Integrating Basic Science in the Clerkships: Innovative Strategies and Persistent Challenges

Michelle Daniel, MD, MHPE, Vice Dean for Medical Education, UCSD Former Assistant Dean for Curriculum, U of M



Strategies From 11 U.S. Medical Schools for Integrating Basic Science Into Core Clerkships

Michelle Daniel, MD, MHPE, Gail Morrison, MD, Karen E. Hauer, MD, PhD, Arnyce Pock, MD, MHPE, Christine Seibert, MD, Jonathan Amiel, MD, Molly Poag, MD, Nadia Ismail, MD, MPH, MEd, John L. Dalrymple, MD, Karin Esposito, MD, PhD, Cathleen Pettepher, PhD, and Sally A. Santen, MD, PhD



Abstract

Calls for curricular reform in medical schools and enhanced integration of basic and clinical science have resulted in a shift toward preclerkship curricula that enhance the clinical relevance of foundational science instruction and provide students with earlier immersion in the clinical environment. These reforms have resulted in shortened preclerkship curricula, yet the promise of integrated basic science education into clerkships has not been sufficiently realized because of barriers such as the nature of clinical practice, time constraints, and limited faculty knowledge. As personalized medicine requires that physicians have a more nuanced understanding of basic science, this is cause for alarm. To address this problem, several schools have developed instructional and assessment strategies to better integrate basic science into the clinical curriculum.

In this article, faculty and deans from 11 U.S. medical schools discuss the strategies they implemented and the lessons they learned to provide guidance to other schools seeking to enhance basic science education during clerkships. The strategies include programlevel interventions (e.g., longitudinal sessions dedicated to basic science during clerkships, weeks of lessons dedicated to basic science interspersed in clerkships), clerkship-level interventions (e.g., case-based learning with online modules, multidisciplinary clerkship dedicated to applied science), bedsidelevel interventions (e.g., basic science

teaching scripts, self-directed learning), and changes to formative and summative assessments (e.g., spaced repetition/ leveraging test-enhanced learning, developing customized examinations). The authors discovered that: interventions were more successful when buy-in from faculty and students was considered, central oversight by curricular committees collaborating with faculty was key, and some integration efforts may require schools to provide significant resources. All schools administered the United States Medical Licensing Examination Step 1 exam to students after clerkship, with positive outcomes. The authors have demonstrated that it is feasible to incorporate basic science into clinical clerkships, but certain challenges remain.

ISSN: 1040-1334

Teaching and Learning in Medicine

An International Journal



Groundwork

Students' perspectives on basic and clinical science integration when Step 1 is administered after the core clerkships

Jacquelyn B. Kercheval, Nicole M. Mott, Eric K. Kim, Christy K. Boscardin, Barbie A. Klein, Karen E. Hauer, Michelle Daniel



Objectives

- Discuss the rationale for integration & potential impacts on learning
- Outline instructional & assessment strategies to promote integration of the foundational sciences during clinical clerkships
- Review student perspectives on integration, including barriers and facilitators

Compartmentalization of Knowledge

Failure to Transfer into Practice

Basic Sciences

Clinical Sciences



"With so much emphasis on integrating basic science courses or extending clinical experiences earlier into a curriculum, extending basic science content into the clinical years has been a challenge and a major shortcoming of integrated curricula." (Schmidt 1998)



Defining Integration



Curricular Integration





Harden's ladder



Strategies to drive integration during clerkships



Program level interventions



Clerkship level interventions





Strategies Used by 11 U.S. Medical Schools to Integrate Basic Science Into Core Clerkships												
		Medical schools										
Strategies	U	U N	P UC	SF U	SU	VU	UW	CU	NYU	BC	HMS	FIU
Program-level interventions	\wedge											
Transition-to-clerkship courses	х					Х			Х		Х	
Longitudinal sessions dedicated to basic science during clerkships (e.g., full or half days weekly or biweekly)	х	Х	Х							Х		Х
Weeks of lessons dedicated to basic science interspersed in clerkships						Х		х				
Clerkship-level interventions												
Emphasizing basic science content in clerkship didactics (e.g., lectures, TBL, CBL, PBL, flipped classroom)	\leq	Х	Х	Х		Х	Х	Х	Х	Х	Х	X
Case-based learning with online modules							Х					
Multidisciplinary clerkship dedicated to applied science	Х											
Bedside-level interventions												
Basic science teaching scripts	Х											
Self-directed learning				Х						Х		Х
Assessment strategies												
Formative assessments												
Clinical science inquiry mobile platform									Х			
Basic science questions related to identified weaknesses sent directly to students				Х								
Access to question banks (purchased by students or institutions)	Х	Х	Х	Х		Х	Х	Х	Х	Х	Х	X
Summative assessments												
Customized NBME exams							Х		Х			
CBSE	Х		Х									
USMLE Step 1 exam administered postclerkships	X	Х	Х	Х		Х	Х	Х	Х	Х	Х	X
	V											



Program level interventions

- Multi-week transition to clerkship courses focused on integrating basic / clinical science applied to patient care
- Longitudinal ½ or full day sessions, weekly or bi-weekly, dedicated to basic science
- Week-long science intensives interspersed between clerkships



5-week transition course or "bootcamp" provides opportunities for review of basic science content previously covered in the curriculum and provides context through clinical integration in anticipation of patient care. Subject areas include anatomy, pharmacology, (patho)physiology, pathology/laboratory medicine and clinical epidemiology.

	Consolidate knowledge and skills from pre-clerkship curriculum				
Course Level	Review content areas from pre-clerkship curriculum with focus on clinical applications.				
	Apply foundational knowledge to clinical medicine.				
Objectives Focused on	• Demonstrate ability to apply analytical skills focusing on inductive reasoning in the application of knowledge to develop relevant differential diagnoses (DDx), and an initial care plan for common clinical presentations.				
Science	Describe basic concepts relevant to care of patients, including use of medical literature to support clinical care; use of clinical tests, EKG, US, radiology; clinical anatomy; addiction medicine; non-adherence; professional boundaries; clinical pharmacology; and clinical written and oral communication.				
	Clinical case-based instruction provides direct clinical application and immediate relevance				
	• Teaching faculty from pre-clerkship courses provides continuity and familiarity of material.				
	• Subject matter mix might include 60-70% review of old/prior content and 30-40% new content.				
Pedagogy Tailored to Subject Material	 Small group, interactive sessions with 8-10 students per faculty facilitator are most effective (e.g. anatomy, EKG/physiology, clinical epidemiology). 				
	• Large group, lecture-based sessions can be helpful for review and dissemination of new content or large volume of material (e.g. pharmacology).				
	• Simulation sessions provide opportunities for clinical context (e.g. anatomy, physiology, pharmacology).				
	 Case-conference provides integration of multiple areas (e.g. critical thinking, DDx, application of (patho)physiology, pathology, laboratory medicine, clinical epidemiology, pharmacology). 				
	Readiness assessment questions prior to small group sessions				
Accossmont	 Formative feedback during small group sessions, simulation exercises and case-presentations 				
Assessment	 Pre- and post-course multiple choice examinations (faculty-developed or commercially-available) 				
	 Evaluation through completion of post-session and post-course surveys and questionnaires 				

University of California, San Francisco School of Medicine



Clerkship level interventions

- Emphasizing basic science content in clerkship didactics
- Case-based learning with online modules
- Multidisciplinary clerkship dedicated to applied science









Surgery and Applied Science Clerkship (Pathology, Radiology, Anatomy, Anesthesiology)

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Surgery and Applied Science Clerkship

As one of the clerkships, M2s spend 12 weeks on SAS, broken into three four-week blocks encompassing: general surgery, general surgery specialties and applied sciences (anatomy, anesthesia, pathology, and radiology). The order of the blocks varies for each student. The reduced clinical workload during the applied science component allows students to have a period of more focused study to review basic science concepts and to study for their surgery shelf.

G	General Surgery 4 weeks	General Surgery Speci 4 weeks	alty App	lied Sciences 4 weeks
	Anatomy	Anesthesia	Pathology	Radiology
Objectives	 Investigate foundational anatomy Correlate to common pathologies 	 Describe anesthesia, analgesia, amnesia, akinesis, autonomic areflexia, and anxiolysis Apply fundamentals of cardiopulm physiology & pharmacology to intra-operative diagnosis and management Outline mechanisms of action of analgesic meds used in the management of pain 	 Review normal organ histology and disease entities on pathology specimens Explain purpose, value, appropriate indications and limitations of a hospital or forensic autopsy Describe how pathology links to clinical care 	 Review principles of diagnostic imagery: cardiothoracic radiology, abdominal radiology, neuroradiology, and MSK radiology Interpret routine clinical imaging Observe procedures
Pedagogy	 Pre-work: complete lectures, quizzes and training videos on dissection prior to lab Hands-on: dissection in anatomy lab Discussion: clinical cases 	 Pre-work: review Canvas modules specific to each day's topic (cardiopulmonary physiology, pharmacology, analgesia, resuscitation & bleeding) Hands-on: ask questions of the operating room team while participating in cases 	 Pre-work: complete online modules (mdcases.net) and review of associated clinical guidelines Hands-on: Observe an autopsy; Participate in clinical sign out (slide review) Discussion: small group case-based learning - microbiology, chemistry, diagnostic tests, blood bank 	 Pre-work: complete online modules and teaching case files Hands-on: interpret routine clinical imaging studies in radiology reading rooms Observe procedures with preceptors
Assessment	• Open resource, timed (60- minute), 30 multiple choice question examination with six image-based questions	• Readiness questions from workbook to prepare for participation in OR (e.g., Pulse Oximetry: Why is it important; How does it work; What affects its accuracy and reliability?)	 Nine Pathology Modules with embedded multiple choice and short answer questions (mdcases.net) 	 Weekly open book, online quizzes Evaluation by radiologists based on professionalism, medical knowledge, clinical reasoning, engagement and preparedness

Bedside level interventions

Basic science teaching scripts



https://www.apgo.org/basicscience

• Self-directed learning

Assessment strategies

- Formative assessments
 - Clinical science inquiry mobile platform
 - Basic science questions related to identified weaknesses
 - Access to ? Banks (purchased by students or school)
- Summative assessments
 - Customized NBME exams
 - CBSE (comprehensive basic science exam)
 - USMLE Step 1 placed after clerkships





Objectives

- Make connections between pre-clerkship basic sciences and clinical care that they deliver to their patients during clinical clerkships.
- Support longitudinal learning without taking away from bedside and team learning during clerkship education.
- Provide just-in-time basic science concepts in a quiz format with clinically-relevant context.
- Support continuous quality improvement of the longitudinal basic science curriculum based on feedback.

Pedagogy

- Mobile-friendly, just-in-time Clinical Science Inquiry (CSI) tool e-mails students
 2-3 clinically relevant basic science questions every week during their clerkships, according to their clerkship schedule
- Content is delivered directly to a learner's phone
- Questions begin with a clinical vignette
- High-quality graphical elements are included
- Leverages spaced repetition and testing effects
 - Start the CSI by clicking on the 1st question imbedded in the email
 - Answer the question
 - See the result and feedback
 - Read the explanations about the correct and incorrect answers

Assessment

- Formative
- Mandatory
- Completion is tracked by clerkships



Spaced repetition of assessment

- Homegrown (USUHS)
- Commercial platforms, e.g.









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Post-Clerkship Administration of USMLE Step 1

Moving the United States Medical Licensing Examination Step 1 After Core Clerkships: **Effects of Moving the United States Medical** Licensing Examination Step 1 After Core Clerkships on Step 2 Clinical Knowledge Performance

Daniel Jurich, PhD, Sally A. Santen, MD, PhD, Miguel Paniagua, MD, Amy Fleming, MD, MHPE, Victoria Harnik, PhD, Arnyce Pock, MD, Aubrie Swan-Sein, PhD, EdM, Michael A. Barone, MD, MPH, and Michelle Daniel, MD, MHPE

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schools undergoing curricular reform are

reconsidering the optimal timing of Step

1. This study provides a psychometric

investigation of the impact on United

States Medical Licensing Examination

Step 1 scores of changing the timing of Step 1 from after completion of the basic

Science curricula to after core clerkships.

Data from four schools that recently

moved the examination were analyzed in

a pre-post format using examinee scores

I from three years before and after the

change. The sample included scores from

2008 through 2016. Several confounders

Amy Heming, MD, MHPE, Victoria Harnik, PhD, Arnyce Poch Aubrie Swan-Sein, PhD, EdM, Michael A. Barone, MD, MPH and Sally A. Canton MD, PhD

An Outcomes Analysis

and sally A. santen, MD, PhD

Abstract

To investigate the effect of a change in the United States Medical Licensing Examination Step 1 timing on Step 2 Clinical Knowledge (CK) scores, the effect of lag time on Step 2 CK performance, and the relationship of incoming Medical College Admission Test (MCAT) score to Step 2 CK performance pre and post change.

Method

Four schools that moved Step 1 after core clerkships between academic years 2008-2009 and 2017–2018 were analyzed. Standard t tests were used to examine the change in Step 2 CK scores pre and post

Teaching and Learning in Medicine An International Journal ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com//oi/htlm20 Does Delaying the United States Medical Licensing UDES Delaying the United States Wedical Licer Examination Step 1 to after Clerkships Affect Student Derformance on Clerkship Subject Examination Step 1 to anter Clerkship Subject Student Performance on Clerkship Subject Daniel Jurich , Michelle Daniel , Karen E Hauer , Christine Seibert , Latha Chandran , Arnvce R. Pock , Sara B. Fazio , Amy Fleming & Sally A. Santen Daniel Jurich , Michelle Daniel , Karen E Hauer , Christine Seibert , Latha Chandran , Arnyce R. Pock , Sara B. Fazio , Amy Fleming & Sally A. Santen to this article: Daniel Jurich, Michelle Daniel, Karen E Hauer, Christine Seibert, Latha Examinations? R. Pock, Sara B. Fazio, Amy Fleming & Sally A. Santen (2020): Does d States Medical Licensing Examination Step 1 to after Clerkships Affect Student

Routledge Taylor & Francis Group

USMLE STEP 1

What happens to scores?

What happens to failure rates?

Descriptive Statistics, Aggregated Across Four Study Schools, Relative to Implementation of a Curricular Change to Administer the United States Medical Licensing Examination Step 1 After Core Clerkships

Cohort relative to			Mean difference	
implementation ^a	No. of students	Step 1 score, mean (SD)	from national average, (SD difference score)	Fail rate
-3	548	230.09 (20.94)	6.38 (20.84)	3.83%
-2	566	229.75 (19.79)	5.08 (20.04)	2.12%
-1	554	230.03 (19.71)	3.61 (20.25)	2.71%
1	538	236.86 (17.44)	7.70 (17.63) 6.8	0.74%
2	536	238.36 (17.09)	8.89 (17.09)	0.19%
3	455	236.25 (17.00)	adjusted 6.64 (16.95)	0.22%

^aThe -3 cohort represents three years prior to exam timing requirement change, -2 represents two years prior, and so forth. Cohorts took the Step 1 exam between 2008 and 2016.

USMLE STEP 2

What happens to scores?

What happens to failure rates?

Descriptive Statistics, Aggregated Across Four Study Schools, Relative to Implementation of a Curricular Change to Administer the United States Medical Licensing Examination Step 1 After Core Clerkships

Cohort Relative to Implementation ^a	Number of students	Step 2 CK Score Mean (SD)	Mean Difference from national average (SD difference score)	Fail Rate
-3	537	238.51 (20.08)	3.16 (20.44)	1.9%
-2	558	239.58 (18.26)	1.64 (18.35)	1.4%
-1	542	241.39 (17.63)	2.03 (17.69)	2.2%
1	534	243.63 (16.17)	3.56 (16.33)	1.9%
2	530	244.58 (16.11)	3.45 (16.33)	1.5%
3	498	244.21 (15.99)	2.12 (16.04)	2.0%

Abbreviations: N indicates number of students; Step 2 CK indicates the United States Medical Licensing Examination Step 2 Clinical Knowledge; SD indicates standard deviation

No significant differences

Clinical Subject Exam Scores

What happens to CSE scores?



Shelf scores decrease an average -1.1 points

Medicine & Neurology decrease the most

OB-GYN and Psych are unchanged

Performance on clerkships taken earliest in the sequence are most affected & differences gradually disappear with subsequent examinations



Cognitive Integration



ISSN: 1040-1334

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"I just felt [these sessions] were so irrelevant to what we were doing [on clerkships]. I ... thought, 'I'm never going to use this. There's no way that this is relevant to anything I'll ever do in my whole life.'"

"It's just sort of forcing basic science down your throat."

"It did not translate very well for me because it ended up being, you know, a very knowledgeable person, like a PhD, talking in depth about a particular topic, really going into the clinical trials and, you know, the possible proteins that could be involved. And I didn't think it was as effective as I wish it had been."

Clerkship didactics or bedside teaching

"We had one patient who was admitted for anorexia... So my attending just asked... me and my co-med student to look into the pathophysiology behind refeeding syndrome and why we give thiamine and glucose in a certain order... And then... he also brought up the whole Krebs cycle and all of that, which I never thought would ever come up beyond Step 1 or on clerkships at all, but he kind of tied it together and said, 'Oh yeah, because thiamine is the co-factor.' ... So, that was one example in which the pathophysiology and the actual basic science concept behind it was especially relevant. And it was actually effectively integrated into my learning."

Clerkships with "applied science"

"What I did think was probably the most helpful from a basic science perspective during clinical year was during our surgery clerkship, we rotate... a week with pathology, a week with anesthesiology, a week with radiology, a week with... anatomy. Particularly for the pathology and the anesthesiology... you relearn how to interpret histology, which I think is a really good basic science skill that shows up on Step 1. And then in anesthesiology it's a really strong focus on physiology, which also relates more to basic science. Also, pharmacology too. And so you are forced to learn a lot of the basic science in those rotations."

"I did a peds heme-onc rotation, and that I think was where I got a lot of basic science with the chemotherapy regimens. 'Cause you really need to know, okay, what are we targeting? What are the side effects and why? And what kind of, you know, preinduction workup do we need to do for this kid?"



USMLE Step 1 after clerkships

"It was sort of difficult to encode all the knowledge given to us in our pre-clerkship curriculum. There's just too much over a very short period of time. And I felt like I was entering clinical year with pretty little basic science baggage, kind of really wobbly knowledge."

"I really liked how I was able to come back and synthesize my clinical knowledge with my basic science knowledge. I don't believe you would get that as much if you did all your basic science, took Step 1, and then moved on to clinical medicine."

"I think that there are some clear benefits related to learning with clinical context, and then being able to take basic science in it and put that into that framework. I think that helps with my retention of that information." Compartmentalization

Barriers to integration

- Tenuous basic science foundation
- Cognitive overload and competing demands on time
- Basic science perceived as irrelevant to clinical care
- Educators focused on teaching clinical science
- Longitudinal basic science curriculum irrelevant to clinical care

Facilitators of integration

- Basic science instruction explicitly linked to patient care
- Sub-specialties / disciplines that demonstrate direct application of basic science to clinical care
- Post-clerkship dedicated Step 1 study period as opportunity to revisit basic science with new clinical foundation

Integration

Summary

- Integration overcomes compartmentalization of knowledge and facilitates transfer into clinical practice.
- The ultimate goal of curricular integration is cognitive integration.
- Strategies to integrate basic science in the clerkship include program-, clerkship- and bedside-level interventions, as well as assessment strategies.
- Students emphasized the value of explicit bedside basic science teaching directly linked to patient care over longitudinal returns to basic science that pull learners off clerkships.
- A post-clerkship dedicated Step 1 study period is an ideal opportunity for cognitive integration once a clinical foundation is established.



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