

## Learning through Osmosis: A collaborative platform for medical education

### Authors

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### Abstract

Formative assessment has been shown to improve medical student performance and retention, but many learners lack access to formative assessments because faculty members have limited time to create such resources, and acquiring existing commercial review banks is expensive. In response, we developed a collaborative learning platform for medical student self-assessment called Osmosis (<http://osmosis.org/>). Osmosis is a web- and mobile-learning platform that provides free access to thousands of crowd-sourced, high-yield practice questions and explanations. The quality of these questions and resources is enhanced through a unique social rating and commenting feature.

During the first year Osmosis was launched at the Johns Hopkins School of Medicine in January 2012, approximately 250 students in the first and second

year classes spent over 2,400 hours answering more than 5,000 questions close to half-a-million times (~2,000 questions answered/student). In addition, over 1,000 Creative Commons-licensed images and YouTube videos have been shared. Usage data and reception by students indicate that the platform fits well into busy schedules and that participants value its role in promoting collaboration and self-assessing knowledge gaps.

We are currently developing additional features for the Osmosis platform related to knowledge retention and curricular design. Since the vast majority of questions and resources on Osmosis are shared under non-restrictive licenses, such as Creative Commons, we are making Osmosis available to peer institutions. It is our hope that more students and faculty members will benefit from, and contribute to, the Osmosis library.

### Keywords

content spacing; crowdsourcing; curricular design; education technology; medical education; mobile; retention

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## Osmosis: A collaborative learning platform

Medical school is characterized by frequent summative testing meant to assess basic competency at each stage in a student's training. Some medical schools offer these preclinical assessments on a weekly basis, while others hold examinations only at the culmination of each block, which may be as long as four-to-eight weeks. For many students this latter approach leads to cramming behaviors that are counterproductive to long-term retention<sup>1</sup> and may lead to a reduced level of understanding.<sup>2</sup> In response, some medical school education committees or individual professors have implemented formative assessments as a way of encouraging students to pace themselves,<sup>3</sup> which has been shown to lead to improved retention rates.<sup>4</sup> Unfortunately, as with many interventions, the expense associated with this form of enrichment can be significant in terms of both time and money. This is especially true in the acquisition of a distinct set of formative practice questions that are of comparable quality to those on the summative assessments. In this paper we describe a medical student-developed solution to this problem: a collaborative learning platform for medical education called Osmosis (<http://osmosis.org/>).<sup>5</sup>

Conceptualized at the Johns Hopkins School of Medicine in 2011, Osmosis aimed to address the needs of medical students and faculty alike. Students desired additional resources and practice questions that would help them self-assess in preparation for the summative examinations, notably the United States Medical Licensing Examination. Many faculty expressed a desire to provide formative assessments as a benchmark of student progress, but between clinical and research duties were often unable to devote the time required for *de novo* creation of such resources. In addition, neither students nor administrators had the budget to devote to commercial resources and question banks that students could access beginning on the first day of medical school. Though students often spend hundreds or even thousands of dollars each on these "extracurricular" resources – a practice that has been criticized as contributing to student debt without adding value<sup>6</sup> – this expensive behavior is generally reserved for the weeks immediately prior to the licensing exams. When Osmosis was first conceived, a large, openly-available, and high-quality

resource and question bank that could be integrated throughout the preclinical curriculum for formative self-examinations did not exist.

Osmosis was formed from the realization that many medical students create detailed and often high-quality resources — notes, flash cards, tables, mnemonics, and diagrams — that are either not shared, or shared using educationally ineffective mediums, such as list e-mails, file sharing programs, or social media posts. These sharing modalities do not enable content to be improved by the group through rating, commenting, and editing, nor can content be easily indexed and searched. In response to this, we (Haynes and Gaglani) designed a web-based solution from the ground-up that would facilitate the peer-to-peer diffusion (hence "Osmosis") of resources, beginning with student-created practice questions. There were two reasons for initially focusing on crowd-sourcing practice questions: first, questions are high-yield resources in terms of promoting knowledge retention via the Testing Effect<sup>4,7</sup>; second, it has been shown that the process of constructing question stems, choices, and explanations helps students learn and retain more information,<sup>8</sup> and that students are capable of producing high quality questions.<sup>9,10</sup>

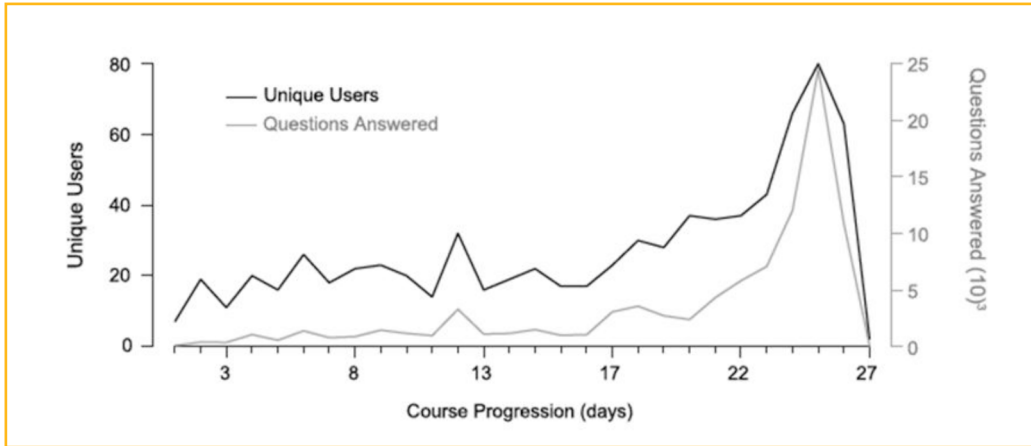
### The Osmosis website

The site went live to the first year medical students at Johns Hopkins (Class of 2015) in January 2012, and over the first year experienced higher-than-anticipated usage (Table 1): among the 120-person class, 43 students contributed a total of 3,818 practice questions with accompanying explanations that the entire class answered 256,017 times. Within two months of launching the platform, students at NYU, University of Pennsylvania, and Columbia had contacted us to use the system, and by mid-March we made Osmosis available to students at the Hopkins-affiliated Perdana University Graduate School of Medicine in Malaysia.

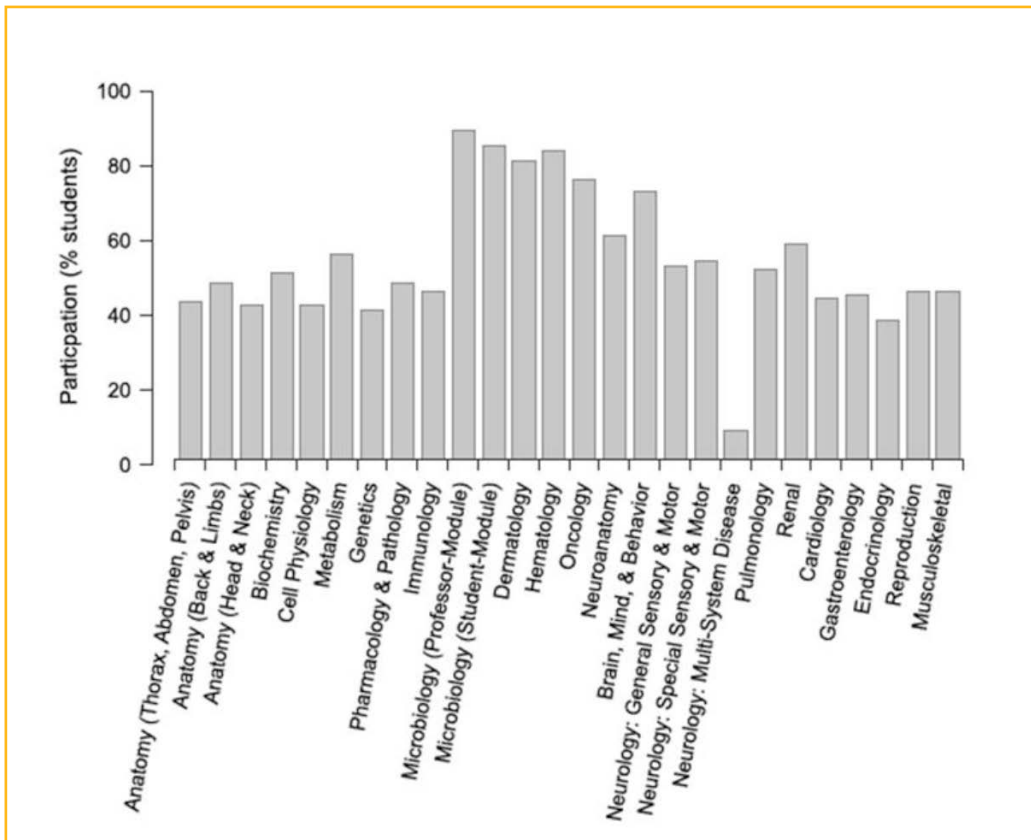
In Fall 2012, the new class of Hopkins medical students started using the platform. Figure 1a shows the number of users per day in the first-year class (Class of 2016) and how many questions they answered during the infectious disease/microbiology block. Figure 1b shows the average participation in consecutive curricular blocks by both medical school

Class Year	Module* on Osmosis	# Users	% of Class	Usage				Contribution				
				Total Questions Answered	Average Quest/User	Total Hours	Average Min/User	# Contributors	% of Class	Questions	Images	Videos
2015	Immunology	24	20%	1529	63	—*	—*	5	4%	224	1	—*
	Class entered in August 2011 and completed the preclinical curriculum in March 2013. These are all of the Genes to Society (GTS) modules offered from 1/12 to 3/13	116	97%	11680	100	—	—	1	1%	120	0	—
	Microbiology (Professor-Module)	102	85%	79577	780	—	—	9	8%	1012	27	—
	(Student Module)	102	85%	21194	207	—	—	12	10%	236	29	—
	Dermatology	102	85%	37012	362	135	135	15	13%	361	7	—
	Hematology	86	72%	21377	248	110	110	16	13%	369	33	—
	Oncology	73	61%	8838	121	68	68	14	12%	135	101	—
	Neuroanatomy	88	73%	11556	131	56	56	11	9%	125	9	—
	Brain, Mind, & Behavior	64	53%	11791	184	77	77	10	8%	137	6	—
	Neurology: General	65	54%	11065	170	74	74	12	10%	226	55	77
	Neurology: Special	9	8%	162	18	10	10	7	6%	47	25	8
	Sensory & Motor	62	52%	11944	192	91	91	18	15%	171	70	13
	Neurology: Multi-System Disease	71	59%	6815	95	66	66	7	6%	106	35	35
	Pulmonology	53	44%	3372	63	39	39	7	6%	74	47	75
	Renal	54	45%	6206	114	59	59	5	4%	0	61	102
	Cardiology	45	38%	4024	89	51	51	7	6%	157	27	71
	Gastroenterology	55	46%	5234	95	54	54	5	4%	113	60	83
	Endocrinology	55	46%	2641	48	21	21	5	4%	121	51	20
	Reproduction	120	46%	256017	2133	541	541	43	36%	3818	644	490
	Musculoskeletal											
	Overall Med15											

Table 1. Osmosis usage and contribution statistics among the Classes of 2015 and 2016 at Hopkins School of Medicine



**Figure 1a.** Number of users per day in the First Year Class (2016) and number of questions they answered during the Infectious Disease/Microbiology Block.



**Figure 1b.** The average participation in consecutive curricular blocks by both medical school classes that have used Osmosis.

classes that have used Osmosis. In total, around 250 Osmosis users have spent over 2,400 hours answering more than 5,000 questions close to half-a-million times (~2,000 questions answered/student).

The exam was held on day 27, and there is a characteristic spike in usage the weekend before the exam (days 24 and 25). More than 80 students logged in on day 25 and answered the practice questions nearly 25,000 times that day. Left axis represents unique users; right axis represents the number of questions answered.

Participation was measured as the percentage of students in the Johns Hopkins School of Medicine classes of 2015 and 2016 who answered practice questions using Osmosis. Curricular blocks are shown on the horizontal axis.

As Osmosis has gained popularity we have added features based on student, faculty, and administrator feedback. The platform now includes a variety of practice question formats (multiple choice, multiple checkbox, true/false, label matching, fill-in-the-blank, and flashcards) and resources (open access images and videos, lecture slides and recordings, mnemonics and article links, etc). Figure 2a shows the slide and lecture-viewer interface that encourages students to share resources and write practice questions as they go through the course material and take notes. There are now over 750 images and 500 videos supplementing the practice questions and lecture slides. The quality and usefulness of the content is improved through our rating, editing, and commenting system that allows users, for example, to add mnemonics, rate a question's learning value, and ask for a peer to clarify a concept. Figure 2a is a screenshot of the Osmosis document-viewer interface. On the left students can view documents (PowerPoints and notes), as well as stream lecture recordings at varying speeds. On the right students can take notes to which they can attach images and videos. In this example, a video on "USMLE algorithms for diabetes mellitus" has been shared and shows up under the resources tab. The questions tab indicates that two practice questions have been created for this particular slide in the lecture. By integrating the document viewer with the question and resource contribution interface we have incentivized their submission.

In addition, almost two-dozen faculty members have signed on to intermittently add their own ratings and comments, or even content, to help improve the learning platform. Figure 2b shows a practice question written by the instructor of the microbiology block that was commented on to include a mnemonic and edited to include a chest x-ray showing lobar pneumonia and video explaining the optochin test for *S. pneumoniae*.

Figure 2b demonstrates a practice multiple choice question written by the course director of the microbiology block. The correct answer is shown in bold. A student has edited the question to include an image of lobar pneumonia, as described in the question stem, and an explanatory video about the Optochin test for *S. pneumoniae*. The rating bar can be seen on the top right. At the bottom a student has added a comment — in this case, by posting a mnemonic for *Streptococci* that are sensitive or resistant to Optochin.

### Earlier online collaborative medical education platforms

Osmosis is not the first online collaborative medical education platform. As early as 2002, the University of Michigan Department of Obstetrics and Gynecology reported using a program called Test Pilot (now APGO's paid uWise service) to develop and deliver practice questions for self-assessment,<sup>11</sup> and Wayne State University's School of Medicine had a student-developed question bank called Exam Source that appears to not have been updated since 2011. Many medical schools, such as the University of Minnesota, also have "wikis" that allow students to share notes and learn socially.<sup>12</sup> Furthermore, this concept is not new to the private sector: now-defunct commercial entities such as WikiTestPrep and Kevada focused on the creation or aggregation of questions and resources, respectively. Why have so many of these online platforms failed to gain traction broadly or even to achieve permanence at their own institutions? Rasmussen and colleagues<sup>12</sup> have enumerated the potential hurdles to successful implementation of web-based collaborative tools for medical education. Based on our experience with Osmosis, we added several others: quality control, technical challenges, setup and maintenance costs, user engagement issues, accessibility concerns, the need for oversight, and the flattening of traditional hierarchies.

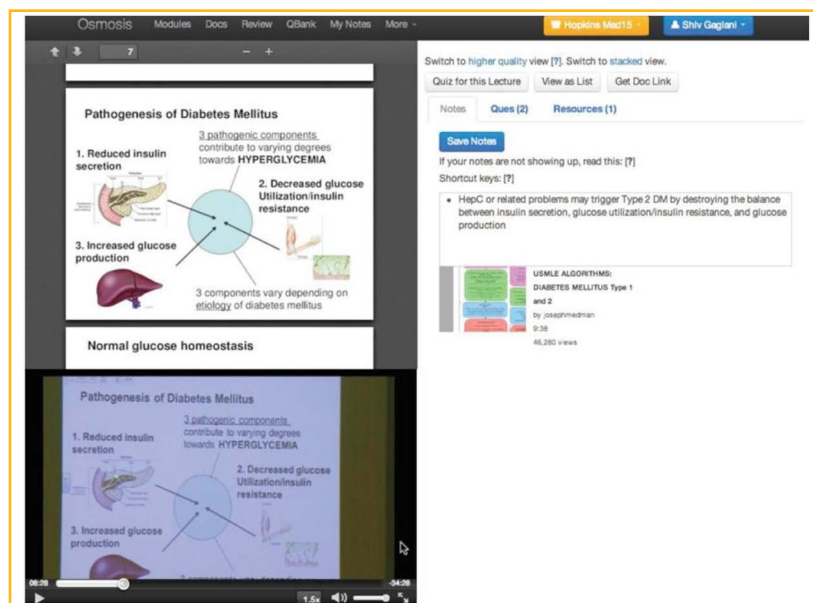


Figure 2a. Slide and lecture-viewer interface.

## Lessons learned

In addressing these issues, we have learned a number of lessons. First, student engagement on a social learning platform depends primarily on four factors: educational effectiveness, content quality/diversity, platform interface, and peer influence. The most popular content modules were those that featured questions written by faculty, since those were perceived as most appropriate for exam preparation. In addition, many users found the diversity of content medium (text, pictures, video, etc.) to be helpful in order to best understand concepts (this is likely a function of different preferred learning styles). We found that between 2–17 percent of students contributed to any given module, but in aggregate more than 40 percent of the Class of 2016 contributed at least one question or resource to the platform (Table 1). When these contributors were asked about their motivations, the top two reasons provided were: (1) the process of generating or even aggregating content helped them learn better, supporting the findings of the papers cited above; and (2) they wanted to help their classmates and younger peers by providing their resources in a more permanent medium. Of note, these reasons are in line with those given for the success of Wikipedia.<sup>13</sup>


Students who did not contribute cited time constraints, fear of being judged by peers, and learning styles that did not place value on answering practice questions. However, many of these non-contributing students improved the database by rating and commenting on the questions. Their involvement may, in part, be attributed to the Osmosis platform interface, which was designed to be intuitive and mimic websites familiar to the students. For example, while only registered institutional students were provided access to the database, they were given the option to log in subsequently using their Google or Facebook accounts, thus lowering the barrier to using the platform. Peer influence was the third key factor because medical students are risk averse in terms of adopting new resources that may or may not be useful for their performance on coursework, licensing exams, or the wards; as with any technology adoption cycle, there are early and late adopters, though the medical student population may be skewed to the latter.

Another lesson is that faculty engagement depends on each individual professor's time constraints and educational priorities. We have been fortunate to have a number of highly engaged course directors who are interested in the insights that




osmosis Modules Docs Review QBank My Notes More

A patient presents with shortness of breath, cough, and fevers. A chest x-ray (below) is consistent with lobar pneumonia. A sputum Gram's stain demonstrates gram positive diplococci. Which of the following characteristics would you not anticipate to occur with the causative organism?



1. Beta hemolysis
2. Capsule
3. Cytotoxin production
4. Optochin inhibition
5. Quellung reaction

The patient most likely has *Streptococcus pneumoniae*. *S. pneumoniae* is not beta hemolytic, all other characteristics are anticipated to occur. The video below shows the Optochin test for *S. pneumoniae*, which is sensitive.



Optochin test for Strep pneumoniae by markmicrobiology 0:48 5,161 views

Pending Group Approval · Comment · Edit · Clone · Retire · Created last year

Shiv Gagiani posted a mnemonic  
*S. pneumoniae* can be distinguished from other alpha-hemolytic strep through the Optochin test. A mnemonic is "OVRPS" (Optochin - Viridans Resistant, Pneumoniae Sensitive)

Figure 2b. Microbiology Professor's practice question.

can be gleaned through Osmosis, such as student understanding on a per-lecture basis. Two key reservations that have been expressed by faculty and administrators include: (1) student opportunity cost in answering potentially low-quality, peer-created questions, and (2) the security of lecture material, as well as the official questions used on summative assessments. The first concern was addressed by showing professors the quality of the questions and explanations produced by students, as well as the literature not only asserting that answering questions is a high-yield activity for both retention and learning,<sup>14</sup> but also one to which students attribute to their improved performance.<sup>15</sup> The second concern was largely allayed by explaining that the Osmosis database structure allows private group sharing so that the only users who have access to professor's lecture slides, notes, and presentations are their own students. In terms of protecting the questions from summative assessments, all user-submitted content is tracked so if there were to be leaks, the user responsible could be readily identified. That being said, we encourage an open access approach to allow the greatest number of students to benefit from the collaborative content.

## Conclusion

The vast majority of questions and resources on Osmosis are shared under non-restrictive licenses, such as Creative Commons. As such, we are making Osmosis available to peer institutions; it is our hope that other students and faculty will benefit from and contribute to the Osmosis library. To promote this vision, Osmosis received a grant from the Robert Wood Johnson Foundation to crowd-source thousands of questions, images, videos, mnemonics, and other resources under open licensing.<sup>16</sup> This project has already brought together more than 250 medical students, residents, and faculty members from around the world.

We are simultaneously working on additional features, such as more in-depth data analytics that will provide insight on collective and individual student performance and learning behaviors; for example, we are now able to track when students watch lecture recordings and how they perform on questions linked to individual lectures, which may reflect how well they were taught or internalized the content. Finally, we are developing a spaced repetition engine that will push out review questions

on top of the Osmosis learning management system to help students better retain what they've learned through Osmosis. In summary, Osmosis is a collaborative learning platform for medical education that has shown that individual student contributions can be leveraged to create a massive database of useful content.

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## Appendix

*Supplemental Digital Content:* Video demo of:

Osmosis platform as of November 2013 —  
<http://vimeo.com/70522185>

Osmosis mobile app as of November 2013 —  
<http://vimeo.com/71287928>

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*Disclaimer:* None

*Previous Presentations:*

The Johns Hopkins Institute for Excellence in Education Annual Conference, 2012, Baltimore, MD.  
Top Poster-Abstract Award:  
[http://www.hopkinsmedicine.org/institute\\_excellence\\_education/Education\\_Conference/2012\\_Conference\\_Awards.html](http://www.hopkinsmedicine.org/institute_excellence_education/Education_Conference/2012_Conference_Awards.html).

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