Role of Basic Sciences in 21st Century Medical Education: An Asian Perspective

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Introduction

Historically, the development of western style medical education in several countries of Asia was closely linked to the establishment of medical schools and initiated quite early in the 20th century by the colonial governments that ruled these countries at the time.

Medical Education in Asia: Our Colonial Heritage

Asian countries such as Hong Kong, India, Malaysia, Myanmar, Singapore and Sri Lanka all inherited the British system of medical education. Others, such as Cambodia, Laos and Vietnam, inherited the French system, whereas medical education in Indonesia was closely linked to the Dutch system.[1,2]

The US medical education system had a strong influence in Korea (South), the Philippines, Taiwan and Thailand mainly because of the strong military arrangements existing in these countries; it also had some influence in China mainly through the work of the early Christian missionaries (for example, establishment of the Peking Union Medical College in Beijing, then known as Peking).

Although medical education in Asia had been strongly influenced by British, French, Dutch and the US systems of medical education, many countries of Asia have now become less dependent on their past colonial links. Much of Asian medical education is now based on *global trends* which provide evidence of best practices (i.e. Best Evidence Medical Education) in curriculum design and delivery.

Role of the Basic Sciences in 20th Century Medical Education: A Case of Self-Serving Science without Boundary Markers

The role of the basic sciences in medical education advanced and flourished greatly in the early period of the 20th century following the submission of the Flexner report. Many Asian medical schools also incorporated the basic medical sciences into their undergraduate curriculum by adopting and adapting various systems of western medical education.

The Flexner Report

In 1910 Abraham Flexner, a research scholar from the Carnegie Foundation for the Advancement of Teaching, submitted a highly influential report on the state of medical education in medical schools of the USA and Canada.[3] Flexner advocated that medical education in the USA and Canada should, not only be university-based, but also be strongly underpinned by a scientific foundation (basis) of medical practice. Flexner had envisaged that medical students would readily acquire basic science knowledge, concepts and principles through learning of the basic medical science disciplines in their early 'pre-clinical' years and, subsequently, can apply scientific thinking and scientific skills in understanding and resolving medical problems encountered in their clinical education.

Flexner's report provided the main impetus for designing the undergraduate medical curriculum with a foundational pre-clinical phase, aimed primarily at providing medical students with the scientific basis (foundation) of medical education, followed by "…*a clinical phase of education in academically oriented hospitals, where thoughtful clinicians would pursue research stimulated by the questions that arose in the course of patient care and teach their students to do the same*".[4] Flexner's advocacy led to the rapid establishment of basic science departments in medical schools, as well as to the intensive recruitment of basic scientists to teach the basic medical sciences.

Thus, the Flexner advocacy unintentionally created two distinct phases in medical education, commonly referred to as the pre-clinical and clinical divide.

Initial Impact of the Flexner Report: Emergence of Departmental Silos

Flexner's recommendation strongly influenced curriculum reforms around the world, including much of Asia. For many decades following the report, medical schools adopted and implemented the concept of a pre-clinical ('scientific') and clinical phase in medical education, resulting in a highly discipline-specific curriculum design which neither promoted nor encouraged cross-talk between and across the medical disciplines, i.e. there was a lack of curriculum integration across the medical disciplines. Instead, each discipline had its own vested interests to protect, and this widened the pre-clinical/clinical divide further. As a consequence, departmental silos became firmly entrenched and responsible for the delivery of highly discipline-specific basic science knowledge to medical students in the pre-clinical years. Interestingly, the late Miller (1961), one of the doyens of medical education, had already cautioned about the need to ensure "*unity in diversity*" in medical education.[5]

"*Each department is responsible for some part of the education of a medical student, but no department should forget that it is no more than a part of the whole which is responsible for the education of a whole student and the fulfillment of the overall objective.*"

Basic Sciences in 20th Century Medical Education: Serious Emerging Concerns

Several educational shortcomings arising from the increasing pre-clinical / clinical divide soon became more apparent. Firstly, the delivery of basic science knowledge in medical education became driven more and more by the academic content of each discipline, as well as the research initiatives of the basic science teachers. Thus, much of basic science teaching focused on in-depth scientific facts rather than on the relevance of the discipline to and in the context of contemporary medical practice. Clinical teachers also complained that students seemed to have a poor grasp and recall of and, therefore, the inability to apply basic science knowledge, concepts and principles acquired in the preclinical years to medical problems encountered in the clinics.[6] These issues are well described by Pawlina.[7]

"The lack of clinical relevance, lack of integration, and the division of pre-clinical and clinical instruction caused dissonance and dissatisfaction among clinical teachers and students alike."

Medical education in Asia was also confronted with the same predicament, as it had inherited the same problems and shortcomings associated with the oft lamented creation of the 'pre-clinical / clinical Divide'. So medical schools in Asia also seriously considered the need for further reforms and refinements in their undergraduate medical curriculum to address the concerns highlighted.

Basic Science Teaching in 20th Century Medical Education: The Tipping Point

"*Too often Ph.D.- basic scientists have set themselves apart from their M.D. colleagues and the clinical activities of the health center and acted more or less as isolated research institutes, to the extent that the question is now often raised, Do we indeed need the basic scientists? …… Their lectures are accurate but sterile and insensitive to the legitimate needs and interests of medical students.*"[8]

Abrahamson' another doyen of medical education, specially drew attention to "*curriculosclerosis…[as]…an extreme form of departmentalization…[which]…in its disease state, becomes a stifling, inhibiting influence on normal development and function of the curriculum.*" [9] By mid to late 20th century, and even into this new millennium, there emerged a persistent chorus of highly critical comments expressing mainly dissatisfaction with the role of the basic sciences in medical education which reached the tipping point! [10-13]

A global consensus then emerged that there should be a thorough re-evaluation of the role of the basic sciences as the scientific foundation of medical education in the 21st century. Indeed the timing is appropriate, considering the fact that the year 2010 is one century (100 years!) after the Flexner report was first published. [4,8,12-16]

ROLE OF THE BASIC MEDICAL SCIENCES IN 21ST CENTURY MEDICAL EDUCATION: FLEXNER RE-VISITED AND RE-AFFIRMATION OF ITS FUNDAMENTAL ROLE

The role of the basic sciences in 20th century medical education came under much flak mainly because of a lack of contextualization and, therefore, relevance in the delivery of the basic sciences to medical students in the pre-clinical years. Much of the teaching then seemed to have ignored the clinical significance of the respective basic science disciplines to the practice of clinical medicine. As a consequence, students found it difficult to apply and to recall their basic science knowledge when they enter into clinical education This unsatisfactory state then became a highly contentious issue in medical education.[6,7] However, "*The critical relevance of basic science to medical practice is emphasized by all of the accrediting agencies*"..[17]

Medical Education Reforms: Asia in Pursuit of a More Globalised Medical Curriculum

There is global consensus that the highly discipline-specific, non-integrated and divisive curriculum of 20th century medical education is neither adequate nor appropriate for the educational preparation of today's medical students to become tomorrow's competent, caring and ethical doctors of the 21st century. Consequently, many reforms in medical education have been initiated and

implemented over the past few decades, particularly in the U.K., U.S.A. and Canada.[18]

Medical schools in Asia have also been in search of a more appropriate curriculum model for the education of their students in the 21st century. In the past two decades or so, medical education in much of Asia adopted and adapted many of the curriculum reforms implemented in U.K., U.S. and Canadian medical schools. For example the *SPICES* curriculum model, proposed by Harden, Sowden and Dunn in 1984, which emphasizes student-centered, problem-based and integrated learning had strong appeal to and was readily adopted by many Asian medical schools.[19]

Several other pedagogical initiatives implemented and adopted globally have also strongly influenced curriculum reforms in medical education in Asia. The initiatives include the concept of an outcome-based education, and well-defined outcome-based statements on professional competencies which medical students must acquire.[20] These outcome-based statements have been crafted, documented and implemented by some leading medical schools and professional organizations like the ACGME, CanMEDS and the GMC (see Medical Teacher, 2007 for a more detailed description).[32] Furthermore, the Global Minimum Essential Requirements (GMER) project in collaboration with 8 leading medical schools in China, the establishment of three FAIMER Regional Institutes in India and the conduct of the Essential Skills for Medical Educators (ESME) course annually, since 2006, at the Asia-Pacific Medical Education Conference (APMEC) held in Singapore have all contributed to the curriculum reforms undertaken in many Asian medical schools. [21, 22]

Another major force strongly influencing the design and delivery of medical education in Asia is the intensive drive to globalize healthcare in several Asian countries as an economic imperative. This has created a medical tourism industry with an estimated worth of US$60 billion and growing.[23] In order to impress and attract international patients with their high standards of clinical care and practice, international accreditation by Joint Commission International (JCI) serves as the yardstick.[24] Thus, in order to sustain and enhance the trend in globalized healthcare, medical education in many Asian countries will now be more closely aligned to the western system of medical education, in fact towards a more globalized curriculum.

Flexner Re-visited: Re-Affirmation of the Role of the Basic Sciences in 21st Century Medical Education

"…*a comprehensive understanding of the basic sciences is* ***essential*** *for the future of medicine as a profession, as physicians will be expected to contribute to the development of* ***clinically relevant*** *basic science understanding and to bring this knowledge to the bedside through the development of new diagnostic and therapeutic options for patients."*[17]

"*Given that medicine is rooted in fundamental scientific principles, both human and biological sciences must be learned in relevant and immediate clinical contexts* ***throughout*** *the MD education experience."*[25]

"*The graduate will be able to apply to medical practice* ***biomedical scientific principles****, method and knowledge…."* [26]

In the last decade or so, there has been strong re-affirmation of the fundamental and critical role of the basic sciences in 21st century medical education. [15] (see quotations above). Moreover Cohen, in reviewing Flexner's recommendations, has also clearly expressed that *"…commitment to the scientific foundations of medicine… remain as valid as ever."*[27] In the recently published AAMC-HHMI report it was also pointed out *"…that the basic science content in the medical school curriculum has not kept pace with the expanding scientific knowledge base of medicine and fails to reflect accurately the importance of the sciences in the practice of medicine."*[28] Other national and international reports have also addressed the critical role of the basic science as the building blocks of medical science and their vital role in the effective practice of medicine. [25, 26]

The re-affirmation of the fundamental and critical role of the basic sciences in 21st century medical education poses a major challenge to medical education around the world; it raises the important question 'How should the medical curriculum be re-designed to effectively deliver the basic sciences as the scientific foundations of medicine in the 21st century'?

ROLE OF THE MEDICAL BASIC SCIENCES IN 21st CENTURY MEDICAL EDUCATION: SHIFTING THE EDUCATIONAL PARADIGM

Just as there is a need for an educational paradigm shift from the highly teacher-directed instruction (teaching) to student-centered learning (learner-centered education), [29,30] there is also now an urgent need for a major paradigm shift from the teaching of intensive, in-depth and non-contextual scientific facts in the basic medical sciences to student acquisition of scientific competencies resulting from the learning of basic science knowledge, concepts and principles relevant to and in the context of 21st century medical practice, i.e. in the context of the diagnosis, treatment and prevention of disease in the 21st century. [7,25,26, 28,31]

Thus, there is now strong re-affirmation and global consensus that the basic medical sciences are even more important than ever before as the scientific foundation of 21st century clinical medicine. However, basic medical science educators around the world must have clear understanding and insights of the paradigm shift required to deliver basic science knowledge, concepts and principles to medical students in 21st century medical education. It is only in this context and with such

prevailing mindsets that the significant and critical role of the basic sciences can be sustained and its health ensured in 21st century medical education.

Design and Delivery of the Basic Medical Sciences in 21st Century Medical Education: What Should Students Learn?

In the document Tomorrow's Doctors, the section on 'Outcomes for graduates' ('Outcomes 1') specifically refers to 'The doctor as a scholar and scientist' under which it is clearly stated that "*The graduate will be able to apply to medical practice biomedical scientific principles, method and knowledge relating to anatomy, biochemistry, cell biology, genetics, immunology, microbiology, molecular biology, nutrition, pathology, pharmacology and physiology.*"[26] These sentiments are reflected in the HHMI-AAMC report on the Scientific Foundations for Future Physicians.[24]

An outcome-based approach should therefore be applied to select relevant course content from the individual (or combination of) disciplines specified in the GMC document.[32] The relevant content selected should ensure an adequate basic science knowledge base to facilitate student learning for the acquisition of scientific competencies required as the scientific foundation of medical practice in the 21st century.

The inclusion of the "traditional" basic science disciplines in the current listing by the GMC and also considered essential for medical education in the 21st century, raises the issue whether there is a need to're-engineer' (re-structure and re-organize) the 'traditional' basic science departments at the risk of some disciplines becoming even 'extinct'- at least in name? [33]

Design and Delivery of the Basic Medical Sciences in 21st Century Medical Education: How should Students Learn?

How should we design learning strategies in the basic sciences for medical students to learn and acquire the desired scientific competencies? Cohen stated that "*all medical schools should adopt promising pedagogical innovations to enrich the learning experience for students* [including] *underscoring the relevance of 'basic science' topics by integrating pre-clinical and clinical education throughout the curriculum.*"[23] Today, the design of any learning strategy in medical education should be aimed primarily at creating learning experiences for students to analyse, integrate, evaluate and to apply scientific knowledge and information. Such a pedagogical approach can be expected to facilitate and enhance student acquisition of critical thinking and reasoning skills, problem-solving and decision-making skills, as well as self-directed learning skills (and, therefore, laying the foundation for lifelong continuing self-education). These skills are also the main hallmarks of scientific competencies which, if successfully acquired, will equip medical students with the intellectual capacity to understand the relevance of and apply basic science knowledge, concepts and principles to clinical practice and, therefore, to have the enhanced ability to explain or resolve medical problems encountered in the diagnosis, treatment and prevention of diseases. Wilkerson, Stevens and Krasne have already emphasized the importance of designing learning experiences for students based on sound pedagogy to enhance more effective integration of the basic sciences with clinical medicine. [6]

Indeed, several well-established and pedagogically sound learning strategies are already available for designing such learning experiences for students, either in *large* group or *small* group settings.[6] The underpinning educational principle in all these learning strategies is to engage students actively in an interactive teaching-learning process, i.e. in 'discussion pedagogy', so that students will actively involve themselves in the social construction of knowledge with peers.[34-,37] Of course, learning in *small* group settings will also have the advantage of providing students with opportunities for *collaborative learning* and for the acquisition of *social* skills, including *interpersonal* and *team-work* skills, as well as *communication* skills, so essential to medical practice in the 21st century.[38]

Thus, the use of interactive teaching-learning strategies to deliver basic science knowledge in 21st century medical education can be expected to address the two major shortcomings of 20th century medical education, namely, poor student recall of basic science knowledge in the clinical years, and the lack of ability of students to apply knowledge of the basic sciences to medical problems encountered in the clinics.

Design and Delivery of the Basic Medical Sciences in 21st Century Medical Education: How should the Learning for Students be Organized?

How then should we organize (or design) student learning of the basic science disciplines in 21st century medical education? Today, medical educators and professional organizations strongly advocate greater integration of the basic sciences with the clinical disciplines in the curriculum design of the 21st century. This will require a paradigm shift, from the predominantly compartmentalized type of teaching of the basic sciences (mainly in the preclinical years) to more integrated learning of the basic sciences with the clinical disciplines, i.e. *"…to optimally integrate the sciences into the[clinical] years of medical school education*."[27]

HOW CAN WE OPTIMISE THE INTEGRATION OF STUDENT LEARNING OF THE BASIC SCIENCES WITH CLINICAL MEDICINE IN 21ST CENTURY MEDICAL EDUCATION?

Although many medical schools around the globe (including much of Asia) have already implemented curriculum reforms to update basic science knowledge and

to ensure greater clinical relevance of the basic science disciplines to medical practice, medical students in the clinical years still seem to have poor retention of and, therefore, lack the ability to apply basic science knowledge, concepts and principles acquired in the preclinical years. [4,6,17,39,40]

Since "*The basic sciences will continue to have a fundamental role in the development of physicians of the twenty-first century*",[17] there is now an urgent need to facilitate and enhance student retention of basic science knowledge, concepts and principles delivered to the students in the preclinical years. In this context then, medical educators need to seriously consider designing new and innovative curriculum structures which will ensure, not only the clinical relevance, but also result in better understanding and student retention of basic science knowledge in the clinical years. There is strong consensus that appropriate integration in the teaching-learning of the basic medical sciences with clinical medicine will achieve the desired outcome.

The question now becomes: How best can we optimize integration of the basic sciences with clinical medicine for student learning in 21st century medical education?

OPTIMIZING THE INTEGRATION OF THE BASIC MEDICAL SCIENCES WITH CLINICAL MEDICINE

In the past several decades, curriculum reforms with the primary aim of enhancing integration of the basic sciences with clinical medicine have been initiated in many medical schools around the world, including many medical schools in Asia. However, the process of integration varied greatly among the medical schools with significant differences in design structure, including: time allocation, sequencing, electives or compulsory courses, and pedagogy.[40]

The early efforts at integrating the basic sciences with clinical medicine did not have as strong an appeal and impact in the world of medical education, as did problem-based learning (PBL) following its first implementation by McMaster university medical school about four decades ago.[41,42] More recently, however, several new approaches have been well documented, and these are likely to receive more attention and to be adopted and adapted by other medical schools around the world, including Asia. We describe several of these.

An Early Lesson from Harvard Medical School

In 1985 Harvard Medical School implemented a hybrid curriculum using a block structure, combining PBL with limited lectures and laboratories, instead of the usual concurrent courses. Moreover, in designing the blocks, partnerships between basic science teachers and clinical faculty were strongly encouraged. The Harvard block structure facilitated student integration of the basic sciences with clinical medicine with strong evidence of continued retention of basic science knowledge by the students in the clinical years.[6,43]

University Of Pittsburgh School of Medicine (UPSOM), Pittsburgh, Pennsylvania

In 1995 UPSOM developed the Integrated Life Science (ILS) program as a back to the basic sciences approach for medical students to re-visit the basic sciences during the clinical years when the students will be more clinically mature. Thus, the innovative program was developed primarily to integrate the biomedical sciences with clinical medicine and promote an understanding of the application of the scientific method in clinical thinking and appraisal of the literature. The program serves also to illustrate how collaborative teams of clinicians and scientists translate new scientific knowledge into changes in medical practice.[40,44]

The UPSOM ILS curriculum therefore highlights the advantages of initiating the back to learning of basic sciences when medical students have had at least one year of clinical exposure after which, in the view of Spencer, et. al., [40] medical students are more receptive to re-learning of clinically relevant basic science knowledge, concepts and principles, because their "*…clinical reasoning and analytical skills are more mature…[and so] students gain a more meaningful understanding of the pathophysiology of diseases and targeted therapeutics*."[40]

David Geffen School of Medicine At University of California, Los Angeles (UCLA)

"*Recognizing the limitations of its own traditional, departmentally based curriculum, the medical school…challenged its* ***basic science faculty members*** *to* ***sit down with*** *their* ***clinician colleagues*** *and craft a* ***new, fully integrated pre-clerkship curriculum*** *that would present '****no content without context****'.*"[6]

In 2003, the David Geffen school of medicine launched its "Human Biology and Disease" (HB&D) pre-clerkship curriculum aimed primarily at integrating the "*..traditional biomedical sciences…with social and clinical sciences*." The HB&D curriculum is essentially "*…an integrated foundational curriculum…*" using a block and thread structure consisting of "*…nine sequential block courses over 2 years, each block traversed by five disciplined-based threads…*" and running for "*…either 8 weeks or 5 weeks of classroom and clinical study followed by 3 days for an integrated examination and a 4 day break*." A weekly structure for each block consists of PBL tutorials, lectures (maximum of 10h a week), a clinical session (3-4h), and a formative assessment at the end of each week; the total contact time is 24 h.[6] A significant point to note about the David Geffen school of medicine's fully integrated HB&D pre-clerkship curriculum is that the curriculum and instructional methodologies were based upon established principles of learning theory designed to

achieve deep learning, promote the application of science in clinical care enhance self-learning behaviors. [6]

Mayo Medical School

"*We have made the transformation* ***from*** a '***course-based****' curriculum, where students are 'exposed' to content (material is 'covered') with relatively little emphasis on integration or student retention* ***to*** *a* ***block-based*** *curriculum, which* ***integrates*** *normal structure, normal function, and pathophysiology of disease."*[17]

The Mayo medical school implemented a change from a course-based curriculum to a block-based approach involving an integrated normal structure/function and Pathophysiology of disease with an emphasis on the scientific foundation of the disease process.[45,46] A principle focus is on a longitudinal curriculum. [17]

Leiden University Medical Center (LUMC) Integrated E-Learning Course in Pharmacology

"*…we propose a* ***model*** *for* ***integrating*** *a basic science in the medical curriculum via the* ***implementation*** *of efficient and effective* ***e-learning***.[47]

Dubois and Franson recently described an interesting approach they used to integrate their pharmacology program.[47] The LUMC e-learning program was initiated in 1999 and is based on the development of the Teaching Resource Center (TRC) Pharmacology Database which provides links to the Dutch national formulary This association promotes integration of basic pharmacology and pathophysiology with clinical application.[47,48]

The LUMC integrated e-learning program (TRC Pharmacology Database) provides a good example of a successful and strategic e-learning model that promotes and facilitates the integration of basic science knowledge and concepts into clinical medicine through the use of information-communication technology (ICT). However, apart from careful and diligent planning with a project team, the authors also cautioned that the e-learning initiative "*…is a serious undertaking which has many parallels with curricular changes*" and, therefore, ensuring buy-in by all stakeholders will be just as important

CONCLUSION

The role of the basic sciences as the scientific foundation of clinical medicine gained much prominence and status after Abraham Flexner submitted his seminal report in 1910. The report highly influenced the curriculum design and delivery of medical education, not only in the U.S.A. and Canada, but also across much of the world, including Asia. However, by the mid 20th century, serious concerns were raised about the lack of clinical relevance and poor student retention of basic science knowledge and concepts delivered to medical students in their early preclinical years.

Today, in this new millennium and one century after the Flexner report, the critical and fundamental role of the basic science disciplines in medical education has re-emerged, with strong endorsement from influential medical bodies like the AAMC-HHMI of the U.S.A., the AFMC of Canada and the GMC of UK. However, a paradigm shift is now required: From students receiving intensive instruction of in-depth scientific facts derived from disciplinary courses, to student acquisition of scientific competencies required for the development of the desired habits of mind, behavior and action for medical practice in the 21st century. The importance of this shift in approach is highlighted by the thoughts of Pickering:

"…method is remembered when facts have been forgotten, and method can be used in a new situation where there are no, or too few facts. The students learn how to learn and can go on acquiring knowledge for the rest of his life." (Sir George Pickering; 1958)

The teaching of basic science knowledge, concepts and principles must, therefore, be aimed at inculcating in students the methods of science and scientific thinking. Thus, courses must now be designed to integrate across the medical disciplines, and departmental silos must not be allowed to impede the integration process. Course integration should ensure student re-learning of the basic sciences in the clinical years, perhaps, after one year of clinical exposure when students have reached a more "mature level" clinically. The design of integrated courses should be strongly underpinned by current learning concepts and principles. Importantly too, the positive outcome of pairing a basic scientist with a clinician in developing, organizing and teaching in the integrated courses should be given priority. ICT can also be exploited to advantage in designing integrated courses for medical student learning. Simulation-based learning should also be considered in this light.

Finally, basic science teachers should take heed of the caveat from Norman who, in a recent editorial, urged them not to yield to temptation no matter how important they may perceive their disciplines to be.[49] This, then, is the ultimate challenge to basic science teachers who must respond positively and must not repeat the self-serving scientific excesses of the past. Only then can basic science teachers ensure the continued good health and status of the basic sciences in medical education for the 21st century, and only then can they consider that it has 'passed the litmus test.'[7]

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