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Medical Curriculum at KU Leuven - University of Leuven, Belgium

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Abstract In this paper we reflect on the evolution of medical education, with the medical curriculum at the University of Leuven as a concrete example. Formally, the Leuven curriculum follows a bachelor's and master's structure that leads to the degree of Medical Doctor after which further advanced training is required to become a practising physician. The Leuven curriculum takes the CanMEDS model as its educational framework. Embedding the CanMEDs roles within the curriculum is achieved using four learning pathways (Knowledge and Fundamentals of Medicine; Scientific Training; The Physician in Society; Skills and Communication) that run across the bachelor's and master's programmes. A stepwise approach is adopted whereby students progressively acquire the required competences to translate medical knowledge into evidence-based clinical practice. The learning process initially takes place in a simple and controlled environment, e.g. lectures or demonstrations with (simulated) patients. As the programme progresses, learning and assessment occur in ever more authentic medical situations, e.g. during the clerkships. In the future it will be important to capture new developments in e.g. education technology, health care organisation and patient involvement, and incorporate them into the medical curriculum. In this way we may fulfil our ambition to train medical doctors that are ready to participate in the 21st century health care system and take their responsibility towards both the individual patient and public health care.

Keywords Medical education, CanMEDS, Clerkship, Health care, Medicine

Introduction

"Medicine is both an art and a science" is a commonly used expression, indicating that a successful physician should have both strong scientific skills and understand the art of applying medical knowledge to address a patient's individual needs. This vision of medicine clearly has a significant impact on the design and content of the medical curriculum.

Initially medical curricula started from a theoretical and scientific foundation and subsequently immersed students in clinical practice through bedside teaching and medical clerkships (Norman 2012). In the previous century, most medical schools were inspired by this traditional model that included an explicit distinction between preclinical and clinical education. Gradually, however, this formula became inappropriate. The formal division between preclinical and clinical training was a hindrance for the integrated acquisition of the necessary medical skills. In addition, new developments occurred in science and the evolution of health care that questioned the traditional model. For example, the boundary between the traditional basic sciences (biochemistry, physiology and histology founded in the natural sciences) and applied clinical sciences has become blurred by the tremendous advances in genetics, the omics sciences and technology, including imaging. The landscape of health care has evolved significantly as well with an ever-increasing importance of chronic care for aging patients, often with multimorbidity. Finally, new educational insights have led to the replacement of the classic ex cathedra lectures with interactive, case-based teaching methods.

This raises the question of whether or not medical programmes at the beginning of the 21st century are future-proof and what the requirements are to prepare the educational system for the needs and expectations of the future (Borleffs 2013). In this article, we discuss how medical schools can respond to these trends using the concrete example of the

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[1] See http://med.kuleuven.be/ for website in Dutch; http://med.kuleuven.be/eng/ for website in English.

medical programme at the University of Leuven (KU Leuven), Belgium [1].

The structure of the medical programme at KU Leuven

In Belgium, a doctor of medicine (MD) has obtained a bachelor's and master's degree of 360 credits[2] in total (equivalent to six years' basic medical training), but cannot immediately practice medicine. According to the Belgian medical legal system, additional residency training in combination with an advanced master's education (general practice, specialty medicine ...) is compulsory to become active as a professional physician who can and may practice medicine at his or her own responsibility within the Belgian legal and social security framework. This article is confined mainly to the basic training as a doctor of medicine (MD), i.e. the bachelor's and master's programmes. In those cases the term MD will be used, whereas the word physician will refer to medical practice beyond the scope of the educational framework described here.

The education to become a professionally active physician is phased through three cycles with an increasing degree of acquired competences: the bachelor's degree (180 credits, equivalent to three years), the master's degree (180 credits, equivalent to three years) and an advanced programme that consists of an advanced master's degree of 120 to 180 credits as well as a professional medical residency training lasting three to six years depending on the discipline(Figure 1)[3].

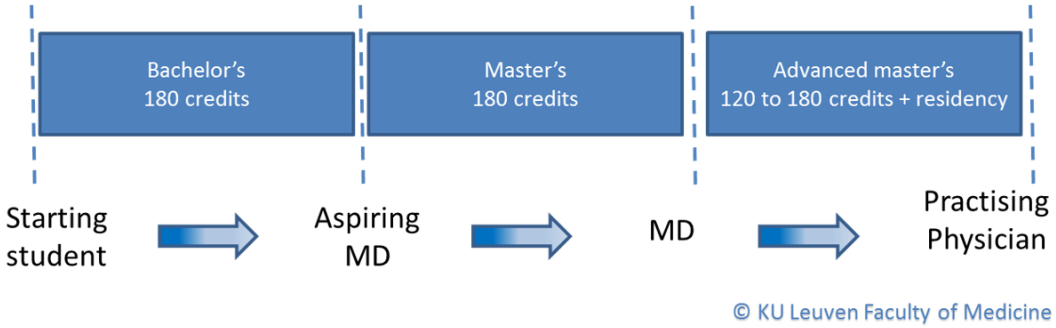

Fig. 1: Phased structure of the medical curriculum leading to a practicising physician.

The most important individual milestones throughout the education are:
— student at the start of the medical programme (this requires a secondary education degree, meeting the general admission requirements for a bachelor's programme as well as passing the entrance examination for medicine and dentistry organised by the Ministry of Education and Training of the Flemish Government[4]);
— aspiring MD/doctor of medicine after bachelor's degree;
— MD/doctor of medicine after master's degree;
— practising physician after advanced master's education and residency training.

A new vision for the medical curriculum at KU Leuven

KU Leuven's medical programme has the ambition to train doctors of medicine that, upon graduating from the advanced master's programme, are ready to participate fully in the 21^{st} century health care system and direct their expertise towards both the individual patient and public health care. The programme expects the medical doctor to:
— embed the medical competences in a multi-dimensional care landscape that is increasing in complexity, e.g. acute treatment versus chronic care, preventive versus curative care, and individual approach versus population-based approach;
— underpin medical practice with a scientific attitude including an attitude of lifelong learning;
— use a holistic approach for each patient with attention and respect for each patient's individuality;
— have an eye for the participation and involvement of the patient and his or her relatives;
— be aware of the social responsibility and the ethical role of the doctor of medicine with attention to vulnerable patients or patient groups; and
— have a professional attitude and deal with others (patients,

[2] In April 2005 KU Leuven was given the ECTS label by the European Commission. ECTS stands for European Credit Transfer System and is Europe's own system for the accumulation and transfer of credits.

[3] We describe the new medical curriculum that started in September 2012 of which the first cohort graduates in June 2018.

[4] Note that in Belgium entrance to university studies is regulated at the level of the communities (Flemish Community in the case of KU Leuven), whereas entrance to the medical profession is regulated at the federal level.

colleagues ...) and the assigned tasks in an honest and conscientious manner.

Contextualisation of the CanMEDS model, the prototypic reference framework for medical education

The important question is then how to transfer this ambitious 21^{st} century vision into specific learning outcomes that in turn need translating into specific curricular courses. For this exercise, the medical programme at KU Leuven used the CanMEDS Framework as elaborated by the Royal College of Physicians and Surgeons of Canada (Frank and Danoff 2007). Initially developed for the training of medical specialists in Canada, the framework was adopted worldwide as a reference point for educating doctors of medicine in general. It describes the competences, i.e. the knowledge, skills and abilities that a physician needs to possess, across seven roles: Medical Expert, Communicator, Collaborator, Manager, Health Advocate, Scholar, and Professional (Figure 2).

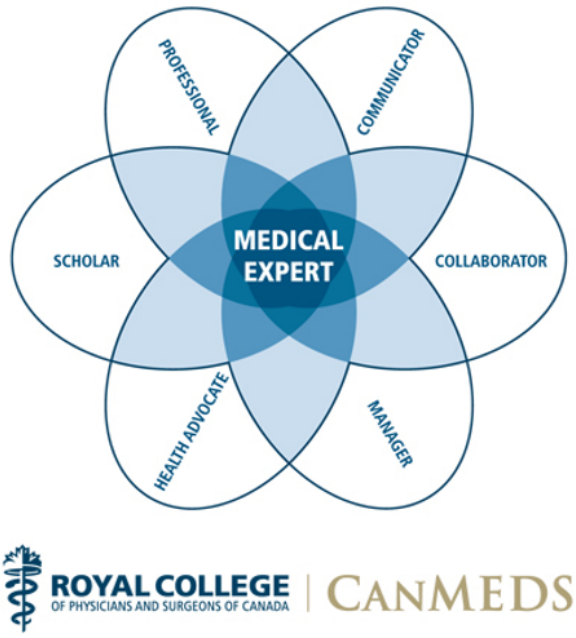

Fig. 2: The CanMEDS model with the seven roles of a medical expert[5].

When implementing the CanMeds framework, it was important for the Faculty of Medicine of KU Leuven to slightly adapt it and create an institutional profile in line with the previously mentioned vision. The adaptation of the model emphasises the following aspects:
— First, the programme attaches great importance to educating MDs with a solid theoretical foundation, both in the domain of the underlying basic sciences as well as in the various clinical disciplines. Courses facilitate not just the acquisition of knowledge in the individual components of the curriculum, but also of integrated clinical reasoning. The MD should be able to connect basic health and disease at different levels of understanding (cell - organ-healthy human-patient-population and society) and action (preventive versus curative treatment; acute treatment versus chronic care; individual approach versus population-based approach).
— A second important aspect is that students learn how to translate knowledge into practice. That conversion takes place in a simple and controlled environment initially and, as the courses progress, in ever more authentic medical situations.
— The acquisition of a scientific attitude is a third point of the KU Leuven profile. This manifests itself in a doctor of medicine that dares to question the current knowledge and practice critically and evaluates new concepts and developments in order to offer the best patient care. The MD is able to monitor new scientific findings and incorporate them into the medical practice (lifelong learning).
— Fourth, the MD uses a holistic approach with each patient and pays attention to both the questions of the individual patient as well as the needs and concerns of relatives and loved ones. This requires an empathic attitude that leaves room for participation and involvement of the patient and his or her relatives.
— Fifth, the medical programme desires graduated doctors of medicine to practice medicine with high standards of professionalism and integrity. The MD is guided by ethical values and professional standards that translate into a respectful attitude towards patients, colleagues and employees. Having a self-reflective attitude is essential.
— Finally, the medical programme devotes the necessary attention to the international context of medicine. The different roles of the physician may have different meanings depending on the location (international differences) and context (intercultural differences) of the practice. This means that the physician should be aware of the local and global aspects surrounding his or her profession.

Profiling the programme

Bachelor's programme: the aspiring doctor of medicine (MD)

Outlining a profile for the aspiring doctor of medicine is not straightforward since obtaining the bachelor's degree is an intermediate step on the way to the master's degree rather than a goal in itself. Over 98% of those attaining the bachelor's of medicine continue with the medical master's programme. The medical bachelor's degree therefore has a rather limited outflow to other programmes and little direct professional valorisation. In addition, the increasing medicalisation

[5] Copyright ©2009 The Royal College of Physicians and Surgeons of Canada. http://www.royalcollege.ca/canmeds. Reproduced with permission.

of the bachelor's programme has caused the once very clear distinction between the preclinical and clinical years (see above) to become blurred. At KU Leuven this international trend has resulted in the inclusion of clinical courses such as general surgery, general medicine, family medicine and primary care in the bachelor's programme. Thus, the bachelor's programme focuses upon the foundation of medicine and their scientific underpinnings (cf. courses such as introduction to medical research, scientific hypothesis testing, biostatistics ...). In addition, short-term clerkships help translate theory into practice through immersion in various medical competences. In doing so, a new profile of the bachelor's programme emerges, namely that of an aspiring doctor of medicine who is ready to take the step towards integrated clinical reasoning as it is offered in the master's years.

Master's programme: the doctor of medicine (MD)

The primary goal of the master's programme is to connect the building blocks of the bachelor's curriculum and have them result in an integrated clinical scientific reasoning according to the principles of Evidence-Based Medicine (EBM). At that moment, various frameworks of understanding (cellular - organ - healthy human - patient - population and society) and action (preventive versus curative, acute treatment versus chronic care, individual approach versus population-based approach) come to the fore. The master's curriculum translates theory into practice, for instance through the availability of a comprehensive national and international medical clerkship programme. Master's graduates are expected to command the required academic, clinical and professional skills and be able to apply them in real-life situations. The combined focus on integrated clinical reasoning and competency-based clinical practice ensures that master's graduates can seamlessly enter the advanced master's programme. During the master's years, they have taken on more responsibility progressively in order to become accustomed to professional practice (level medical doctor).

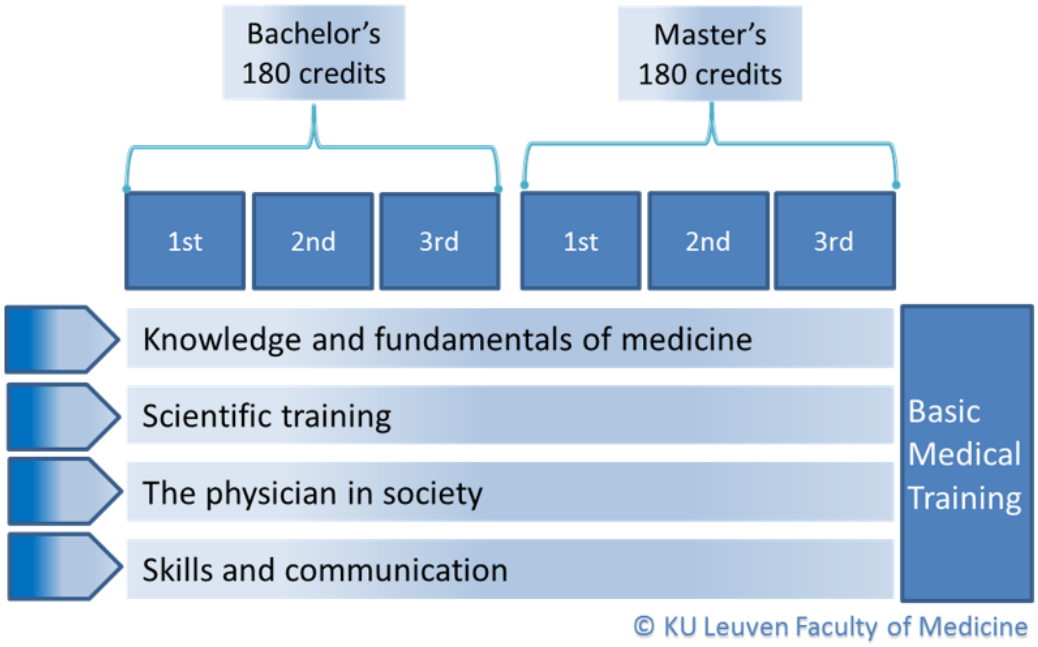

Fig. 3: Composition of the bachelor's and the master's programme along four learning pathways.

From Profiling to Building a Curriculum

In view of the previously described vision and profiling, the content of the bachelor's and the master's curricula was built on the basis of four parallel learning pathways that pass through the various stages of the programme:

1. Knowledge and Fundamentals of Medicine
2. Scientific Training
3. The Physician in Society
4. Skills and Communication

These four pathways describe the main content components of the medical programme. Together, they ensure that the seven CanMEDS roles are embedded in the KU Leuven curriculum.

The knowledge and fundamentals of medicine learning pathway

Education in the pathway 'knowledge and fundamentals of medicine' is mainly organised according to multidisciplinary themes. At the bachelor's level this translates into courses with morphological, functional and scientific perspectives. The study process follows a logical sequence with a particular focus on the layered complexity of the human body. Cells and tissues form the perspective in the first year, after which the curriculum's second year continues with organs and systems. In the third year, the learning pathway focuses on the human, both healthy and ill. The learning pathway includes therefore a double movement: from small scale (cell) to large scale (body) and from normal function (health) to dysfunction (disease). At the end of this learning pathway, the bachelor's student has an understanding of human health and disease. The integration of this knowledge into clinical scientific understanding and practice then follows in the master's programme. Offering a solid basic biomedical sciences component remains an important objective of the programme as well. This scientific basis needs to be integrated into the biomedical and clinical courses. This approach has the advantage that the student enters into contact with the intrinsic multidisciplinarity and complexity of modern medicine and its research areas from the onset.

The master's programme also follows the thematic approach with lecturers from different medical and surgical disciplines teaching in organ-specific pathology modules that are led by one course coordinator. This reflects the interdisciplinary care model as practised in contemporary medicine. The creation of different care programmes and pathways within the teaching hospital UZ Leuven has facilitated this educational reform. In addition, better consistency within the same thematic course was achieved by bringing onboard clinicians who work in non-invasive (internist), invasive (surgical) and supporting (radiology, pathology, laboratory) services. As a result, the focus has shifted from a unidisciplinary to a cross-disciplinary approach towards disease management. Some courses even go a step further as far as thematically oriented education is concerned. The evaluation of knowledge and insights is integrated into an oral examination by a multidisciplinary panel of lecturers. In doing so, this learning pathway provides a core curriculum that is subsequently deepened with discipline-specific expertise during the advanced master's education.

The scientific training learning pathway

A key objective of this learning pathway is that the MD obtains a scientific attitude, i.e. that he or she is able to assimilate new scientific findings and incorporate them into the medical practice. This includes a critical attitude towards current knowledge and common practice combined with an attitude of daring to question and assess such knowledge and practice. This allows the MD to provide the patient with the best care possible while applying new concepts in practice. A physician will also have to learn to apply his or her expertise to make clinical decisions based on scientific evidence in consultation with the patient. The need for this scientific attitude will only increase in the future.

Early, critical analysis of biomedical literature and a thorough understanding of biostatistics and epidemiology are necessary to familiarise the bachelor's student with the principles of Evidence-Based Medicine (EBM). The master's programme builds on the EBM framework that was acquired in the bachelor's programme and students learn to distinguish different research designs and their distinct uses. The medical clerkships ensure an integration of EBM into clinical practice. At the end of the master's programme, students integrate scientific competences in the master paper. Master's students are expected to independently analyse a clinical problem scientifically and report in the form of a research article.

It is important that this scientific reflection is integrated throughout the curriculum and comes into play repeatedly in the preclinical and clinical courses. Students must learn to transfer this scientific attitude and apply it to other learning pathways, e.g. by referring to a recent scientific article or news item related to the subject matter. This attitude should permanently instill lifelong learning skills in each physician.

A number of MDs will become involved in scientific research after they graduate. Physician-researchers play an increasingly crucial role in the large demand for more translational research, both to provide the clinical part of this research as well as to bridge to basic research. In order for MDs to opt for the research track, it is important that they are exposed to scientific research during their medical education and get a flavour for e.g. writing a scientific article or a master's paper. An important asset of the medical programme at KU Leuven is the status of the student researcher. This status allows students to participate in scientific research in one of the (bio)medical laboratories or research groups from KU Leuven. Students have the opportunity to gain first-hand experience with scientific research early on in their study process. Besides the general educational aspect, this approach has other advantages as well: some students become co-authors of one or more publications, while other students get a taste of scientific research and lay the foundation for later study, often in the form of a doctorate.

The physician in society learning pathway

Being a physician is one of the most respected professions in our society. This renders the necessity for a physician to be able to think at various levels: patient, population and community. A physician recognises and actively advocates the importance of (preventive) health care for the individual patient, patient groups and society. To this end, he or she must understand the determinants of health and disease both at the level of the individual and at the levels of the community

and the health system. The different levels of care – family medicine, social medicine, preventive proactive care and hospital care – are discussed with a major focus on transmural care, namely the interaction between the different care levels. The task description, financing structure and differences in decision-making methods between these levels are studied. Finally, it is important that the graduate MD knows about quality of care and patient safety at the different levels. In addition, a physician should have a clear understanding of the biological, psychological and social models of health and illness. Based on this biopsychosocial model, the student learns to deal with health and preventive behaviour, stress, illness and physician-patient relations. Understanding modern psychosomatics is an intricate part of this approach. The future MD also studies the legal framework, i.e. the principles, rules of conduct and practices for the medical profession that each physician must respect or use as guidance in the physician-patient relation. A physician is expected to have the ability to deliver high quality care in an honest and involved manner with the integrity of the patient in mind. Further attention is paid to the personal reflection and the formation of an informed judgment about a number of existential, societal and especially philosophical issues related to experiences of suffering and death. Students will learn to make use of various ethical argumentation models and apply them to specific areas of medical ethics.

The skills and communication learning pathway

This learning pathway includes - at the level of the doctor of medicine - education in the physical examination, the instrumental-technical skills and communication skills. A stepwise approach—in which the student first acquires the basic skills and then practices more complex procedures, techniques and interview forms—is paramount. Students practise these skills actively in small groups. Particular attention is paid to collaboration, learning how to cooperate and the development of peer-assisted learning. In this latter stage student-teachers help groups of students to practise instrumental-technical skills. These student-teachers are first trained in a number of pedagogical concepts and teaching skills, and follow advanced training in a number of specific technical skills. A final special feature of this learning pathway is the evolution towards simulation-based learning environments, by means of human simulation patients, digital simulators or virtual reality simulations. Such learning environments offer students the opportunity to practise skills in a standardised situation and in a safe environment for both the patient and the student. These skills can then be fine-tuned in practice later on, including during the medical clerkships (see below).

Clerkship	When	Duration	Where
Nursing clerkship	After bachelor 1	2 weeks	Nursing team in hospital
Patient care	Bachelor 2	1 week	General practitioner
General practice	Bachelor 3	1 week	General practitioner
Specialist practice – 1	Bachelor 3	1 week	University hospital
Specialist practice - 1	Master 1	2 weeks	University hospital
Core clerkship	Master 2 and 3	12 months	Hospital, general practice, primary care
Elective clerkship	Master 3	12 weeks	Practice of student's choice

Fig. 4: Overview of the medical clerkships throughout the medical programme.

An important part of the learning process concerning skills and communication occurs during the medical clerkships that are divided across the entire programme (Figure 4).The preparation for the clerkships is crucial: the curriculum is designed to ensure that students have acquired the necessary skills prior to patient contact (see above). During the clerkships, students can elaborate on real professional situations and competences, as expressed in the different CanMEDS roles, with direct feedback from the clerkship supervisors. It is important that the student learns to reflect on his or her own professional activity during the clerkship. This is supported by a portfolio that the student keeps during the clerkship, and by debriefing sessions where specific events or experiences during the clerkship are discussed.

Clerkships are also a unique opportunity for internationalisation of the programme (see below). About one third of the students choose to go abroad during the core clerkship period in the master's programme. To this end, the faculty has an extensive network of international contacts, both inside and

outside of Europe. Figure 5 gives an overview of the various clerkships abroad.

The programme's international dimension

Although not explicitly mentioned, internationalisation is a common factor that runs through the entire medical curriculum. Indeed, the lingua franca for the exchange of medical knowledge and scientific communication is English. In addition, the roles of a communicator, team player and health promoter are interpreted differently depending on the location (international differences) and context (cultural differences) of the professional practice. This means that the physician has to be aware of both the local and global aspects of the profession. These (inter)national and intercultural settings should be addressed during each educational phase of the medical programme.

2013-2014 data Country	Number of Partners (hospital or university)	Students per year
Argentina	1	6
Austria	2	2
Benin	2	6
Cameroon	2	4
Chile	2	12
Ecuador	1	6
Finland	1	1
France	11	33
Germany	7	15
Italy	1	2
Malta	1	4
Paraguay	1	6
Philippines	1	12
Rwanda	1	3
Switzerland	2	5
The Netherlands	3	8
United Kingdom	2	4
Uruguay	1	6

Fig. 5: Overview of the medical clerkships abroad (academic year 2013-2014).

Several initiatives contribute towards internationalisation:
— Using international (usually English-language) educational material: manuals, articles, databases...
— Teaching medical English, French, German and Spanish to students and making these courses and their subsequent examinations compulsory for students who intend to fulfil their clerkships abroad. In addition, introductory courses, albeit not compulsory, are offered for languages for which no medical language course is provided (e.g. Finnish, Portuguese).
— Participating in the Erasmus+ exchange programme[6] whereby students study at a European university abroad for one or two semesters.
— Providing medical clerkships abroad, in particular the core clerkship in the master's programme for a period of six to twelve weeks. In general, clerkships abroad are approved through a competitive merit-based application process. The Faculty of Medicine currently has formal collaboration agreements with 42 partners in 18 countries accounting for 135 clerkships (see Figure 5), or approximately two-thirds of the medical clerkships abroad. In addition, students are encouraged to submit personal initiatives for clerkships abroad (approximately one-third of the medical clerkships abroad). These personal initiatives are decided on a case-by-case basis by the Faculty Board in collaboration with the Faculty's International Office. Some of the clerkships found through personal initiatives have become recurrent clerkships over the years. Having this combination is ideal since it instils a sense of creativity and responsibility in the students.

The faculty also facilitates free participation in the International Foundation of Medicine (IFOM) exam, an internally validated examination organised by the National Board of Medical Examiners (De Champlain, Grabovsky et al. 2011). This offers students the opportunity to gain experience with international, English-language tests, e.g. to prepare for the United States Medical Licensing Examination® (USMLE) that candidates need to pass before they can enter a medical school in the United States of America. In addition, participation in such international examinations also provides a benchmarking tool for the Leuven curriculum as it allows comparison with the results of international control groups.

A final aspect of internationalisation is the GHLO™ (Global Health Learning Opportunities) project of the AAMC (American Association of Medical Colleges). After having been chosen as a European partner in the pilot project, the Faculty of Medicine of KU Leuven is the only participating Belgian institution - and one of the few European partners in the GHLO™ project. This is a service designed for final-year U.S. and international medical students that facilitates the application for clinical and research clerkships at other universities.

Future challenges

How to provide adequate training time?

The amount of medical knowledge has increased tremendously, as have the expectations the physician has to meet. In parallel, the practice of medicine is becoming increasingly complex. Paradoxically, there is at the same time a downward pressure on the duration of the basic medical training and a wide range of provisions, such as the European Working

[6] European Community Action Scheme for the Mobility of University Students, an exchange programme launched by the European Union in 1987. Erasmus+ was launched in early 2014 and brings together seven existing EU programmes in the fields of Education, Training, Youth and Sport.

Time Directive, that limit the trainee's training time (Pickersgill 2001, Editorial 2010). One question is how to reconcile these conflicting tendencies.

In addition to a shift in the educational content from basic medical training to advanced level training, the efficiency of the learning process is now brought to attention. Whereas students and trainees used to be dependent on the number of patients in the emergency or consultation rooms to come into contact with certain diseases, skills or techniques, there is now the possibility to intensify and hopefully increase efficiency through simulation (e.g. simulated patients, digital simulators, virtual reality learning environments). This requires specific investments in specialised infrastructure and in the recruiting and training of simulation patients.

An additional benefit of education through simulation is that the student can gain expertise and confidence in a patient-safe manner before having contact with real patients. Important questions related to simulation education are (Norman, Dore et al. 2012):
— How representative is the simulation environment, i.e. does the simulated condition adequately reflect the real-life situation and allow for enough variation so that not only standard situations but also complications or atypical presentations are addressed?
— How to rein in the cost of simulation education? The most spectacular examples always call for high-end simulators that are very expensive. To be deployed on a larger scale, simulation education will also have to use so-called low cost, low-fidelity simulators that can be used for basic skills training.
— How effective is the transfer from the simulation environment to the real world? In other words, can students apply the skills acquired through simulation easily to real-life situations?

Translational medicine and research: the vanishing physician scientist?

As described above, the medical curriculum is highly medicalised from the onset. This has the advantages that training can be concluded in less time (see above) and that the medical student can immediately make the connection between medical-scientific knowledge and clinical practice.

This medicalisation, however, occurs at the expense of the traditional scientific training as present in the classic curricula: a basic education in the natural sciences (chemistry, physics, biology) followed by an exploration of the basic medical sciences (biochemistry, histology, physiology, immunology, genetics ...) which paved the way for a career as a physician-researcher (physician-scientist). The question therefore arises whether the new curricula will lead to the disappearance of the physician-researcher (Schafer 2009, Gutierrez-Hartmann 2010).

This conclusion seems premature, but it is certain that the physician-researcher will take on another position in the biomedical research chain. At one end of the chain are highly trained and specialised basic researchers and technologists that apply their (inter)disciplinary training to new (molecular, cellular, technological ...) findings with potentially far-reaching applications in medicine. At the other end of the chain are practicing physicians who shape medicine through patient contact. The issue is that both groups - basic researchers and practicing physicians - do not always speak the same (disciplinary) language, which may lead to a cumbersome translation of findings into medical practice and vice versa as well as a cumbersome fertilisation of research from the hospital. The physician-researcher has a crucial role to play in that crossover area, namely the translation between bench and bedside (and vice versa).

However, it is crucial that interested students are given the opportunity to delve into research as a complement to their medical training. The classic route follows the different versions of the known MD/PhD programmes whereby medical students temporarily put their basic medical training or their subsequent advanced master's training on hold to conduct scientific research, or to obtain a master's or doctorate degree. At the same time, a number of additional interesting alternative pathways have emerged. For example, the SUMMA programme of Utrecht University allows students with a biomedical bachelor's degree to join a specifically adjusted master of medicine programme that emphasises clinical training and research[7].

Educational structure of the medical programme

The medical-educational landscape evolves rapidly. On the one hand, there are new methods focusing on 'student centered learning' in a response to the ever-increasing medical knowledge base which renders an encyclopedic approach to the material obsolete – if it has ever been possible. It is important that students learn how and where to find new information, evaluate it critically and integrate it into their medical thinking and practices where appropriate. This is closely related to a paradigm shift in medical education that is no longer eminence-based (i.e. based on the authority of the professor) but is now evidence-based (i.e. starting from what medical science has to offer) (Cassels 2012).

On the other hand, there are the changes in testing and evaluation. There is the question of whether it suffices to test different courses of the education separately or whether a change towards more integrated tests, possibly offered in a

[7] See SUMMA website http://www.uu.nl/university/masters/NL/summ/Pages/default.aspx

longitudinal manner throughout the programme, is required. The underlying rationale is that in medicine it is vital to be able to apply the learned skills in an integrated manner in real-life situations, and that students go through a learning process in which they progress from neophyte to ever higher skill levels. An additional element is that the method of testing also affects the learning behaviour of the student. Integrated and longitudinal tests should thus encourage students to accumulate the knowledge, skills and attitudes offered in the different courses and progressively turn them into active competences, so that they can evolve from neophyte into aspiring doctor, practitioner and professionally active physician. This also ties in with the discussion about assessment for learning (Schuwirth and van der Vleuten 2011).

It goes without saying that both elements – experimenting with methods in which student learning is the central starting point, and introducting integrated, longitudinal tests – should be monitored with the necessary critical sense. Medical education, like medical practice, should be evidence-based. This creates opportunities for interdisciplinary schools of medical education with doctors, educators, educational technologists and IT specialists collaborating on new aspects of medical education.

A systems-based curricular design

In the past, medical curricula grew (as it were) 'organically'. As medical science progressed and new disciplines emerged, the programme was altered. This approach serves to keep the programme up-to-date, but carries the risk of it becoming a kind of 'mixed crop garden'. An alternative is to take a systems approach as a starting point in which a number of a priori questions are asked related to the form and content of the curriculum. Examples of such questions are:
— What are - locally and globally - the main medical conditions, differentiating between frequent, life-threatening and urgent pathologies?
— What are the major trends in health care that a future physician will face?
— How should the link between medical science and clinical practice be structurally embedded into an evidence-based curriculum (see above)?
— How should the content, methods and tests be aligned with the purpose of assessment for learning (see above)? Such questions urge us to view and outline a medical programme from the top down, while keeping in mind that the lecturers must retain enough creative space to stimulate the enthusiam of the students.

Conclusion

These are exciting times for medical education. The traditional paradigm of the two-step preclinical to clinical curriculum has given way to a new paradigm of an integrated competence-based curriculum. This has led to profound changes in curricular design, content and assessment. Further changes loom ahead because of the evolution in education technology, health care organisation and patient involvement. How will the emerging wave of MOOCs (massive open online courses) affect the educational approach in medical faculties? How will the medical curriculum prepare students for the new modes of health care delivery (transmural care, integrated care pathways, interdisciplinary care teams...)? Will patients - who are the ultimate disease specialists - take a more active role in the curriculum, e.g. by being part of the didactic team? Whatever the future directions, it will be important to engage both students and lecturers, because in the end they are at the heart of the education process. Finally, the ultimate benchmark for changes in medical education should be better patient care and higher quality of health care delivery.

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