Defining Core Conceptual Knowledge: Why Pharmacy Education Needs a New, Evidence-based Approach

Abstract

No pharmacy program, however well-resourced, has sufficient time or resources to teach students all current, practice-relevant knowledge. And while the volume of potential pharmacy education curriculum content increases exponentially each year, available time for direct instruction continues to decline. Given these constraints, pharmacy curricula must focus on promoting deep learning of the most critical, fundamental, broadly applicable and lasting knowledge. Yet, in terms of didactic knowledge, pharmacy education currently has no agreed upon, evidence-based criteria for determining which foundational concepts are most important to teach, and no research-based assessment tools to demonstrate how well students have learned those core concepts. This lack of consensus regarding core conceptual knowledge makes disparities in learning outcomes both more likely to occur and less likely to be detected or addressed.

Over the past 30 years, several scientific disciplines undergirding pharmacy have developed research-based lists of core concepts and related concept inventories, demonstrating their transformative educational potential. Core concepts are big, fundamental ideas which experts agree are critical for all students in their discipline to learn, remember, understand, and apply. Concept inventories are research-based, psychometrically validated multiple-choice tests designed to uncover learners' prior knowledge and potential misconceptions and determine their depth of understanding of disciplinary core concepts. This commentary proposes adapting and applying this evidence-based core concepts approach to enhance pharmacy education's overall effectiveness and efficiency and outlines an ongoing, multinational research initiative to identify and define essential pharmacy concepts to be taught, learned, and assessed.

Keywords: Concepts; Conceptual Change; Core Concepts; Concept Inventories; Pharmacy Education

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Introduction

Since the early 1990s, educational research on core concepts and development of related concept inventories have led to the adoption of a new evidence-based approach to undergraduate teaching in foundational courses in biology, chemistry, genetics, physics, physiology, statistics and several other science, technology, engineering, and mathematics (STEM) disciplines.[1] Simply put, this approach focuses on ensuring that higher education students learn to understand deeply and apply appropriately a finite set of core concepts – big, foundational ideas identified, agreed upon, and defined through research with disciplinary experts. In scope, core concepts inhabit a semantic Goldilocks Zone: neither as broad as topics nor as narrow as facts. Figure 1 offers illustrative examples of possible pharmacy education core concepts, contrasted with related topics (broader) and facts (narrower).

Once core concepts have been identified and defined, concept inventories – research-based, purpose-built, psychometrically validated multiple-choice tests – can provide valid and reliable data to uncover learners' misconceptions, target formative feedback, assess learning gains, and evaluate alternate teaching approaches. Since 1992, for example, undergraduate physics education research and teaching internationally have been transformed by the development of evidence-based concept inventories. These physics concept inventories, beginning with the Force Concept Inventory (FCI), have been administered at hundreds of universities worldwide, with two ground-breaking FCI publications cited more than 12,000 times.[2,3] Similar concept inventories have been developed, often with funding from the US National Science Foundation, and employed in many other undergraduate STEM disciplines. Despite three decades of core concept and concept inventory research and development in relevant STEM fields, there have been very few documented attempts to adapt and apply this research-based approach to health sciences education in general or to pharmacy education, specifically.[4,5] The Pharmacy Education Core Concepts Educational Research Initiative (PECCRI) aims to address this gap in the research literature and position pharmacy education as a leader among the health professions in this regard.

Perspective

Unlike many STEM fields, pharmacy education currently has no agreed upon, evidence-based criteria for determining which foundational concepts are most important to teach, and critical for students

to demonstrate they have learned, prior to licensure and practice. While lists of essential pharmacy topics exist, they differ significantly in content and scope, reflecting in part the varied perspectives of stakeholders and organizations which develop and promote them. In the United States, for example, the content of pharmacy curricula is heavily influenced by accrediting bodies, licensing exams, textbooks, and faculty expertise. In the US, authoritative bodies such as the Accreditation Council for Pharmacy Education (ACPE), American College of Clinical Pharmacy (ACCP), National Association of Boards of Pharmacy (NABP), and American Association of Colleges of Pharmacy (AACP) provide lists of topics and skills deemed necessary to include in curricula. The Australian Pharmacy Council and the United Kingdom's General Pharmacy Council play similar roles.

Existing standards and recommendations for pharmacy curriculum, such as those noted above, are usually framed at very high levels of abstraction, listing subdisciplines and broad topics. To date there has been no research examining the degree to which these existing, high-level standards reflect what pharmacy educators see as the core concepts to be taught and learned in their programs. As Figure 1 illustrates, core concepts occupy a semantic space between broad topics and specific facts. The lack of an evidence-based consensus on essential core content hinders progress in many areas of pharmacy education, including: research and scholarship, curriculum design and development, outcomes assessment, program and course evaluation, teaching evaluation, and learning assessment and improvement.

In sum, core concepts and concept inventories are not meant to supplant existing content standards, but rather to serve as additional organizing schemata and tools. For example, core concepts can be used as the key knowledge elements in foundational curricula, to which examples, facts and details are explicitly linked. Concept inventories can provide curriculum designers and teachers with information on what students know and how well they know it pre-, during, and post-instruction, allowing for more efficient use of teaching time, better targeted feedback, and more personalization. In these and other ways, research defining essential core concepts could enhance instructional effectiveness and efficiency in pharmacy education in the US, the UK, and Australia and, perhaps, internationally.

If to be effective is to *do* the right things well, then instructional effectiveness requires *defining* the right learning outcomes and *teaching and assessing* the right things well. Determining which are the

essential “right things” is challenging for three reasons. First, the foundational knowledge content required to become a pharmacist is drawn from several different underlying disciplines, each with different terms, concepts, and problem-solving methods. Second, the sheer volume of potential pharmacy curriculum content – including new scientific discoveries, new drugs, new devices, and new treatments – increases exponentially year on year, requiring constant and difficult decisions about what content to include and exclude. Curriculum hoarding further exacerbates these pressures. And third, the prior preparation of pharmacy students, what they enter knowing, varies greatly across individuals, programs, and nations. For all these reasons, developing an evidence-based consensus regarding the “right” core concepts to be taught, learned, and assessed could enhance curriculum design and instructional effectiveness in pharmacy education.

No pharmacy program, however well-funded, has sufficient time or resources to teach students all the relevant, current knowledge. As noted above, while the sheer volume of potential pharmacy education curriculum content increases exponentially each year, available faculty time for direct instruction continues to decline in most settings. In the United States, increased competition, declining enrollments, saturated job markets, and rising tuition and instructional costs have also prompted change in pharmacy programs. To increase affordability and, thus, enhance enrollments – and in hopes of improving efficiency – some American pharmacy degree programs are compressing four years into three, off-loading content online and/or integrating disciplinary content. In every post-industrial country, time and cost pressures favor rationalizing curriculum content. Consequently, pharmacy programs which aspire to become more efficient and affordable, without sacrificing instructional effectiveness, could benefit from evidence-based means to determine exactly which concepts their students must master.

Implications

Over the past two years, the authors of this commentary have designed and piloted a multi-method, multi-year, multinational effort – the Pharmacy Education Core Concept Research Initiative (PECCRI) – to adapt and apply this core concepts approach and its associated research methods to pharmacy education in the US, the UK, and Australia. The central research question we seek to answer is: What specific conceptual knowledge do pharmacy education disciplinary experts see as the *core concepts* that all pharmacy students must master prior to licensure and practice? While our research focus is limited to

conceptual knowledge, we recognize that concepts are only one aspect of the pharmacy education curriculum, which includes skills, competencies, attitudes, dispositions, and values.

This initiative builds on a quarter century of research on core concepts and common misconceptions in STEM education. In adapting and extending prior discipline-based research to a professional heath education field, our team is engaging multiple stakeholders and employing multiple educational research methods, including: document analysis and text mining, perception surveys, focus groups and interviews, and interactive online work by expert panels to refine initial core concept lists, define core concepts, and draft concept inventories.

To reap the benefits described above, pharmacy education must first develop a common, criterion-based definition of core concepts. While there is currently no single agreed-upon definition of core concepts in the STEM literature, common definitions include “big ideas,” “fundamental,” “basic,” “key,” “essential,” and/or “critical.” Drawing on relevant literature and our own pilot research, we propose the criterion-based definition below to advance research on, development, and use of core concepts in pharmacy education.

Core concepts are ideas that experts in pharmacy education determine to be:

- Fundamental – Foundational and essential to learning, understanding, and practicing pharmacy;
- Useful – Widely applicable to analyze data, solve problems, and interpret new scenarios; and,
- Enduring – Likely to remain relevant and essentially unchanged for decades.

PECCRI is currently using these defining criteria in surveys with pharmacy educators, and in work with expert groups to evaluate and revise draft consensus lists of core concepts resulting from those surveys. We expect these initial criteria may evolve as the research advances.

Recognizing that the core concepts of pharmacy education will derive from several underlying disciplines, our research design focuses on the specific expertise and judgement of pharmacy educators who teach courses in the biomedical, pharmaceutical, social/administrative/behavioral, and clinical sciences. Due to the syncretic nature of pharmacy education, we predict this research is likely to yield multiple lists of core concepts, each derived from a specific subfield, and thus lead to the development of multiple, specific concept inventories. Relevant examples of the development of such subfield-specific concept inventories can be found in microbiology[5] and physiology[6] education.

To date, our team has developed and piloted core concept research designs and methods with three groups: a sample of United States PharmD program faculty, a sample of Australian university faculty teaching pharmacology,[7] and an international sample of university pharmacology faculty.[8] Next, we plan to elicit survey data from broad samples of pharmacy education academics globally. While PECCRI's proof-of-concept work has been done largely in pharmacology, a science-based field, the authors expect that educators in all subfields of pharmacy will be able to identify core conceptual knowledge. Long-range plans are to extend subsequent data collection to include current pharmacy students, recent graduates, practicing professionals, and leaders in professional bodies. The authors are currently launching Stage Four of a seven-stage research and development plan, [See Figure 2] and welcome inquiries, comments, and expressions of interest regarding this initiative.

The evidence-based approach to defining and assessing core concepts described above has already demonstrated potential to enhance educational research, curriculum design, teaching, assessment, and learning in several pharmacy-related STEM disciplines. Adapting this approach to pharmacy education could provide more effective and efficient ways to focus, organize, present, and assess essential knowledge content, thus complementing the work of scholars and professional organizations who have developed the existing standards and assessments. Widespread engagement with this approach by pharmacy educators in the US and worldwide could also offer new opportunities for international collaboration, research, and development. In sum, the Pharmacy Education Core Concept Research Initiative embodies our Academy's commitment to evidence-based practice and could help position pharmacy as a global leader in educational research among the health science professions.

References

[1] Libarkin J. Concept inventories in higher education science. National Research Council, 2008. Accessed 5 June 2022. https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072624.pdf

[2] Hestenes D, Wells M, Swackhamer G. Force Concept Inventory. Physics Teach. 1992;30(3):141-158. doi:10.1119/1.2343497

[3] Hake RR. Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. Am J of Physics. 1998;66(1):64-74. Accessed 5 June 2022. https://files.eric.ed.gov/fulltext/ED441679.pdf

[4] Prunuske A, Hunter C, Nemeth, K. Application of the Introductory Molecular and Cellular Biology Assessment to health professional students. Med Sci Educ. 2014;24:263-271. Accessed 5 June 2022. https://doi.org/10.1007/s40670-014-0046-x

[5] Seitz HM, Horak REA, Howard MW, et al. Development and validation of the Microbiology for Health Sciences Concept Inventory. J Microbiol & Biol Ed. 2017; 18(3): doi.org/10.1128/jmbe.v18i3.1322

[6] Michael J, McFarland J. Another look at the core concepts of physiology: revisions and resources. Adv Physiol Educ. 2020;44: doi.org/10.1152/advan.00114.2020

[7] White PJ, Davis EA, Santiago M, et al. Identifying the core concepts of pharmacology education. Pharmacol Res Pers. 2021;9(4): doi.org/10.1002/prp2.836

[8] Santiago M, Davis EA, Hinton T, et al. Defining and unpacking the core concepts of pharmacology education. Pharmacol Res Pers. 2021;9(6): doi.org/10.1002/prp2.894