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From Drug Literature Evaluation to Evidence-Based Medicine: Transforming the Focus of a First Year Pharmacy Curriculum

Shannon Reidt
University of Minnesota College of Pharmacy, reid0113@umn.edu

Keri Hager
University of Minnesota College of Pharmacy, khager@umn.edu

James Beattie
University of Minnesota Medical School, jbeattie@umn.edu

Amy Pittenger
University of Minnesota College of Pharmacy, alp@umn.edu

Maureen Smith
University of Minnesota College of Pharmacy, maureen@umn.edu

See next page for additional authors

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Authors
Shannon Reidt, Keri Hager, James Beattie, Amy Pittenger, Maureen Smith, and Kristin Janke

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Shannon Reidt, PharmD, MPH[a]; Keri Hager, PharmD, BCACP[a]; James Beattie, MLIS[b]; Amy Pittenger, PharmD, PhD[a]; Maureen Smith, MEd[a]; Kristin Janke, PhD[a]*

[a]University of Minnesota College of Pharmacy; [b]University of Minnesota Medical School

**At the time of this work, James Beattie was associated with the University of Minnesota Biomedical Library*

Abstract

This case study describes a longitudinal curricular sequence implemented to teach evidence-based medicine (EBM) skills. The longitudinal sequence is innovative in its approach, design, and assessment of EBM. This approach moves away from the conventional strategy of teaching drug information and drug literature evaluation as stand-alone courses and instead embraces the EBM Framework and its use in the context of authentic problem solving. The EBM Framework—Ask, Acquire, Appraise, and Apply—was used as the basis for defining seven EBM skills. These skills were targeted in the evidence-based, integrated design of 17 learning episodes delivered with eight faculty members through six courses in the first year. Student perceptions of relevance of EBM and performance on assessments and learning activities throughout the sequence suggest that integrating EBM across the first year of the curriculum is an effective strategy for teaching EBM skills. Three themes emerged from analysis of the data and experience, including the need for: a strong teaching team, a whole task approach with a focus on solving authentic problems, and care in interpreting the progression of assessments and patterns of student performance. Through instructor observations and peer review, the longitudinal sequence has been refined and has had an impact on the rest of the curriculum.

Key words: evidence-based medicine, literature evaluation, pharmacy curriculum

INTRODUCTION

Evidence-based medicine (EBM) is the systematic approach to clinical problem solving that involves integrating the best available research evidence with clinical expertise and patient values.[1] The practice of EBM is based on a framework of four steps: *Ask* a well-constructed question and then *Acquire*, *Appraise* and *Apply* information to answer the question.[2] EBM skills are essential to provide patient care and manage population health. The Institute of Medicine (IOM) outlined the ability to practice EBM as an essential competency that health care professionals must achieve in their education.[3] The Interprofessional Education Collaborative (IPEC) also endorses EBM as a core competency health care providers must demonstrate to provide interprofessional care.[4] As interprofessional care and education has evolved, the EBM framework has emerged as a thought process and language used by all health professions. To be functional and integral members on the interprofessional team, student pharmacists must learn the EBM framework and "speak its language."

EBM is not a new concept in pharmacy curricula. In fact, a 2012 survey conducted by the American College of Clinical Pharmacy (ACCP) Drug Information Practice and Research Network (PRN) found that 66% of Doctor of Pharmacy (PharmD) programs reported emphasizing EBM in their curriculum.[5] However, most EBM instruction described in the literature is taught in elective courses[6-10] rather than in the required curriculum. Additionally, curricular examples described in the literature do not apply the entirety of the EBM framework; instead they focus mostly on the appraisal of information and do not emphasize other steps in the process.[11,12]

IMPETUS FOR CHANGE

At the University of Minnesota College of Pharmacy, EBM skills were historically taught in the fall semester of the second year of the PharmD program in a two-credit, required Drug Literature Evaluation and Biostatistics (DLEB) course that was primarily lecture-based. The College of Pharmacy operates on two campuses, and the DLEB course was taught using a live video connection between campuses. The overall goal of the course was for students to develop the ability to critically evaluate the pharmacy and medical literature, in order to identify findings that have implications for pharmacy practice. In this course, students learned applied biostatistics, searching techniques for the primary literature, study designs, and concepts related to study methods and analysis, such as intention-to-treat analysis and the use of composite endpoints and surrogate markers.

A deficiency of the DLEB course was that students did not develop a process for using evidence to solve problems. Skills related to asking well-constructed questions, and acquiring and applying evidence were not emphasized or exercised regularly. Instead, the DLEB course focused mainly on article appraisal. In addition, it didn't connect to authentic decisions made in pharmacy practice. An alternative approach using a longitudinal curricular sequence based on the EBM framework

was needed for students to develop a consistent, rational process for using evidence to solve patient care and population health problems.

Several findings from the literature supported the development of the initiative described in this case study. The work of Khan and Coomarasamy suggests that stand-alone didactic work is ineffective for teaching EBM.[13] In this type of teaching, there is often a lack of context, making it difficult for learners to grasp the relevance and practicality of the EBM skills. Instead, EBM teaching should be integrated with other topics. In their hierarchy of effective teaching and learning to acquire competence in EBM, Khan and Coomarasamy also argue for a focus on solving real-life problems.[13] In addition, Shaneyfelt and colleagues emphasize the need for teachers to link assessment to learning aims.[14] In other words, if the goal of instruction for learners to perform EBM, learners should be assessed performing EBM. Third, self-assessment is an essential component of instruction. The CREATE system (Classification Rubric for EBM Assessment Tools in Education) organizes EBM assessment into seven categories ranging from learner attitude and self-efficacy assessment to the benefits to patients and recommends that EBM be assessed in multiple categories.[15] With this input and previous experience in mind, this initiative sought to: integrate EBM with other topics within the curriculum, emphasize a process for using evidence to solve authentic, real-life problems, use multiple forms of assessment and align performance assessments with the skills students needed to demonstrate upon completion of the sequence.

The case described in this report is a longitudinal EBM sequence integrated in the first year pharmacy (PDI) curriculum. This sequence is innovative in its approach, design, and assessment of EBM skills instruction. In a recent survey of US schools of pharmacy, 71% of schools reported how medical literature evaluation is taught to professional pharmacy students. Of these respondents, 43% taught literature evaluation in the second professional year while only 25% integrated it throughout the curriculum.[16] In addition to taking a longitudinal approach, in this initiative faculty broadened their philosophy from teaching drug information and literature evaluation to teaching the comprehensive process of EBM using the EBM Framework -- Ask, Acquire, Appraise, and Apply. Based on this philosophy, faculty transformed a stand-alone course into an integrated, longitudinal sequence in the core curriculum that used evidence-based teaching strategies. Lastly, an evidence-based assessment tool was used to evaluate students' ability to perform EBM skills. The goal of the sequence is to introduce and exercise the steps of EBM to solve patient and population problems in a variety of contexts. The expected outcome of the sequence is for PDI students to have a solid foundation of EBM skills enabling them to use a rational, methodical process to solve complex clinical problems later in the curriculum. The University of Minnesota Institutional Review Board reviewed this project and deemed it to be exempt.

DESCRIPTION OF THE CASE

Design

For each of the seven EBM skills targeted by the Curricular Sequence, a PDI-specific objective was written (Table 1). PDI specific objectives were developed to highlight that EBM skills are acquired over time and t to ensure that learning activities and assessments were designed at the most appropriate skill level. The PDI longitudinal EBM sequence included: five Foundations of EBM Workshops, 17 Integrated Curricular Activities, and an End-of Year Milestone Assessment (i.e. the Modified Fresno Test). Instructors consulted sources from the University of Oxford Centre for Evidence-based Medicine[17] and the Tufts Center for Information Mastery[18] to construct the longitudinal sequence.

Foundations of Evidence-based Medicine Workshops

The Workshops were designed to provide a foundation of EBM skills using the EBM Framework. Each of the five Workshops was two hours in length with each elaborating upon skills from the previous so that skills accumulated through the series, The sequence of Workshops followed the process of EBM—Ask, Acquire, Appraise, Apply (Table 2) and was delivered over two weeks in the Foundations of Social and Administrative Pharmacy (FSAPh) course. While students were building their skills in the Workshops, strategies to improve efficiency in their practice were also discussed.

Prior to each workshop, students completed required reading. Thirty minutes of workshop time was spent reviewing the pre-reading and, as a large group, solving practice problems related to the EBM skill of the day. Then, students worked in small groups to complete an In-Class Learning Activity that provided an additional opportunity to practice the new skills. The last fifteen minutes of the Workshop were spent debriefing in a large group. For example, prior to the workshop related to appraisal skills, students read articles summarizing biostatistics relevant to practitioners. In class, as a large group, highlights of the articles were discussed, and the class interpreted abstracts, tables, and figures taken from studies. In small groups, students completed additional, similar exercises. The workshop concluded with students sharing answers from the small group problems and asking questions.

Integrated Curricular Activities

The Foundations of EBM Workshops introduced the basic components of EBM, while the Integrated Curricular Activities were designed to reinforce and introduce more advanced

concepts, such as searching the Cochrane Library and applying systematic review and meta-analysis findings to a patient case. To plan the Longitudinal Sequence, the lead EBM faculty person met with faculty members who taught courses in the first year. Together, they reviewed course content, identified opportunities for EBM integration and designed learning activities. EBM competencies were integrated longitudinally throughout the year with 17 learning episodes placed into six courses (Table 3).

For example, Integrated Curricular Activities were woven into the Pharmaceutical Care Skills Lab class periods. During these activities, students were presented with a scenario that drew from other courses, such as Health Systems, Pharmacy Practice, and Biochemistry. For instance, one scenario involved rationalizing the benefit of oseltamivir in elderly patients and developing a protocol for its use. This scenario was chosen because students had learned about pro-drugs in biochemistry, influenza in pharmacotherapy, and practice management in health systems pharmacy. More importantly, this scenario represented authentic problem solving students would do as pharmacists. Once presented with the scenario, students had to construct a question, then acquire, appraise, and apply literature to answer the question. In the Integrated Activities, students presented their work in the form of an Activity Deliverable, such as a patient or provider letter. Related to the oseltamivir example, the Activity Deliverable was a one page memo suitable for presentation to public health officials. In pairs, students then compared their work by reviewing each other's Activity Deliverable, using instructor-provided questions. At the end of the class period, a large group debriefing was facilitated by the instructor to emphasize best practice techniques in formulating questions, searching for the answers, and developing the Activity Deliverable. These debriefings were essential in providing students with immediate feedback.

Modified Fresno Test

An end-of-year skills assessment adapted from the work of Tilson, called the Modified Fresno Test,[19] was administered as part of a Professional Development and Assessment course. A key feature of the Modified Fresno Test is that it asks learners to describe their *process* of addressing a clinical scenario, but does not require learners to find answers to the clinical scenario. Resources, such as point of care references, are not provided so students cannot simply find an answer and then retrospectively describe their process in finding that answer. The test consists of seven case-based open-ended questions that align with the seven EBM objectives. A rubric is used to evaluate responses and classifies performance as Excellent, Strong, Limited, Minimal, and No Evidence.

Evaluation of Student Learning

Assessment of Student Perceptions

By presenting EBM in the context of patient care and population health, instructors sought to establish relevance for EBM instruction. Student attitudes related to relevance of EBM and barriers to its practice were assessed prior to the Foundations of EBM Workshops, immediately after the Workshops, and four weeks after the Workshops, using a four question survey administered via paper questionnaires distributed in class. Items were derived based on previous evaluations within the DLEB sequence, as well as conversations with students, other EBM instructors and consultation with literature discussing perceptions of EBM and relevance.[20] Four weeks post-EBM Workshops was chosen because it marked the completion of the semester. Response rates to the surveys were 100%, 69%, and 63%, respectively. Student responses are summarized in Table 4. Prior to the workshops, nearly all students (99%) perceived EBM as relevant to their education and career. However, 46% agreed or strongly agreed that "My workload as a pharmacist may be too heavy to stay up to date." There were not significant changes to perceptions across the three survey administrations.

Assessment of Learning

CheckPoint Quizzes. An online CheckPoint quiz was available for students to take outside of class after each Workshop. Each five-item, multiple choice quiz focused on the learning objectives covered in the Workshop and was administered on the Moodle learning management system (Moodle HQ, Moodle 2.2, Perth, Australia). The quizzes were optional, but students were encouraged to take the quizzes to self-assess skills gained from the Workshops and to prepare for the Proficiency Exam administered at the end of the workshop series. Students were allowed to take the quizzes an unlimited number of times, and the quiz scores did not contribute to any course grade. Student scores on each quiz are outlined in Table 5.

In general, quiz scores were higher when more attempts at the quiz were made. Student performance was highest on the quiz related to formulating questions using the PICO (Population, Intervention, Comparison, Outcome) method and searching primary literature. Student performance was lowest on the last quiz where students used all skills taught in the Workshops (i.e. formulating a question using the PICO format, identifying strengths and weaknesses of study designs and using confidence intervals to determine statistical significance and interpret results). Participation in quizzes decreased somewhat over the sequence, with 89% of students (148) completing the first quiz, and 82% (137) completing the last quiz.

Proficiency Exam. At the end of the Foundations of EBM Workshop series, a 25-item multiple choice online proficiency exam was administered with exam questions similar to those used in the CheckPoint Quizzes. The sixty minute closed-resource exam was administered outside of class. Questions relied on factual knowledge, but were written in the context of short vignettes or article abstracts. The exam was available midway through the semester, and students had to achieve at least 72% by the end of the semester. Because failing to achieve 72% resulted in failing the FSAPh course, students were allowed to take the proficiency exam three times. Seventy-two percent was chosen because it equates to a C-, and faculty members felt this represented a minimum acceptable level of performance.

One hundred two students (61%) successfully passed the exam on the first attempt (average score = 78%). Sixty-one students (37%) required two attempts to pass the exam (average score = 90%), and four students (2%) required three attempts (average score = 98%). Many students reported using the first attempt as a "trial run," since they had three attempts to pass. Students performed well on questions asking them to formulate a clinical question using the PICO format, calculate and interpret number needed to treat, and identify searching techniques using medical subject headings (MeSH) in OVID Medline. Students performed poorly on questions asking them to identify study designs and use confidence intervals to determine statistical significance of risk ratios.

Integrated Curricular Activities. Student learning from the integrated learning activities was not formally assessed. Instead, students reviewed each other's work using criteria provided by instructors. In addition, observations on student learning were documented by the lead EBM faculty following each session and considered as the sequence of activities continued. Two examples of instructor observations from the spring semester are reported here. During a Journal Club Discussion, instructors observed that students were able to facilitate discussion with peers with minimal instructor coaching. Students were able to engage each other in conversation about the journal article, even if it was sharing questions they had about the article. Typically, students could identify the study objective, describe methods, and articulate one strength and limitation of the study. However, they struggled to interpret tables and figures. Specifically, they had difficulty articulating the main point of the table or figure and independently summarizing trends or patterns illustrated by the tables and figures. When instructors asked students to apply study findings to a patient case, students struggled to articulate a clear answer and often gave superficial responses. Early in the curricular sequence, instructors often observed students misusing terminology; however, this improved as students progressed through the year. Students often reported to instructors that they "knew what they want to say" but struggled "to find the right words to say it."

During an Integrated Activity, instructors observed that students excelled at constructing a question using PICO format. Given a complex scenario, students could easily isolate the pertinent patient information, intervention in question, and outcome relevant to the question. Students appeared to be comfortable using point-of-care references like DynaMed, Natural Medicines, and Micromedex, likely because these were used most often in other classes. . Overall, instructors observed that students did not demonstrate a rational process to select sources. Instead of considering the best source to provide the most valid and relevant information within the time constraints given, students typically used the source with which they were most comfortable. Students had the most difficulty identifying when a point of care reference did not give adequate information and searching the primary literature was needed. Although students could execute a basic search when directed to do so, students needed substantial coaching to consider using resources like professional websites (American Diabetes Association, American Society of Health-System Pharmacists, etc) and the Cochrane Library.

Modified Fresno Test. Goal Performance Scores were defined by a team of EBM instructors by reviewing each test item and setting a performance standard, based on the difficulty of the question and the opportunities students had in the first year to develop the skill. For example, the performance standard was higher for constructing a question using the PICO format and lower for determining magnitude and clinical significance of study results. Based on these performance standards, instructors prospectively defined three performance groups—green, yellow, and red—with green being the goal performance for all students. Those students performing in the yellow group were told their performance fell short of the goal and were cautioned to self-remediate. These students were given feedback highlighting what they did well and what skills needed improvement, as well as links to websites and tutorials to help build their skills. Students performing in the red group were given the same type of feedback and resources as students in the yellow group and were encouraged, not required, to attend a remediation workshop. In addition, students in the red group were required to follow up with a faculty member with expertise in student counseling to outline a plan for self-remediation. Only 24% of students achieved the goal performance score (green group), while 14% were in the red group. A detailed analysis of performance on the exam is beyond the scope of this paper. However, skill level data was used to improve future iterations of the

sequence and performance improved following the next offering of the sequence.

Peer Review

Faculty review of the Longitudinal Curricular Sequence was imperative to monitor its success and make refinements. Eight faculty members were involved in the development and implementation of the Curricular Sequence; however, feedback from additional faculty was sought to identify areas of improvement and other opportunities to integrate EBM into the PharmD curriculum.

Ten faculty members attended a Peer Review/Focus Group Session. Four of these faculty members were members of the Modified Fresno Test Development Team and the other six were recruited because they taught content in which EBM skill development could be integrated. The group included faculty members from pharmaceutical sciences, social and administrative pharmacy, and pharmacy practice, as well as both campuses. Prior to the session, an executive summary of the Longitudinal Curricular Sequence and Modified Fresno Test performance data was distributed to participants, along with discussion questions. At the 60-minute session, the executive summary was reviewed and questions were discussed. The feedback provided centered on four themes and is summarized in Table 6. Much of the discussion centered on the Modified Fresno Test. Faculty believed the Test offered valuable information related to student EBM skills. Because EBM skills are relevant to many pharmacy disciplines, participants offered suggestions about engaging all faculty in the instruction of EBM and methods for carrying the Longitudinal Curricular Sequence through the rest of the didactic and experiential curriculum.

CASE THEMES

By considering the experience gained in offering the sequence, as well as evidence of student perceptions, student learning, and faculty peer review, a number of observations were made From these observations, three themes were identified as having contributed to and having implications for the future of this transformed, EBM-focused, first year curricular sequence. An overview of these themes is presented to provide a more complete understanding of the innovation. These themes could be confirmed, refuted or enhanced by future work in EBM teaching in pharmacy.

Investment in Building a Strong Teaching Team

Prior to the longitudinal sequence, EBM instruction relied solely on one or two faculty members who taught the stand-alone DLEB course. However, an engaged team of instructors was needed to deliver the 17 learning episodes across six courses. In the three years leading up to the design and implementation of the longitudinal sequence, five of the eight faculty responsible for delivering the sequence attended an offering of an annual University of Minnesota Bio-Medical Library EBM teaching workshop. The goal of this interprofessional workshop was to improve participants' EBM skills and to introduce them to best practices for teaching and assessing EBM skills. As a result of this commitment and these interactions, the College's librarian has become an integral member of the EBM teaching team in the College of Pharmacy.

A risk of a longitudinal sequence is that it can leave students feeling as though skills were taught in a piecemeal fashion or not taught at all. It was important for instructors to be "on the same page", using consistent EBM terminology and operationalizing the EBM framework in the same way to help students see the continuity between all the sessions. In addition, the teaching team members were assigned roles according to their expertise. For example, the librarian was heavily involved in instruction related to acquiring evidence, clinical faculty were vital to identifying problems faced in practice and a faculty member with assessment expertise helped develop the Modified Fresno Test.

Focusing on Whole Task, Authentic Problems

Many educators argue that whole-task, authentic, collaborative educational experiences are required for meaningful learning, which makes transfer to real-life scenarios possible.[21-24] Learning requires authentic problems that are complex and ill-defined. Thus, learners are required to actively engage in problem solving with each other, struggle with the many possible solutions, and build on prior knowledge to create new understanding.[25] Learning activities earlier in the EBM sequence were designed to include content with which students were familiar. For example, students were asked to find evidence to support a recommendation whether or not a patient should use a multivitamin. Later in the sequence, students were challenged with problems with which they had less experience. For example, students were asked to write a memo for executive level hospital administrators explaining the benefits of having a pharmacist involved in antibiotic stewardship. Students struggled with the latter exercise and relied more heavily on their peers to acquire evidence and reconcile conflicting evidence. To guide students through this struggle, EBM instructors emphasized that although students may be less familiar with the content of the problem, the EBM skills required to solve the problem were the same. To promote authenticity, assignments were accompanied by time limits so that students could develop efficiency in their problem solving skills.

Interpreting the Progression of Assessments and Patterns of Student Performance

Student performance did not follow a linear, predictable pattern. Scores on CheckPoint Quizzes ranged from 62% to 81%, while the average score on the first attempt of the Proficiency Exam was 78%. Yet, only 24% of students met the benchmark performance goal on the Modified Fresno Test. These scores illustrate an unpredicted trajectory of growth, which may be explained by the design of the curricular sequence. Performance may not have progressed linearly because learning episodes progressed in complexity. The focus of the assessments shifted, and expectations were elevated. While quizzes confirmed factual knowledge, the Modified Fresno Test was a formative assessment focused on the students' ability to describe their process for defining a question, identifying relevant resources, determining their quality and the appropriateness of their application. As discussed in the design and peer review, this could be considered a more difficult test. In addition, the Goal Performance Level on the Modified Fresno Test was set to provide benchmarking information to individual students on performance relative to expectations for this point in the curriculum. As pharmacy curricula integrate EBM skills across courses and focus more intently on evolving individual EBM skills, instructors need to consider the collection of assessments used. Consideration should be given to formative and summative assessment, types of assessments beyond multiple choice and short answer exams, levels of expectations and opportunities for remediation. A collection of learning activities should also be used, and these activities should move beyond journal clubs to include authentic problems students will encounter in their careers as pharmacists.

EXPLORATION OF CASE IMPACT

Creating meaningful EBM practice opportunities and assessing EBM skills are challenges faced by many PharmD programs. Although EBM is most commonly thought of as a process used in direct patient care, it should be considered as a process used to solve problems related to all disciplines of pharmacy. The curricular innovation described in this case study report was purposefully constructed to connect all disciplines within the first year pharmacy curriculum. In fact, all pharmacists, regardless of the area of pharmacy in which they practice, need EBM skills. Pharmacists in managed care, industry, academia, ambulatory care, and inpatient practice ask questions, and then acquire, appraise, and apply information to answer those questions. Because of the universal nature of EBM, initiatives described here have a high level of practicality and transferability.

The Longitudinal Curricular Sequence described in this case study has had local impact in a number of ways. The sequence now extends into the second and third year of the didactic curriculum. The EBM Framework has been incorporated into the research skills course taught to second year pharmacy students. In this course, the scientific method is taught within the context of asking a question, acquiring, appraising, and applying the evidence to answer the question. Incorporating the EBM Framework into the research skills course seeks to impress upon students that EBM skills are used to solve direct patient care questions and population health problems. In the third year of the curriculum, learning activities that utilize the entirety of the EBM Framework have been incorporated into pharmacotherapy courses. In these activities, the focus is on EBM skills themselves, but placed in the context pharmacotherapy and typical problems. Impact has also occurred within Advanced Pharmacy Practice Experiences (APPEs). EBM skills are reflected in one of the Entrustable Professional Activities (EPAs) used to assess student performance on APPEs. EPAs are competencies or abilities that serve as outcomes of curriculum.[26] The EPA related to EBM requires that students "Incorporate the medical literature to provide evidence-based supported best practice clinical care." Additionally, a learning activity used in medicine called Education Rx[27] has been developed for use in all required APPEs. Education Rx is a learning assignment co-written by a preceptor and learner in which a clinical problem is posed and answered using EBM skills. The learner and preceptor agree on a time to "fill" the Rx; this represents a time when the learner presents his/her work and receives feedback from the preceptor using a rubric. In addition, within the College of Pharmacy a community of practice has developed around scholarship and teaching of EBM. Communities of Practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.[28] With a critical mass of faculty involved with the teaching of EBM at various points in the curriculum, there is a growing familiarity with the discipline, excitement and ongoing dialogue. Subgroups have coalesced around particular EBM teaching activities and leaders of those teaching activities are emerging. As the community is maturing, early successes are propelling forward strategic discussions and more ambitious projects.

The Longitudinal Curricular Sequence described in this case study has also had broader impact. Elements of this case study have been presented to educators from the American Association of Colleges of Pharmacy (AACP) and will be presented at the next Medical Library Association Annual Meeting. In addition, AACP recognized this work with an Innovations in Teaching Award.

One of the keys to success of this initiative was collaboration with librarians. The successful collaboration illustrated in this

case study may be used as a model for other colleges of pharmacy. In addition, a pharmacy-library collaboration could be the start of interprofessional instructional teams that could eventually instruct interprofessional teams of learners. Since EBM is a skill employed by interprofessional teams in practice, faculty may consider teaching EBM with interprofessional instructional and learning teams.

Future work in this area should continue to describe and evaluate other methods of integrating the EBM Framework into pharmacy curricula. The case study described here is only one approach of integrating the framework and focuses on solving authentic problems. This example is tailored to the needs of a large program across two campuses. Variations of this model may be needed to fit other institutions.

Student performance, perceptions, and instructor observations have uncovered future directions for this work. For example, instructors observed that students struggled with having a systematic approach to selecting information sources when answering questions. Instead of selecting sources based on their relevance and validity, they often relied on those sources with which they had the most experience. Additionally, students struggled to execute steps of the EBM framework efficiently. Despite tailoring learning activities to students' level of skill and using time limits on assignments, students did not improve in efficiency throughout the Longitudinal Sequence. Students also reported being concerned that time might be a barrier to practicing EBM in their future career. Future work should investigate methods to instill a rational approach for selecting information sources and build efficiency in EBM skills.

The longitudinal curricular sequence in the first year curriculum was based on seven learning objectives that were tailored to first year students. EPAs have guided performance standards for students in the last year of the PharmD curriculum. EBM-specific learning objectives for students midway through the PharmD program are needed. Milestones of EBM skill progression are needed to guide curriculum development to ensure that learning activities and assessments build in complexity and students progress in skills. For example, milestones may differentiate a novice's ability to construct answerable questions compared to a master's ability.

Lastly, as the Longitudinal Curricular Sequence expands to APPEs, opportunities in preceptor development have been identified. A strong teaching team was needed for the first year sequence, and this team was built by having some members attend a University of Minnesota Bio-Medical Library EBM teaching workshop. It is likely that preceptors use EBM skills in their daily lack the skills to teach students EBM skills. Future work should explore preceptor development in the area of teaching EBM to students.

CONCLUSION

Pharmacists have historically been seen as "drug information" experts; however, pharmacy practice demands more than simply providing information. To contribute medication expertise effectively in team-based health care, pharmacists must be proficient in asking, acquiring, appraising and applying evidence to best care for patients. This requires a consistent approach and ample opportunities to practice during training. The approach to teach EBM described in this case study reflects how students will use these skills as practitioners.

In addition, the EBM framework is a thought process and language used by other health professions. To contribute to the interprofessional team, it is imperative that pharmacists are versed in the same EBM thought process and language used within the health system. To optimally prepare students to be members of the interprofessional team, pharmacy educators should continue to examine and evolve their approach to teaching EBM.

This case study describes an innovative approach to teaching EBM by integrating a longitudinal sequence based on the entire EBM framework in the required first year curriculum. In this sequence, students were taught to use to the EBM framework to solve patient care and population health problems. Three themes emerged from analysis of the data and experience, including the need for: a strong teaching team, a whole task approach with a focus on solving authentic problems, and care in interpreting the progression of assessments and patterns of student performance. Through instructor observations and peer review, the longitudinal sequence has been refined and has had local impact on the rest of the curriculum. For example, the Longitudinal Curricular Sequence that started in the first year now crosses all years of the curriculum. Future work in this area should explore defining milestones in EBM skills progression, instilling a rational approach in selecting information sources, and building efficiency in skills.

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Table 1. Learning Objectives for First Year (PDI) Pharmacy Students

Objective number	Objective
1	Formulate a clear, searchable question from a population health or patient care scenario using the PICO (Patient/population, Intervention, Comparison, Outcome) format
2	Apply a systematic strategy for finding evidence to answer the question using primary literature search engines and point of care references
3	Describe the systematic search strategy using appropriate terminology related to primary literature search engines
4	Identify and define study designs/methods relevant to answering the question by citing basic advantages and disadvantages of study designs
5	Critically appraise any evidence found by determining whether the evidence is relevant to the population identified in the question and for OTC-related clinical scenarios, determine if the evidence fits the intervention outlined in the question.
6	Identify obvious critical threats to validity of the findings/evidence using basic study design principles and biostatistics.
7	For OTC-related clinical scenarios, identify outcomes from the evidence that are significant and patient care oriented/centered.

OTC=over-the-counter

Table 2. Description of Foundations of EBM Workshops

Workshop	Objectives
1	**Theme: ASK & ACQUIRE** • Construct a clinical question using PICO (Person/population, Intervention, Comparison, Outcome) format • Conduct a literature search using PubMed and Medline, building on PubMed demonstration covered in Becoming a Pharmacist course. • Use electronic resources including: Micromedex, DynaMed, Natural Standard
2	**Theme: APPRAISE** • When analyzing the literature, apply statistical concepts regularly used in pharmacy and medical journals including: risk ratios, absolute risk reduction, relative risk reduction, number needed to treat/harm
3	**Theme: APPRAISE** • Recognize and describe levels of evidence (i.e. case report, systematic review) • Summarize advantages & disadvantages of commonly encountered study designs (i.e. randomized controlled trial, cohort, case-control, cross-sectional) • From an abstract, define the study hypothesis and the reason for study design. Interpret primary findings and conclusion.
4	**Theme: APPRAISE & APPLY** • Develop a systematic approach to appraising a study • With faculty guidance, facilitate discussion of a study with peers
5	**Theme: ASK, ACQUIRE, APPRAISE & APPLY** • Utilize a systematic approach to appraising a study. • Facilitate discussion of a study with peers. • Given a population health or patient care problem, outline a question using PICO format • Acquire primary literature to answer the question • Appraise the validity and relevancy of the literature with peers • Apply the findings from the evidence to the question

Table 3. Evidence-based Medicine Curriculum Components in the First Year

Becoming a Pharmacist *Fall semester)*	**Foundations of Social Administrative Pharmacy** *(Fall semester)*	**Pharmaceutical Care Skills Lab I and II** *(Fall & Spring semester)*	**Applied Pharmaceutical Care** *(Spring semester)*	**Professional Development and Assessment Days** *(Spring semester)*
• Introduction to Drug Information Resources, including Micromedex, DynaMed, Natural Standard, and PubMed. (2hrs)	*Workshops* • ASK & ACQUIRE: Formulating Clinical Questions & Primary Literature Searching (2hrs) • APPRAISE: Biostatistics, including risk ratios, confidence intervals, and number needed to treat (2hrs) • APPRAISE: Study & Grades of Clinical Evidence Designs (2 hrs) • APPRAISE & APPLY: Approach to Appraising a Journal Article with 1 Journal Clubs (2hrs) • ASK, ACQUIRE, APPRAISE & APPLY: Construct a question, acquire evidence, appraise it with peers, and apply it to the question with 1 Journal Club (2hrs) • EBM Proficiency Exam (administered online after Workshops)	• Drug information resources (building on BaP instruction) (2hrs) • Integrated Drug Information Activities-Part I (2hrs) • Intention-to-Treat & Per Protocol Analysis with Journal Club (2hrs) • Surrogate Markers with Journal Club (1hr) • Composite Outcomes with Journal Club (1hr) • Integrated Drug Information Activities-Part II (2hrs) • Modified Fresno Test Preparation with practice cases (2hrs)	• Use of meta-analysis & systematic reviews in the context of analyzing conflicting evidence with Journal Club (2hrs)	• Critiquing research (conducted at Research Day, a college-wide research symposium) (2hrs) • End-of-Year Milestone Assessment (Modified Fresno Test) (2hrs)

BaP=Becoming a Pharmacist
FSAPh=Foundations of Social and Administrative Pharmacy
EBM=Evidence-based Medicine
PDAD=Professional Development and Assessment Days

Table 4. Student Perceptions of Relevance of Evidence-based Medicine

	Pre-Workshop n (%)[a]	Immediately Post-Workshop n (%)[a]	4 Weeks Post-Workshop n (%)[a]
Learning EBM is relevant to my PharmD education	165 (99)	162 (97)	164 (98)
Practicing EBM will be relevant to my career	162 (97)	162 (97)	162 (97)
My workload as a pharmacist may be too heavy to stay up to date	77 (46)	72 (43)	67 (40)
As a pharmacist, I will need to assess my EBM ability	164 (98)	162 (97)	164 (98)

[a]: Number and percentage of students who rated agree or strongly agree
EBM=evidence-based medicine
PharmD=Doctor of Pharmacy

Table 5. Summary of Scores from CheckPoint Quizzes

CheckPoint Quizzes (n=167 students)	Constructing a Question & Literature Searching	Applied Biostatistics	Study Designs	Approach to Article Appraisal	Review of All Workshops
Participation Rate n (%)	148 (89)	145 (87)	140(84)	143 (86)	137 (82)
Average Score	81	72	69	78	62
Number of Quiz Attempts	213	212	180	206	171
Median Number of Attempts per Student	1	1	1	1	1

Table 6. Summary of Faculty Peer Review of Modified Fresno Test

Feedback Theme	Faculty Comments
The Modified Fresno Test is process-focused	*-This is a tough test. But skills are very relevant to practice.* *-Evaluating EBM skills can be difficult given multiple paths students might take, which may all lead to varying products/outcomes with varying degrees of quality* *-We need more discussion of where might it be coupled with application of skills (vs. just process) (e.g. ability to evaluate an actual article vs. what would you look for)? The Test focuses on HOW you acquire, appraise, and apply information, but we also need an assessment that evaluates the end product.*
Students didn't perform as well on the Modified Fresno Test as expected.	*-We could "lower the bar"; however, that might be premature. We should make adjustments to instruction and watch test performance for another year. We're not convinced that the desired performance levels are inappropriate.* *-All students should attend a Refresher Workshop at the start of their second year.* *-Remediation is "expected" but not required. As a result, many students won't likely remediate. We need to figure out a way to engage students to improve skills even when a grade isn't being assigned.* *-All faculty need to know about the EBM weaknesses in students.*
The Modified Fresno Test is resource intensive to grade.	*-Generating reports on performance was resource intensive. We may need to look at how our course management website can be used differently to generate these reports.* *-In addition to assisting with test development, the Librarian from biomedical library could be engaged to assist with test administration and evaluation.*
Future Directions	*-Administering this in first year provides information to help intervene early with some students. We should consider administering this again later in the curriculum, such as at the end of the PDIII year.* *-We may be able to suggest small activities to increase the effectiveness of EBM in the curriculum. Examples to be circulated to faculty.* *-These skills require repetition. We may want to consider goals for repetition especially in APPE year (e.g. journal clubs, point of care assessment such as EducationRx)*