

An Integrated Approach to Learning Anatomy, Physiology and Micro-Anatomy: A Clinician-Based System at Duke-NUS Graduate Medical School Singapore

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ABSTRACT

Faculty members from Duke-NUS Graduate Medical School Singapore (Duke-NUS) faced interesting challenges when developing a curriculum based on the Duke University School of Medicine's course. Given the short time frame to get the first year basic science courses set up and the desire to enhance the learning environment required some innovative learning approaches as well as creativity. After consultation with the Normal Body course directors from Duke, Durham, North Carolina, Duke-NUS Normal Body course directors embarked on a journey to create a pioneering course for Singapore while implementing some of the curricular enhancements desired by the Duke-NUS faculty.

Keywords: anatomy, clinician-based teaching, histology, integrated learning, normal body, physiology, student-centered learning, team-based learning

INTRODUCTION

Duke-NUS Graduate Medical School Singapore (Duke-NUS), established in 2005, resulted from a collaboration between Duke University School of Medicine (DSOM) from Durham, North Carolina, USA and the National University of Singapore (NUS). While the Yong Loo Lin School of Medicine (YLL) at NUS is based on the British MBBS model, the MD programme at Duke-NUS targets students with a first degree (bachelors or higher) who are interested in providing leadership in clinical specialisation, and translational medicine. The expectation was that Duke-NUS would implement the DSOM curriculum in Singapore with necessary regional adjustments, contextualisation, and best medical education practices.

The DSOM curriculum is unique even in the United States. In the 1960s the typical 2 year basic science instruction was compressed into 1 year, enabling students

to enter their clinical clerkships in their second year and providing approximately 11 months of dedicated research time, resulting in a thesis¹. Of the core courses in the first year, Normal Body (comprising of anatomy, physiology and micro-anatomy) consists of approximately 100 hours of dissection and lasts 11.5 weeks. These 3 topics are foundational subjects that are usually taught in medical schools in the first year. However, in the traditional model, still adopted by many medical schools, these components from Normal Body are often taught as separate academic subjects over a period of 6 to 12 months by basic-science academic staff.

One of the immediate challenges our new school faced was the short start-up time given to establish all of the elements of a medical school curriculum. The leadership of Duke-NUS had approximately 12 months to identify teaching faculty, learn and

understand the DSOM Normal Body course structure, train faculty on the key learning strategy, and procure resources (such as facilities, manikins, and cadavers). The purpose of this paper is to outline how Duke-NUS faculty members designed the Normal Body course, how it differs from DSOM, and provide preliminary results on student performance and student feedback.

DEVELOPING THE COURSE FACULTY

Duke-NUS is located adjacent to the Singapore General Hospital (SGH) which is the largest and most established teaching hospital in Singapore. SGH has a long history of teaching both undergraduate and graduate medicine and surgery and has many excellent clinician-teachers. These senior clinicians are specialist doctors who are intimately familiar with both the anatomical and physiological basis of their specialties and relevant clinical medical knowledge. Duke-NUS chose to capitalise on these clinicians' expertise and understanding of relevant aspects of anatomy and physiology and their ability to guide students to become excellent clinicians and clinician leaders.

FACILITIES

The inaugural class of 26 students at Duke-NUS matriculated in August 2007 and the first Normal Body Course started in October of the same year at the Duke-NUS interim facilities. Cadaveric dissections and other wet-lab activities are conducted in the well-equipped Clinical Skills Hall at SGH and the cadaver repository facilities in SGH. Because of the difficulty faced with acquiring sufficient high-quality cadavers for teaching, additional cadavers were imported from the United States to supplement the locally sourced teaching specimens.

CURRICULUM

As with all the first year Duke-NUS courses^{2,3}, one of the fundamental learning strategies involves the use of Team-Based Learning (TBL)⁴ for various aspects of the integrative learning sessions. The TBL approach includes working and learning in teams, using assessments to facilitate learning, and guided faculty interactions. TBL is conducted in a very structured manner and requires significant preparation time by both faculty and students. This is one of several aspects of the Duke-NUS Normal Body course that is different from the DSOM course, and will be described in detail later.

THE NORMAL BODY COURSE DESCRIPTION AT DUKE-NUS

Normal Body is 1 of 4 integrated courses and 2 additional content themes taught in the first year at Duke-NUS

and is conducted over 11.5 weeks from October to mid December. The aims of the Normal Body course are:

1. To establish a strong scientific foundation in anatomy, physiology and micro-anatomy relevant to the clinical practice of medicine;
2. To provide a broad conceptual and integrated base in these sciences to facilitate the further incorporation of new and evolving knowledge throughout an individual's clinical and scientific career;
3. To stimulate an integrated and analytical approach to resolving clinical and research problems based on firm scientific principles.

Four main features characterise the delivery of this course.

- The course is designed as an integrated and clinically-focused approach to the teaching of anatomy, physiology and micro-anatomy. The course cuts across the artificial boundaries of separating these subjects and presents the material in a way most relevant to future clinicians and clinician-scientists. It also facilitates cross-disciplinary applications.
- The course is taught primarily by practicing specialist clinician-teachers from 4 clinical institutions in Singapore. The clinical institutions are SGH, the National Heart Centre, the National Cancer Centre and Tan Tock Seng Hospital.
- The modules are integrated and clinically relevant. Each module benefits from the academic and clinical input of the content experts who are clinical practitioners and experienced teachers in the medical specialty relevant to that module. Content experts bring their clinical experience into the course and help orientate, integrate and focus the teaching of anatomy, physiology and micro-anatomy in a manner most useful to future medical practitioners. Data interpretation in an applied clinical context is emphasised, especially during the team-based learning sessions. This clinically oriented integrative approach is designed to permit students to put a large amount of important materials into a clinical context, thus making it more relevant.
- Use of TBL. The Duke-NUS uses an adaptation of TBL that is locally known as TeamLEAD (Learn, Engage, Apply, Develop). TeamLEAD is a highly structured team-based learning strategy, composed of

Table 1. Format of Normal Body Course.

Module	Beginning Module Quiz	Gross Anatomy Lab	Physiology Lab	Micro Anatomy Lab	Clinical Correlation	Team LEAD	End Module Quiz)
Body Segments	√	√		√	√	√	√
Cardiovascular	√	√	√	√	√	√	√
Respiratory	√	√	√	√	√	√	√
GI	√	√		√	√	√	√
Endocrine	√			√	√	√	√
Blood/Immunity	√		√	√	√	√	√
Reproduction	√	√		√	√	√	√
Renal	√	√	√	√	√	√	√
Upper/Lower Limbs	√	√			√	√	√
Head/Neck	√	√			√	√	√

3 phases: Pre-class preparation, Readiness Assurance, and Application.

- Pre class preparation: Under faculty direction, student review assigned material to come to class fully prepared to discuss and answer questions about key concepts.
- Readiness Assurance Phase. There are 2 components to this phase. The Individual Readiness Assurance (IRA) and Group Readiness Assurance (GRA). During this phase students are asked a series of multiple choice questions about the preparation work — first as an individual (IRA), then as a team (GRA) where the same test is repeated. In class, following the GRA, faculty facilitate a clarification discussion with the students.
- Application Phase. In the application phase, students are expected to apply what they have learned from their previous sessions to relevant laboratory and clinical case problems. This is an open-book, open-resource session.
- TeamLEAD enables the faculty to work with multiple groups of students, supports independent learning for the students, and enables the coverage of a significant amount of material efficiently in a time-effective and integrated manner^{5,6}. Most importantly, this educational methodology is designed to cultivate critical thinking

skills and develop the skills crucial to outstanding clinician leaders.

FORMAT AND METHODOLOGY

The content is organised and taught as 10 integrated modules (comprising body segments, spine, and principles of Homeostasis; Blood/immunology; Cardiovascular; Respiratory; Gastro-Intestinal; Renal and Retro-peritoneum; Endocrine; Reproduction and Pelvis; Upper and Lower Limb; Head and Neck) covered in 11.5 weeks. The course shares core content materials with the Durham course, but differs significantly as it is organised around clinically specific areas and not along traditional subject lines. While a large amount of material is covered in the course, the focus and emphasis of the course objectives is on materials that are most clinically relevant. Elements of Anatomy, Physiology and Micro-Anatomy are integrated in each of the modules through clinical correlation seminars and TeamLEAD sessions. Application of the basic sciences to clinical problem solving and data interpretation is emphasised during the application phase of the TeamLEAD sessions. Each module also capitalises on materials covered by the previous modules in order to bring linear integration. The components and delivery of each integrated module follows the format described below and in Table 1.

Students are assigned core content materials which they are expected to familiarise themselves with prior

to the commencement of the module. These are in the form of reading assignments and DSOM lectures. The formal module begins with a briefing of module learning objectives and planned activities by the module content expert and the course director at the beginning of each module.

Lab Work

Gross dissections laboratory sessions (n=21) relevant to the modules are usually carried out at the beginning of the modules. The dissection is supervised by the module content experts who are mainly practising consultant surgeons. The approach to the dissection differs significantly from traditional gross anatomy courses as these surgeon teachers approach the dissection in a surgically utilitarian manner. Besides being very time efficient, this approach exposes the students to anatomy in a manner most useful to future clinical practitioners.

Physiology practical lab sessions (n=6) in the module are also conducted by module content experts. Where relevant, the labs are integrated with the dissection and use simulation technology⁷ such as SimMan⁸ and BioPac (www.biopac.com) devices to reinforce key principles. The topics covered are: Arrhythmias and circulation (using SimMan); Cardiac function (using physical model); Spirometry (using Biopac), Oxygen transport and respiratory regulation (using SimMan); Immune system and blood typing (tutorial); Kidney function (tutorial), and regulation of extracellular fluid volume, acid-base and potassium balance (tutorial).

Micro-anatomy labs are conducted by the pathologists. These labs are also coordinated with the appropriate module and uses Bacus Virtual Microscopy⁹ to cover the coordinated materials to the module topics.

Interactive Seminars

Clinical correlation seminars also facilitated by module content experts, are important components of the module and are conducted after gross dissection and physiology lab sessions. These seminars relate anatomy and physiology to clinical materials provided by faculty with an emphasis on the integrated nature of the course and the application of course materials to clinical medicine and data interpretation.

TeamLEAD Sessions

TeamLEAD sessions similarly integrate the material through the use of clinically-based applications designed to demonstrate and enhance the clinical

relevance of the content. These sessions demand prior preparation on the part of the students. The team learning process helps students internalise principles through participation.

Assessments

Continual assessment is carried out during the course and for each module. This assessment includes beginning and end-of-module quizzes, and the individual and group readiness assessment of the TeamLEAD sessions. Further summative assessment is carried out by 3 integrated examinations.

Beginning and End of Module Quiz

Each module opens with a beginning of the module quiz based on assigned reading or multi-media materials which the students are expected to complete on their own before the module. This is conducted using the IRA/GRA format from the TeamLEAD methodology. There are 10 of these quizzes. This ensures that students are suitably prepared to benefit from faculty interactions during the module. All the modules end with an end-of-module quiz and interactive closing session which provides opportunities for both faculty and students to identify and rectify gaps in knowledge.

Integrated Exam

Three integrated examinations are conducted during the course. Each examination comprises of two parts, containing Multiple Choice Questions (MCQ) emphasising integration of course materials taught to that point in time and an Objective Structured Clinical Exam (OSCE). The OSCE comprises data-interpretation questions based on prosections, osteology, applied radiology, clinical pictures and vignettes, movie clips (e.g. endoscopy), laboratory tests (blood tests, ECGs, spirometry) and micro-anatomy slides.

While the course is modular in structure, the course director provides oversight, continuity and linear integration and the TeamLEAD Education Leader is involved in the oversight of all TeamLEAD sessions.

EARLY EXPERIENCE AND OUTCOME

While the inaugural course proved demanding for both students and faculty, the concepts were eminently workable and satisfactory. Good administrative coordination and adequate logistical support were fundamental to the success of the course as faculty are mainly busy clinicians. Despite differences in students' academic background, all 26 students in the inaugural class and the 48 in the second cohort passed the

Table 2. Average weekly ratings of Normal Body TeamLEAD sessions for 2007-8 academic year.

Please indicate the degree to which you agree or disagree with the following statements (1=strongly disagree, 5=strongly agree)	2007
I had NO difficulty accessing the Duke lecture material.	4.37
Subject content was clearly presented in the Duke material.	4.04
I found my group helpful in facilitating further learning of the material.	3.80
The objectives for this week's TeamLEAD Session were clear.	3.91
I was well-prepared for the Session.	3.51
I had sufficient opportunities to interact with the faculty members.	4.20
The faculty members were responsive to my questions.	4.21
I enjoyed the learning experience during the Session.	4.09
I found the IRA /GRA questions to be helpful for my learning.	4.12
The application exercise enhanced my understanding of content material.	4.15
I was able to achieve the learning objectives specified for the session.	3.94

course, with three students from each cohort qualifying for honours.

Student feedback is a critical component of the Duke-NUS curriculum. During the course, students were invited to complete a weekly online Student Feedback survey. Students, starting with the second cohort, are also given an End-of-course evaluation. The weekly survey in the first year asked students to rate (1–5, 5=Strongly Agree) very specific questions on the TeamLEAD process and had open ended comment box for any other issues to be raised. Table 2 represents an average of student responses across the nine TeamLEAD sessions developed, as an approximation of what the students thought about the course. There was no end-of-course evaluation.

Beginning with the second cohort, the weekly evaluations were revised to provide more feedback about the faculty activities and other learning activities as well as including a new standardised end-of-course evaluation. The sets of questions between the 2 cohorts are not the same, so it is not possible to provide a direct comparison. Table 3 provides a summary of the end-of-course evaluation for that academic year. The only item that was similar across the 2 years related to the achieving of objectives. In 2007 the mean was 3.9 and in 2008 4.1, very similar. Overall students in the second cohort felt the course was well structured and generally an outstanding course.

In some of the qualitative comments from the first year students concluded the main challenge in the Normal Body course was to manage the volume of materials covered in such a short period of time.

MODIFICATIONS TO THE COURSE IN THE SECOND YEAR

The experience of the inaugural Normal Body course both convinced faculty of the feasibility of their concepts and enabled them to introduce modifications to the course to improve its delivery based on student feedback.

For example,

- time allocated to the different modules in the course was significantly changed in the second cohort to lengthen and shorten modules according to the density of the content;
- assigned reading and multi-media materials for self study were better mapped to the assessment questions and spaced out to allow time for preparation;
- faculty started a pilot project to create videos of faculty demonstrating the steps involved in cadaveric dissections to enable students to preview the lab sessions.

Even with these changes, the workload was still of concern with the second cohort, where the students

Table 3. Summary of end-of-course evaluation of Normal Body for 2008-9 academic year.

Please indicate the degree to which you agree or disagree with the following statements (1=strongly disagree, 5=strongly agree)	Mean (n=47) 97.9%
The course:	
1. met the objectives stated in the syllabus	4.06
2. was well organized	3.85
3. provided me with useful knowledge, skills, or insights	4.38
The content material:	
1. was presented at an appropriate level	3.85
2. was well paced so that the workload was spread evenly across the block.	3.04
3. was constructively challenging	4.04
4. The effort required to learn the material was reasonable	3.11
5. The clinical relevance of the course was made apparent	4.15
6. Overall, this was an outstanding course	4.00
7. The assigned readings(including textbooks, journal articles, handouts) were valuable adjuncts to the course.	3.81
8. Sessions by different instructors were well integrated within the course.	3.66
Exams:	
1. were clear and in an appropriate format	3.81
2. were an appropriate length	3.87
3. tested material covered by the course (lectures and outside readings)	3.89
Labs:	
1. were integral and contributed to learning	4.15
2. had well organised lab manuals	3.40

rated the workload and effort to learn as lower than our desired rating of 4.0 or above. We will continue to review student feedback each year to identify additional areas of revision that might be needed in order to achieve the educational aims of the course in the most efficient manner.

CONCLUSION

Many clinical faculty members intuitively feel that the traditional approach to the teaching of anatomy and physiology lacks clinical focus and over burdens students with less relevant information and that there are few opportunities to initiate a clinically focused programme in practice. An integrated approach to the teaching of anatomy and physiology has been described in a number of medical schools⁹, but we are not aware of another course of less than 3 months which

has adapted team-based learning to address the clinical relevancy issues. The early experience and the student performance in this course have been gratifying, but further data will be required to fully assess the impact of this approach.

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