Medical Education

Introducing a molecular basis to physiology in undergraduate medical education

ARPITA MUKHOPADHYAY, D. SAVITHA, ANURA V. KURPAD

ABSTRACT

Background. Medical professionals in India need to understand the concepts of molecular genetics to stay up-to-date with clinical care as well as to strengthen basic research in the biomedical sciences.

Methods. We introduced a modular course on 'Fundamentals in molecular and cellular biology' for first-year medical undergraduate students in the second semester of the first MBBS year in 2015, as part of 'Innovations in teaching physiology' at St John's Medical College. This was a voluntary, add-on course with didactic lectures, hands-on practical classes and a research paper presentation. Evaluation of students' performance in the course took into account their performance in the research paper presentation-based group activity and their attendance for the hands-on practical sessions. Feedback on the content, delivery, evaluation and future improvements of the course was sought from the students.

Results. About 65% of students regularly attended the 10-hour long course. Of the students evaluated for the course, 43% achieved the highest, and 11% achieved the lowest grade assigned. Nearly 72% of the students provided feedback on the course.

Conclusion. This first outing of the modular course on 'Fundamentals in molecular and cellular biology' generated excitement among the students and achieved some learning for them. It also brought to light hidden challenges in conducting such a voluntary course for medical students in India. Our experience with the course will help in designing a better-integrated course for exposure of first-year medical students to advances in molecular biology and its applied aspects as they progress through the MBBS course.

Natl Med J India 2018;31;228–30

INTRODUCTION

Abraham Flexner influenced the medical community to include 'preclinical curriculum': Teaching of the basic to clinical sciences at the beginning of medical education.[1] Providing the basic foundation for understanding molecular and cellular mechanisms of disease pathophysiology as well as integrating this knowledge with clinical aspects of disease have become the main agenda for modernizing the preclinical curricula in many medical schools in the USA and Canada.[2] This is crucial, especially as there is evidence that diagnostic accuracy improves if the clinician has knowledge related to causation of disease to its symptoms.[3] In its Vision 2015 document, the Medical Council of India (MCI) has envisaged, among other goals, developing competencies in clinicians towards knowledge of abnormal human structure, function and development from a molecular and cellular perspective for improving medical education.[4] However, medical education in India at present has little input of molecular biology either as part of the syllabus for medical undergraduates (MBBS course) or in terms of integrating modern molecular research and diagnostics with fundamentals of clinical medicine.

As modern molecular biology is not an integral part of the courses required for medical school undergraduates, we designed and conducted a modular course in fundamentals of molecular and cellular biology for first-year undergraduate medical students. To provide motivation for participation in this course, we sought to implement an integration with physiology as the bridge to learning and further exploration of the topics taught.

METHODS

Course schedule and content

The course was for first-year MBBS students (n=60) and was started in 2015. A faculty meeting in the physiology department decided on the schedule for this course, which was beyond the MBBS curricular requirements of the MCI. Public holidays and the days around theory and practical examinations of the routine courses were excluded from the study. Two practical hours were planned to be held in the haematology laboratory of the department of physiology. Since this laboratory is not equipped for conducting advanced molecular biology experiments, the other 2 hours of the module were planned to be conducted in the molecular physiology laboratory at the St John's Research Institute, which has equipment such as centrifuges, facility for agarose gel electrophoresis and polymerase chain reaction (PCR). The students attended the practical classes in batches of 15 each as neither laboratory had facilities or physical space to accommodate all 60 students.

The course content was based on 2 guiding principles: (i) coverage of basic molecular and cellular biology concepts; and (ii) integration of those concepts with concepts from the physiology syllabus. The topics covered in lectures were: introduction to biomolecules, history of genetics and molecular biology, DNA replication, transcriptional and translational control of gene expression in health and disease. The practical classes included topics such as buffering systems in pH homeostasis, cells and organelles, mammalian DNA extraction, PCR and understanding proteomic tools for discovery of disease biomarkers.

Method of evaluation

The students were split into 6 groups of 10 students each. Each

St John's Research Institute, St John's National Academy of Health Sciences, Sarjapur Road, Bengaluru 560034, Karnataka, India
ARPITA MUKHOPADHYAY Division of Nutrition
D. SAVITHA, ANURA V. KURPAD Department of Physiology

Correspondence to ARPITA MUKHOPADHYAY; *arpitam@sjri.res.in*

group was provided with a primary research publication. The articles were chosen such that they included the concepts and techniques taught during the integrated molecular biology module. The students prepared for a month and then presented the paper within the allotted 15 minutes. The presentations were held on 2 consecutive days (3 per day). The evaluation criteria were: presenting within the allotted time; explanation of the research question(s), methods, results and discussion; quality of responses to audience questions.

Evaluation of individual students based solely on the performance in the group-based presentations had the potential of over-inflating the performance of underperformers and vice versa. Therefore, for the final evaluation of each individual student, 60% of weightage was given to the group-based presentation whereas 40% of weightage was given to attendance in practical sessions.

Assessment of learning by the students

The students were provided anonymous, questionnaire-based feedback form. The feedback form provided for collection of demographic information (age and gender) of the students. The questions within the feedback form pertained to understanding students' evaluation of the strengths and weaknesses of the course as well as requesting suggestions for future improvement of the content, schedule, delivery and evaluation of the course.

RESULTS

The criterion for eligibility for evaluation was having attended a minimum of one practical class. Based on this criterion, performance of 7 students (12%) was not evaluated. Of the remaining 53 students, 43% achieved an A+ grade, 23% each an A or a B+ and 11% achieved a B grade. The students were provided anonymous feedback forms within 2 weeks of the end of the course—43 students (72%) filled and submitted the feedback forms. Forty of the students who replied were between 18 and 20 years of age, and 23 were men.

The themes that emerged from responses of the students are given below.

Imparting novel and interesting knowledge

The students found learning about advanced techniques developed in cellular and molecular biology a novel experience. The course inspired students to take up self-guided reading of molecular concepts in medicine. In the students' words: 'This course helps to put us at par with our foreign counterparts who have been studying this course as an integral subject. Since the future of medicine is personalized medicine, the knowledge of molecular biology is a must.'

Insight into research

The course offered a new perspective of medicine-associated research. Student presentations of original research papers gave them an insight into how a research question is asked, experiments planned to address the question, data collected and interpreted.

Practical aspects

The students got an insight into the instruments and techniques that are routinely used to unravel cellular and molecular basis of the pathophysiology of disease. Topics such as DNA extraction, estimation and PCR that form the backbone of both basic biomedical molecular research and current methods of disease diagnosis found ready reception.

'The practical sessions helped us to see what we've only heard about or read in textbooks and helped us to understand the concepts better.'

Advantages of integration

The students acknowledged the role of the course in helping them to understand their regular course topics better.

Some suggestions to improve the course were:

Course content

Many students felt that the initial lectures were easy to understand. However, since there were 5 hours of classroom lectures available, they felt rushed through few advanced topics. Students found the practical sessions fascinating and requested for the inclusion of more practical sessions and further interactions with biomedical researchers.

Method of teaching

There were suggestions for making delivery of the topics more engaging by distribution of written material, active discussions, more practical sessions and student presentation of research articles from journals. Some students suggested including more multiple-choice question tests and clinical problem-based assignments.

Logistics

There were requests for conducting the classes within the prescribed college hours.

Increased integration

An interesting comment was to design the content around diseases or physiology topics taught during their normal course classes. To quote, 'The content can be planned better to integrate with the MBBS course subjects so as to improve our understanding of both. Genetic/molecular causes of various diseases/conditions can be dealt with.' Some even suggested discussing achievements of clinician–scientists to inspire the students.

Future applications

Most students thought the course gave them a better understanding about molecular biology and genetic aspects of medicine and is likely to be of use to them if they pursue medical research. Some also felt the course gave them a platform to be curious about the molecular basis of disease pathophysiology and will help them later in understanding the cause of a disease and not just treat the symptoms as clinicians.

DISCUSSION

The course on 'Fundamentals of molecular and cellular biology' was started as a response to the need for integrating molecular concepts in medical education. Every lecture covered was rounded up with a contemporary example of how the concepts have been used to develop new diagnostics or therapy targets. For instance, the example of sodium-glucose cotransporter 2 (SGLT2) was included in the lecture on biomolecules. SGLT2 is an insulin-independent glucose transporter located in the proximal tubules in the kidneys that is responsible for 90% of the reabsorption of glucose into blood. The elucidation of the molecular details of glucose reabsorption by SGLT2 led to designing and testing of SGLT2 inhibitors for treatment of type 2 diabetes, of which dapagliflozin was approved by the US Food and Drug Administration in 2014.[5,6]

Assessment usually is a key driver of learning. We evaluated

the students in terms of their ability to critically interpret primary biomedical literature. We took this approach towards student assessments for multiple reasons. First, such an exercise is unique for medical undergraduate students in India. Second, there is evidence to show increased student involvement, learning and interest in the course material when such an approach has been taken.[7] Third, this approach helped us further integrate and reinforce the role of biomedical research in advancing patient care. Overall, the students' evaluations suggested that they performed well.

About 72% of students provided feedback. They appreciated having been given a chance at getting introduced to the modern applications of molecular and cellular biology concepts in medicine. This is important for multiple reasons. First, the course was conducted in hours beyond the scheduled college hours involving extra planning and dedication by the teaching faculty. Second, starting from 1958 when the Noble Prize in physiology or medicine was given to G.W. Beadle and E.L. Tatum for their discovery that genes act by regulating definite chemical events and to J. Lederberg for his discoveries concerning genetic recombination and the organization of the genetic material of bacteria, there have been extremely few instances of this prize being given for discoveries that do not concern molecular genetic or cellular aspects of physiology and disease biology. This underscores the relevance of including molecular concepts in teaching physiology to medical students.[8] Third, the phase 3 of the Graduate Medical Education according to the 2012 regulations of the MCI includes 2 months of 'Elective', of which Block 1 of 4 weeks is to be done in pre-selected preclinical or paraclinical or other 'basic sciences laboratory' or under a researcher on an ongoing research project. This course gave the students a foundation for doing their 'Elective' in a basic sciences laboratory.[9] Finally, the concept and design of this course are in line with the year 2015 Vision document of the MCI for Graduate Medical Education that aims to develop competencies in clinicians, which include demonstration of knowledge of normal human structure, function and development from, among others, a 'molecular and cellular' perspective.[4]

With respect to improvements of the course, the students requested for further inclusion of problem-based learning: a method that is being wholeheartedly embraced in medical education worldwide.[10,11] The students also asked for inclusion of more interactive sessions, which when compared to didactic lectures, have been shown to improve students' learning and perceived value of the course content.[12]

Conducting the course posed certain unique challenges. First, the students came from multiple school examination boards with diverse levels of curriculum coverage of biology. Second, the course had to be held after the regular college hours. This was cited by the students as a deterrent to regular attendance. Finally, generalizability of this course will depend on 3 critical factors. One, faculty with the necessary expertise needs to be available. Two, the equipment and facilities required for the practical classes are specialized. Investment in recruiting faculty and procuring required equipment will provide medical colleges the added advantage of promoting cutting-edge translational research. Three, the high numbers of students being taught makes scaling a challenge.

Conclusion

To summarize, this course was an experiment, which aimed to learn the practical issues of implementation, with the hope that it could introduce laboratory-based basic biology as an integral part of modern clinical learning. It also provided the faculty with insights into motivations of the students for this learning, which will improve future course design.

Conflicts of interest. None declared

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