VOL
6
NÚMERO 1

Suplemento Especial de la Editorial Physiological Mini Reviews sobre Educación

CURRENT STATUS AND DIRECTIONS OF MEDICAL PHYSIOLOGY INSTRUCTION

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Resumen
La instrucción en la fisiología médica debe cambiar para permitir que los estudiantes florezcan en el ambiente clínico. El papel de la instrucción ya no es la simple transmisión del conocimiento – es el desarrollo de un profesional. Los estudiantes reconocen la importancia crítica de la fisiología como base para sus pasantías clínicas. Hay cuatro acciones que mantendrán a los estudiantes de medicina involucrados en la Fisiología: 1) La instrucción tiene que extenderse más allá de la transmisión del conocimiento para incluir los otros dominios de competencia de un médico profesional; 2). La instrucción de la fisiología tiene que enfatizar la pertinencia clínica de los conceptos científicos; 3) Los instructores deben colaborar con colegas médicos para entender cómo la fisiología se utiliza actualmente en el contexto clínico, y 4) La instrucción de la fisiología tiene que ser presentada como parte de un continuo entre la educación del nivel universitario hasta la práctica profesional. La instrucción de la fisiología médica tiene que enfocarse en métodos de enseñanza centrados en los estudiantes para permitir que ellos dominen los conceptos de la fisiología en el contexto clínico.

Abstract
Medical physiology instruction must change to allow learners to flourish in an evolving clinical practice environment. The role of instruction is no longer knowledge transmission – it is the development of a professional. Students recognize the critical importance of physiology as a foundation for their clinical clerkships. There are four actions that will keep medical students engaged in the discipline of Physiology: 1) Instruction must extend beyond knowledge to include the other competency domains of a medical professional; 2). Physiology instruction must emphasize the clinical relevance of the concepts; 3) Instructors must collaborate with clinician colleagues to understand how physiology is currently used clinically, and 4) Physiology instruction must be viewed in the context of a continuum from university to practicing professional. These actions require a shift to student-centered teaching approaches that allow students to master physiology concepts in clinical context.

INTRODUCCIÓN:

Physiology, the study of normal body function, is a key component in all health science education programs. An appreciation of homeostasis and control systems provides a framework allowing learners to understand the complex functions and interactions of the body systems. The instructor's challenge is to organize a learning experience that will assist the mastering of physiological concepts that students will need in their clinical practice.

Historically, the function of physiology instructors was tightly coupled to the instructor's role as a provider of information. In this context, physiology content expertise was the core requirement. Once content mastery was established, the primary teaching activity was the packaging and the presentation of that information to the students. Learning, where students interacted with the content, was an activity separate from teaching.

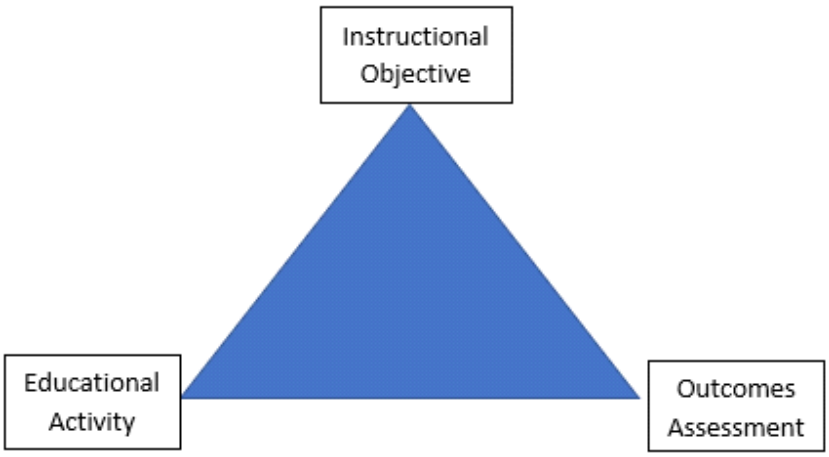
Medical education in the USA and globally is adapting to a world where massive amounts of quality information (and some unreliable information) is instantly available [1]. A second challenge is that mastering knowledge is still an essential component of medical education but is now complemented by other expectations of a professional [2]. To flourish in 2019, physiology educators need to shift from being a provider of information to be a facilitator of learning [3].

Throughout most of the 20th century, the subject of physiology was approached as a 'stand-alone' course, with little consideration of the other curricular components nor the ultimate application of the knowledge [4]. This approach separates physiological understanding from the context in which it will be applied. This is unfortunate as knowledge is useful only when it can be appropriately accessed and

incorporated into practice [5].

This paper will focus on how the current changes in medical education have reshaped the teaching environment. Understanding these changes will allow physiology instructors to ensure that physiology as a foundational science prepares learners for the intelligent practice of medicine. The paper will close with recommendations that instructors can implement to strengthen the teaching and learning of physiology.

The guiding framework for this minireview is a triangle, emphasizing the interactions among the objectives of the instructional activity, the format of the educational activity and the assessment of the outcomes of the activity. The advantage of the triangle is that it illustrates how a change in one of these three components necessitates the change in the others. For example, as the objective of the instruction in the United States is changed, this requires a change both in the format of the educational activity and modification of the assessments used to determine the outcomes of the experience.



Objective of Physiology Instruction

In the 1950s, the educational psychologist Benjamin Bloom chaired a committee that devised a taxonomy or classification scheme outlining three hierarchical models dealing with the cognitive domain (knowledge), the affective domain (emotion or attitudes) and the psychomotor domain (action or skills) [6]. The combination of these three models forms the basis of "competencies", which describe the knowledge, skills, and attitudes that are the desired outcome of an educational program [7]. The Accreditation Council for Graduate Medical Education (ACGME) has identified the competencies that are expected of a practicing physician in the USA in order to guide activities during the residency training [8]. These competencies are grouped into six domains: Patient Care, Medical Knowledge, Interpersonal and Communication Skills, Practice-Based Learning and Improvement, Professionalism and Systems-Based Practice. In this broader context, knowledge is only one of the desired outcomes of an educational program.

Physiologists are very comfortable when teaching is focused on knowledge, and studies of teaching and evaluation describe how Bloom's taxonomy can be used to develop learning objectives and assessment tools [9, 10]. The 'lowest' of the Bloom Cognitive Domain levels focuses on facts, while instruction aimed at the higher levels in the taxonomy centers on concepts and application.

The instructor's focus on knowledge manifests in the question "How many hours are needed for physiology instruction?", based on the premise that the instructor is the sole source of knowledge and that the curricular footprint is a measure of the 'worth' of the subject. This is exactly the wrong question to ask. This line of questioning leads instructors to an unproductive end, as curricular decisions are often indifferent to the footprint of any individual discipline. The more productive question is "How is my course/block preparing students for the next step in their training?". This question places the discipline in context.

The distinction between knowledge and competencies was underscored by two initiatives of the American Physiological Society in the early 2000s. A joint project between the APS and the Association of Chairs of Departments of Physiology led to the development and approval of a national set of medical physiology learning objectives (focused on knowledge, concepts and application),

including broad consensus on the topics [11, 12]. In contrast, a similar project seeking to identify the learning objectives for graduate education proved impossible. There was little to no overlap in the knowledge funds of a PhD graduate from a physiology graduate program emphasizing genomics and one that emphasized comparative physiology. In contrast, the "professional skills", or competencies, needed to successfully complete these programs (critical appraisal of the literature, experimental design, data analysis, communication, ethics) were very similar [13]. Medical Education has expanded from knowledge to include the other aspects of professional behavior. For physiology instructors, this shift requires us to teach our medical students more like we teach our graduate students.
The link between training programs and professional practice is illustrated in the competence by design framework (CanMEDS) developed by the Royal College of Physicians and Surgeons of Canada [14]. This organization of six interrelated competency domains all of which are components of a medical expert. Each of the key competencies is also tied to enabling competencies as well as milestones to assess their attainment.

Educational Activity: How is Physiology Currently Taught in the USA
Through most of the 20th century, instruction at the University and in professional schools was generally synonymous with lecturing. Physiology as an experimental science also included laboratory activities, but lecture remained the dominant form of instruction. The function of physiology instructors was tightly coupled to their role as a provider of information. Teachers were assessed on the packaging and the presentation of that information to the students.
In a survey of curriculum approaches, the Association of American Medical Colleges reported that between 2010 and 2018, the percentage of medical schools where physiology was taught as an independent course decreased from 42% to 22%. During this time, the percentages of schools using an integrated course for physiology instruction increased from 62% to 84%.
This same report shows a shift in the formats used for physiology instruction. The lecture format was used in almost 100% of US medical schools [15]. At the beginning of this interval, over half of the schools reported using laboratory instruction, but that percentage had decreased to 37% by 2018. The decline in laboratory instruction was offset by an increase in computer-assisted instruction from 30% in 2010 to 44% in 2018.
In 2010, 84% of schools reported using learner-centered teaching approaches, either team-based learning (21%) or problem based learning/care-based learning (63%) approaches for physiology instruction. Use of these teaching formats increased through 2018, with 61% reporting use of case-based instruction and 39% problem-based learning, and an additional 36% using team based learning. By 2018, it appears that essentially all schools have adopted one or more learner centered instructional approaches in their physiology courses.

Table 1: Medical School Reported Use of Teaching Formats for Physiology Instruction

	2010-2011	2011-2012	2012-2013	2013-2014	2017-2018
Physiology taught in independent course[1]	42%	40%	35%	34%	22%
Physiology taught in integrated course[1]	62%	70%	77%	80%	84%
Lecture	94%	99%	99%	100%	96%
Laboratory	51%	52%	54%	52%	37%
Computer-assisted instruction	30%	30%	38%	41%	44%
Team-based learning	21%	31%	32%	33%	36%
Problem-based learning[2]	63%	66%	65%	40%	39%
Case-based learning[2]			33%	71%	61%

[1] Schools can use more than one curriculum design, so percentages total to > 100%
[2] Problem-based and Case-based learning responses were grouped together in the survey in 2010-2012. A school can report using more than 1 format in a year, so the percentages for a given year total to > 100% [15].

The changes in teaching format are paralleled by changes in the curriculum organization. The number of schools reporting discipline based curriculum structure decreased from 55% in 2015 to 48% in 2017 [15]. The number of schools reporting an organ systems-based instruction increased from 85% in 2015 to 88% in 2017. These categories are not mutually exclusive, as some institutions have an organ systems-based curriculum in the M2 year and also a standalone physiology course in the M1 year. The impetus for this change is the need to ensure that information is learned that as a component of the discipline, but in the integrated context needed to provide medical care.

Outcomes Assessment: How well is Physiology Currently Learned in the USA.

Each year in the United States, the Association of American Medical Colleges administers a questionnaire to all graduating medical students. This comprehensive questionnaire examines all aspects of the students' educational experience. In 2019, 16,657 students responded to the questionnaire [16].

This survey reports that 89% of medical students are satisfied with the quality of their medical education. In terms of the integration between the foundational sciences in the clinical sciences, only 75% of students felt that basic science coursework provided enough illustrations of clinical relevance, while 80% of students felt that clinical experiences integrated basic science content. Together these three questions highlight the importance of bridging the gap between the foundational and the clinical sciences.

The graduation questionnaire also reveals that is spite of a wide variety of curricula and instruction formats (table 1), 90% of students feel that their study of physiology provided a good or excellent preparation for the clinical clerkships. This ranking has remained remarkably consistent over the past five years (table 2)

Table 2: How well did your study of Physiology prepare you for the clinical clerkships and electives?

Graduation year	Poor	Fair	Good	Excellent
2019	2.2%	8.0%	37.6%	52.2%
2018	2.1%	8.1%	37.0%	52.8%
2017	1.7%	7.5%	37.3%	53.5%
2016	1.6%	7.5%	37.1%	53.9%
2015	1.8%	7.4%	37.3%	53.6%

Data from the 2019 AAMC Graduation Questionnaire [16].

A similar question is asked for 14 of the foundational science disciplines. Among that 14, pathophysiology (ranked 1), and physiology (ranked 3) were regarded as a strong preparation for clinical clerkships and electives. Students have a very high regard for normal physiology and for the abnormal physiology reflected in the pathophysiology courses. In this ranking, the clinical skills course (ranked number 2) was the only course held in equally high regard as preparation for the clinical clerkships.

Four Actions to Support the Teaching of Physiology.

The outcomes data collected at the national level indicate that the discipline of physiology is healthy even as curricula and teaching formats evolve away from the lecture driven standalone physiology course. Our goal in advancing physiology education is not to advocate for return to the teaching of the 1950s, but rather to ensure that physiology supports the curriculum for the next generation of physicians. The current trends in medical physiology teaching provide insights into four steps that can be taken to strengthen physiology instruction.

1. Move beyond knowledge to other competencies. Knowledge transmittal is no longer the only goal of instruction. For physiology to flourish, instructors must incorporate and evaluate other competencies as key components of their teaching. This involves incorporating more student-centered learning environments [17, 18].

2. Emphasize illustrations of clinical relevance in physiology teaching. Knowledge is contextual, and students will be able to better remember and apply the logic of physiology when those relationships are highlighted for them in the format where they will be next encountered [19].
3. Work with clinical faculty to integrate physiological mechanisms in clinical descriptions. Collaborating with clinicians regarding how and what physiology is key to their practice will insure that the clinical illustrations are accurate and relevant to the current practice of medicine [20].
4. Align content to residency expectations. Medical education is a continuum, and physiology instruction must support the curriculum goal of producing competent, caring physicians [21].
Physiology, the study of normal body function, is a key component in life science education. Our role as instructors is to ensure that we design the most effective learning environment possible for our students, become experts in facilitating student learning, and ensure that the assessment challenges the students to mechanistically understand clinical problems.

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