appendices A and B). The pretest questions were also embedded in the LMS as a quiz, several days before the workshop (Appendix C). Students were instructed to first complete the pretest and then both modules before the in-person class. The in-person class required a projector, computer, and small-group handouts (Appendix D).

### In-Person Session

We delivered a 60-minute session to around 100 students using slides (Appendix E) and the class script (Appendix F). We used Mentimeter, a polling software, to deliver the slides and allow for easy group participation, given the larger size of the class. Alternatively, faculty can use any polling software.

Using polling software is not a necessity—the use of PowerPoint slides should not detract from the workshop experience. Students can answer the questions aloud, as prompted by the slides. This can work particularly well in smaller classes.

During the first 5 minutes, we presented the educational objectives and explained the small-group activity. With the goal of increased participation and practice, we created three different patient cases (A-C) and divided students into 18 groups, so that each group consisted of five to six students (handouts in Appendix D). During small-group work, these groups remained in the same auditorium and received one of the three patient cases, as illustrated in Table 1.

Each of the three patient cases asked students to: (a) formulate a background question(s), (b) formulate a foreground question, and (c) look for answers for those types of questions using predetermined resources, which differed for each of the three groups. The goal of using multiple databases was for students to have more exposure to them, both from their assignments and from other groups' responses. Students discussed the case and completed the handout in their small groups during the following 15 minutes.

**Table 1.** Small-Group Breakdown of Resources and Cases

| Group # | Case | Background Resource | Foreground Resource |
|---|---|---|---|
| 1-2 | A | UpToDate or DynaMed | PubMed[a] |
| 3-4 | B | UpToDate or DynaMed | PubMed[a] |
| 5-6 | C | UpToDate or DynaMed | PubMed[a] |
| 7-8 | A | Harrison's textbook | UpToDate or DynaMed[a] |
| 9-10 | B | Harrison's textbook | UpToDate or DynaMed[a] |
| 11-12 | C | Harrison's textbook | UpToDate or DynaMed[a] |
| 13-14 | A | AccessMedicine[a] or similar | Google Scholar |
| 15-16 | B | AccessMedicine[a] or similar | Google Scholar |
| 17-18 | C | AccessMedicine[a] or similar | Google Scholar |

[a]These were the resources presented to the class.

After small-group discussion, we asked all groups to report first their background questions, and then their foreground questions through polls. This activity took about 5 minutes and allowed students to see each other's responses; it also gave faculty a chance to clarify the differences between background and foreground questions.

The following 30 minutes were dedicated to discussion and demonstration. Table 1 shows the group breakdown, illustrating which cases each group worked on and which predetermined resources they used to answer their questions. One group (from groups one through six) presented how they searched PubMed for a foreground answer; one group (from groups 7 through 12) presented how they searched UpToDate (or DynaMed) for a foreground question, and one group (from groups 12 through 18) presented how they used AccessMedicine (or a similar textbook database) to search for a background question.

Groups were randomly selected using Mentimeter's spin the wheel feature. Instead of a virtual spin the wheel, faculty could alternatively use pieces of paper in a similar way. In the last 5 to 10 minutes, we presented takeaways from the class and gave students an opportunity to ask questions not answered during the class.

### Assessment

We developed a pre- and posttest specifically for this curriculum, created and independently peer-reviewed by faculty. We present the results of five questions, which are related to the educational objectives of this workshop—the remaining test questions were related to critical appraisal. The tests were implemented in the LMS. The pretest was employed in December 2022 before the first EBM module, and the posttest in June 2023 after the last module.

### Analysis

For statistical analysis, we performed two tests: Wilcoxon signed-rank test for the open-ended and multiselect questions, and McNemar's test for the multiple-choice questions. We used R version 4.4.0 to conduct the analyses.

### Ethical Approval

In line with the NYU Langone Health Institutional Review Board's guidelines, this project was granted an exemption from review, as it qualifies as an educational quality improvement program. All data were deidentified before analysis.

## Results

Out of 105 preclinical first-year students, 62 students both completed the pre- and posttest and consented to have their educational data used for quality improvement projects. We found that, except for question two, all differences between pre- and posttest questions were statistically significant, showing a significant increase in posttest scores, as shown in Table 2.

Students showed an improvement in their ability to differentiate between background and foreground questions (Q1: $p < .001$, Q4: $p < .001$), formulate clear, answerable clinical questions (Q1: $p < .001$, Q4: $p < .001$), and develop appropriate database searches (Q3: $p < .001$, Q5: $p = .002$).

## Discussion

Overall, this activity achieves multiple objectives within a single class. Introductory EBM classes, like this one, often emphasize the ASK and ACQUIRE steps through didactic lectures. However, formulating answerable clinical questions and finding appropriate evidence require practice—and not memorization—to consolidate learning. Timed at the beginning of students' medical school experience, this curriculum equips educators to build students' foundational EBM skills. The flipped classroom experience for preclinical students has enabled us to establish a baseline understanding of students' level upon entry, set expectations for them to reach, and accurately measure their growth.

Medical students recognize the importance of EBM in their current training and future clinical practice.[9] This class engages students in the preliminary stages of EBM, familiarizing them with various databases and resources as well as helping them build a foundation for future EBM educational experiences. In addition to being exposed to information resources, students can practice, apply skills, see how their peers perform, and discuss the strengths and weaknesses of different tools and sources. The active-learning exercises built in this class can help consolidate learning, as demonstrated by the pre- and posttest results, in addition to giving students awareness of their own skill level. Educators will notice that the examples used in the modules, in-class activities, and assessments are related to cardiology. This choice is intentional, as the class is embedded in the cardiovascular organ system content. We found that students respond better when the EBM class content is linked to their organ system studies. We strongly encourage educators to use examples related to what students are currently studying. Additionally, where curriculum timing permits, future adaptations could include in-class activities where all students practice using all databases of interest. Alternatively, optional activities could be offered for those who feel the need for additional practice.

This workshop distinguishes itself through the combination of required scaffolded EBM instruction in the preclinical curriculum and early EBM skills evaluation. While existing literature describes preclinical EBM instruction,[10-12] we have found our approach to combining these elements provides flexibility that enables adaptation of these materials to suit a variety of medical education settings. We have built on the work of a previous *MedEdPORTAL* publication[13] that explores the teaching of question formulation and information retrieval for preclinical students by further approaching question formulation and information retrieval as distinct skills and providing spaced repetition of key concepts throughout the year. The pre- and posttests capture students' abilities at the beginning and end of the year, with rubrics that can be reused with future educational innovations to track longitudinal progress. According to the literature, preclinical EBM instruction is often folded into an orientation or one-shot.[14] Courses covering extensive EBM content are often optional and thus not fully integrated into the curriculum. Our curriculum is course integrated and is

**Table 2.** Individual Results

| Question | Type of Question | Test | Maximum Score | *p* | Test Value | Educational Objective Related to Question |
|---|---|---|---|---|---|---|
| Q1 | Open ended | Wilcoxon signed-rank test | 4 | <.001 | $V = 108.5$ | 1 & 4 |
| Q2 | Multiple select | Wilcoxon signed-rank test | 3 | .22 | $V = 271.5$ | 2 |
| Q3 | Open ended | Wilcoxon signed-rank test | 4 | <.001 | $V = 29.0$ | 3 |
| Q4 | Multiple choice | McNemar's chi-squared | 3 | <.001 | $\chi^2 = 17.9$ | 1 & 4 |
| Q5 | Multiple choice | McNemar's chi-squared | 3 | .002 | $\chi^2 = 9.1$ | 3 |

mandatory for preclinical students. The literature includes many examples of EBM assessments focused on critical appraisal and epidemiology content, or otherwise consisting of students' self-reported satisfaction and confidence with EBM.[10] *MedEdPORTAL* also includes several examples of critical appraisal instruction for undergraduate medical students.[15-20] This curriculum is unique in its focus on assessment of early EBM steps. In this way, it is more closely calibrated to expectations for students in this stage of their medical education. These materials can be shared synchronously or asynchronously, online or in person, are adaptable for different programs, and may be especially useful to those lacking the time and resources to develop an EBM instruction program from scratch.

In the past, we have used standardized, validated EBM assessment tools.[21-23] However, current EBM assessment tools do not accurately assess or reflect content in the early steps of EBM and what students should know and be able to apply at that stage. This limitation prompted us to develop our own assessment tool. The assessment questions for educational objectives 1, 3, and 4 were effective and provided us with data to track student progress and improve the curriculum. For educational objective 2, more work could be done on clarifying the language both for the question used in the assessment and during the lecture and exercise. The multiple-select question assessing educational objective 2 should be improved in the future. Although we did not collect evidence for this test, we plan to do so in the next iterations of this workshop.

This project has several limitations. The sample size is small, as it involves only one class, with about half of the students included in the analysis. In addition, the assessment has potential shortcomings. First, we used the same questions for both the pretest and posttest. Although the 6-month gap could have mitigated a sensitization effect,[24] educators should consider modifying the questions and scenarios for the posttest to ensure they reflect the participants' true learning.[25] The time gap also makes it challenging to attribute sustained improvement solely to this class. Additionally, the assessment includes two open-ended questions, which may be a potential limitation of the evaluation approach. Future users of this assessment will need to be comfortable evaluating free-text responses. To support this skill development, we provide a rubric as a helpful tool.

When adapting this material to other contexts, educators should consider time limitations, interactivity tools, curriculum timing, instructor experience, and the size of the group. For optimal implementation, we recommend that clinical teaching faculty partner with librarians to co-create and teach this workshop.[26] Also, participation should be made mandatory. Students consistently give positive feedback on the class and find the materials valuable upon completion. However, if the class is not mandatory, students might not participate, assuming they already know the concepts well enough from database searching experiences. This class may not be suitable for groups larger than 100 students. In such cases, educators should consider dividing the class into two or more sessions. Ideally, the classroom should have movable chairs that can be arranged in small groups, although we have successfully taught this class in an auditorium with fixed chairs for several years.

While the curriculum is currently limited to standard resources for medical research, generative artificial intelligence or other newer adaptive technologies could also be explored in the class. Newer types of resources could be included as part of the conversation and class to give students an opportunity to practice using those alongside more traditional and trusted resources. Another future direction for this curriculum is the incorporation of simulation-based practice for clerkship students as a natural next step,[4] aligned with evidence-based pedagogical frameworks, such as the six-step model Learn, See, Practice, Prove, Do, Maintain.[27] With the completion of this class, there is a potential for enhanced longitudinal assessment using the current data as a starting point. We intend to integrate these data with other existing assessments within the curriculum and examine correlations with other similar knowledge and skill assessments. Assessing students' initial skill levels upon entering medical school can guide curriculum design and offer faculty and curriculum leaders deeper insights both into teaching and ways to reinforce these concepts throughout the program. This, in turn, can drive policy and curricula changes.

## Appendices

A. Introduction to EBM Module folder

B. Acquiring the Evidence Module folder

C. Pre- and Posttest Questions.docx

D. Small-Group Handouts.docx

E. In-person Slide Deck.pptx

F. In-person Class Script.docx

*All appendices are peer reviewed as integral parts of the Original Publication.*

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The NYU Langone Health Institutional Review Board deemed further review of this project not necessary.

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