OPINION ARTICLE

Turning science into teaching: a challenge for scientists

[version 1]

Simonetta Ausoni

Department of Biomedical Sciences - University of Padua - Viale G. Colombo

Abstract
This article was migrated. The article was marked as recommended.

Teaching basic science in the medical school remains a challenge, and the lack of appropriate resources is one of important limitation. Building up such resources is difficult, time-costly and does not always result in effective, solid and student-centered instruction.

This "personal view" aims to stimulate scientists and scientific journals to engage with new ideas and innovative resources for biomedical education. The time has now come to plan research and education as mutually beneficial activities, supporting each other rather than competing with each other. Scientific research should be converted into digital learning resources hosted by scientific journals on a regular basis, and subjected to peer-review to ensure quality and integration of contents, appropriate cognitive approach and rigorous criteria of selection.

Turning science into teaching represents an investment with mutual benefits, for students and educators. Academic educators can produce resources to face the teaching burden, and gather the opportunity to increase personal productivity. Students can take advantage from being engaged in innovative learning environments where educators act as catalysts for learning, instead of just transmitters of knowledge.

Keywords
basic science, medical education, peer-reviewed learning resources, virtual lab
The role of basic science in the medical curriculum

The intrinsic value of basic science in medical education and clinical practice is no more questioned. Since the age of Abraham Flexner (1866-1959), who first recognized the importance to link preclinical and clinical knowledge (Flexner, 1910), incorporation of basic science into the clinical contents has become a main goal of curriculum reforms, and has generated multiple experiments of integration at the level of programs, courses, and day-to-day activities (Kulasegaram et al., 2013).

Almost a century of research and experience in the field have lent evidence that teaching basic science in the medical school provides the fundamental knowledge for medical practice, builds the appropriate context for learning, impacts on the development of inquisitive and critical minds (Lisk et al., 2017), and provides essential tools to face with complex contexts whenever clinical cases depart from the routine (Woods et al., 2007).

To best integrate basic science and clinical medicine, MD-PhD programs have been also launched in many academic institutions, with the aim to reinforce the use of basic science knowledge at the end of medical program, when students can better appreciate its relevance in practice (Spencer et al., 2008).

As a matter of fact, integration of basic science and clinical contents is still a matter of debate, and a challenge. Herein, I discuss why and how scientists should invest in producing innovative resources to teach basic science in medical courses and to facilitate integration of different types of knowledge in the medical courses.

Bearing in mind that integration of basic science and clinical medicine goes beyond this level of intervention, I am nevertheless convinced that involving scientists in the production of scientifically validated educational resources could have mutual beneficial effects, for students and educators. This personal view relies on a long-lasting experience of teaching in a medical school (University of Padua, Italy) where basic science courses are grouped within the first 2-3 years of a 6-year medical program.

Teaching basic science to medical students: a challenge for scientists

The explosion of biomedical discoveries has changed our interpretation of diseases at an unprecedented speed. Progression of nontraditional disciplines, such as bioinformatics, nanotechnology, imaging and bioengineering, has also contributed to gain insights into complex mechanisms of human function and pathologies. All scientists agree that students should be aware of the potential impact of scientific progress in medicine (Anderson et al., 2011). However, translating scientific advances into teaching has become extremely complex. Main problems are how to balance contents, where to put the appropriate boundaries between essential and specialized knowledge and how to avoid the overflows of data that can challenge memory and retention, but do not provide substantial contribution to learning. On the other hand, using simplified learning tools can be harmful because they can glue the medical students to old and dated contents largely overcome by new knowledge. One of the mistakes scientists often do as educators is to arrange scientific contents keeping the same level of details as if they were in front of an audience of experts. This has two consequences. The first is the lack of a real students engagement, since activities are centered on educator’s research and scientific fame. The second is that in the context of medical courses such learning resources run the risk to be “lost in translation”, insofar as educator scientists lack practical knowledge of clinical contexts where such discoveries can be applied.

I believe that academic scientists should be in the front line to translate biomedicine, with its basic contents and new discoveries, into innovative resources for education. Scientific journals and journals of education should provide a platform to host such resources on a regular basis. There are some virtuous experiences in this field, but they have too limited impact on teaching. In 2010, to provide new opportunities for science education, PLoS Biology launched PLoS Education (Kerfeld and Gross, 2010), an editorial series of articles and associated resources to teach life science by applying a discovery-based approach and contemporary research methods. With this smart initiative, for the first time research-based teaching activities were hosted in a research journal. Recently, PNAS offered a Teaching Resources Portal containing Core Concepts articles that explain a trending topic in a given field, and allow downloading figures, tables and podcasts for classroom discussion. In the area of clinical medicine, The New England Journal of Medicine provides an enormous repository of texts and videos of clinical cases, which can be adapted to different learning contexts.

Up-to-date, hundreds of learning tools are available on the web, but in most cases they are neither scientifically designed nor tailored to the needs of medical courses. Educators would greatly appreciate having scientifically validated learning tools as digital, easy-to-use and flexible resources. Such resources should be produced and “published” according to specific guidelines, terms and conditions. A peer-review process should ensure their quality, in terms of contents and use of cognitive science methodology. Such learning resources should include basic science knowledge and scientific advances, and should be designed to facilitate mutual links and integration with clinical cases. Innovative learning
resources should also host virtual lab experiences, whose function is remarkably important in supporting scientific training of medical students. Up to date laboratory experience is lacking in many medical curricula and interest in research and translational medicine has fallen into a deep crisis (Carnevale, 2003; Roberts et al. 2012; Waldrop, 2013).

**Investing in basic science teaching: costs, recognition and benefits**

A big hole still separates science and the teaching of science in the academic environment. Some reasons concern the perception that scientists have of their role as educators. Many academic institutions do not reward good teaching and do not even invest in innovative teaching (Anderson et al., 2011). Good teaching and good research run the risk of becoming mutually exclusive, and a largely diffused opinion is that teaching is part of the job, but does not represent a good investment for career. Studies confirm a negative association between excellence in science/clinics and the quality of academic teaching (Marsh and Hattie, 2002).

Despite academic recognition, teaching remains a demanding mission to which many academic educators dedicate passion and big efforts. Traditional lessons and traditional books are no longer adequate to cover the continuous expansion of knowledge in biomedicine (Schwartzstein and Roberts, 2017). Building up new learning tools is difficult, time-costly and does not always result in efficient and innovative instruction. Therefore, investing in continuous production of learning resources for biomedical education is strategic for a number of reasons. From the students’ point of view, most important advantages can be: a) quality of learning; b) integration of basic and clinical contents (Ausiello, 2007); c) more involvement in biomedical research. From the educators’ point of view, I consider: a) the possibility to generate learning resources as academic “production”, combining expertise in research with teaching; b) the possibility to have a repository of new learning tools - a Resourceome for Biomedical Education (Cannata et al., 2005) - ready to use for building up personalized learning activities.

Finally, I want to consider one last point, which probably represents the most important aspect of this personal reflection. I mean the possibility to focus on integration of contents instead of mere contents. Having a good repository of ready-to-use teaching tools would allow teachers to focus on how to organize interactive and engaging teaching, promoting their role as mentors rather than content communicators (Biggs, 2003). It is a widespread belief that an efficacious integration of basic and clinical science does not simply arise from placing contents in close proximity, because integration occurs within students’ mind, not in the curriculum (Woods, 2007; Kulasegaram et al., 2015; Kulasegaram et al., 2017; Lisk et al., 2017). Rapid access to scientifically validated learning resources should enable educators to redirect their efforts to other goals: generate the right causal relationship of basic and clinical contents; support students to view basic science knowledge from the perspective of their application (Schwartzstein and Roberts, 2017); align curriculum and teaching methods to achieve the desired learning outcomes (Biggs, 2003; Bandiera et al., 2017).

**Take Home Messages**

- New learning resources are necessary to teach advanced basic science in medical courses.
- New learning resources should be generated by scientists, peer-reviewed and published on a regular basis in scientific journals.
- A repository of high quality resources for biomedical education would facilitate integration of basic and clinical contents and organization of relevant, student-centered activities.
- It’s time to link research and education as mutually beneficial, not conflictual activities.

**Notes On Contributors**
Simonetta Ausoni is Assistant Professor of General Pathology at the Medical School of the University of Padua. She is a biomedical scientist in the field of Cardiovascular Research. She has been involved in evaluation and curricula design for medical programs. She is member of the Committee for Accreditation and Evaluation of the Medical Course of the University of Padua and member of the group of Medical Education in the Medical School of the University of Padua.

**Declarations**
The author has declared that there are no conflicts of interest.

**Ethics Statement**
This is a personal view with no new or raw data.
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Hassaan Waqar
St Helens and Knowsley Teaching Hospitals NHS Trust – Lead Employer

This review has been migrated. The reviewer awarded 3 stars out of 5

An interesting opinion piece on the teaching of science at medical school. The abstract is a concise summary of the themes explored within the paper. In the introduction, the author highlights the importance of teaching basic medical science in medical school and identifies the aim of the opinion piece. The challenges that exist when scientists are tasked with teaching science to medical students are discussed and their potential solutions are explored. Some of the hurdles in the delivery of teaching science at medical school are explored, namely cost and time required to develop new tools for learning. The take home messages are appropriate and neatly summarise the potential solutions to the problems discussed in the article. Overall, the article is an aspirational piece, in which the author has presented their view on how science can be better integrated into the teaching that occurs at medical school. Perhaps this integration could be achieved through collaboration between doctors and scientists in order to teach science effectively to medical students.

**Competing Interests:** No conflicts of interest were disclosed.
School of Medicine, University of Lisbon

This review has been migrated. The reviewer awarded 4 stars out of 5

It was with great interest that I read the author's reflection on the need to make the learning of basic science relevant and meaningful. The author defends the focus on 'integration of contents instead of mere contents'. The interest in this topic is not new: Flexner, more than a century ago was the first to 'recognize the complementary roles of basic and clinical cycles' and 'integration as a challenge for medical education and all stakeholders' was one of the recommendations of the 1988 Edinburgh Declaration just to mention two landmarks. Despite thirty years had elapsed after Edinburgh, the interest in the topic is growing to improve the current curricular integration models in practice, so far. The 'lack of value attributed to teaching namely when compared to research', the 'lack of resources' and other barriers, are reported by the author with examples on how they can be overcome to achieve curricular integration. According to him, 'integration must be 'a challenging priority for medical and other health care schools requesting Faculty investment'. The author's statement 'new learning resources should be generated by scientists, peer-reviewed and published on a regular basis in scientific journals' may benefit from the complementary perspective proposed by Megan Anakin, a reviewer of this paper, who proposed 'team effort as a possible alternative, namely a small resource building team consisting of academics that include a scientist, a medical practitioner, an education expert, and possibly a senior medical student'. Investing in the complementary of teaching and research is crucial if we want to see integration models to progress. The author, which last take home message stated that 'it's time to link research and education as mutually beneficial, not conflictual activities' also recognizes this need. Increased collaboration, one of the four global medical education trends identified by Harden et al. in his 2018 paper 'Analyzing Forty years of medical education through the eyes of Medical Teacher: From chrysalis to butterfly', is also fundamental if we want integration models to progress. This is why this paper could have been entitled 'Turning science into teaching: a challenge for scientists and teachers', instead of just 'Turning science into teaching: a ‘challenge for scientists’.

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P Ravi Shankar
American International Medical Medical University

This review has been migrated. The reviewer awarded 4 stars out of 5
I read with great interest the personal reflection by the author on incorporating learning of the recent advances in biomedicine into the basic sciences. I agree with the author that this presents a major challenge. I work in an offshore Caribbean medical school where the curriculum is accelerated and students complete the basic sciences within 20 months. This creates a number of challenges for students and faculty members. Integrating the basic sciences into clinical diagnosis, management and treatment is difficult. A number of unconventional areas like artificial intelligence, genomics, genetic engineering and robotics among others are playing an increasingly important role in medicine. Recognizing the appropriate level of knowledge and detail for an undergraduate medical student is an important task for an educator. In many parts of the world doctors with a basic qualification in medicine pursue advanced degrees in different basic science subjects like anatomy, physiology, pathology and pharmacology. I believe this provides advantages in understanding the clinical significance of the advances in the basic sciences and biomedicine. The MedEdPortal hosted by the Association of American Medical Colleges provides learning resources for teachers and faculty. These resources created by different medical educators are peer reviewed and freely available online.

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practitioner, an education expert, and possibly a senior medical student. This way, the academic that produces the scientific knowledge can work alongside an academic who will need to apply that knowledge in practice to provide patient care. An educational expert will help the team to focus on how the breadth and depth of that knowledge can be conveyed to students in ways that are educationally sound and promote active learning. A senior student will provide an additional perspective that can be used to fine tune the deployment and assessment of the resource. The problem of producing more resources that are “neither scientifically designed nor tailored to the needs of medical courses” will persist unless we address the process of producing resources while developing expectations and standards for the ‘content’ the resources. Thank you for making me think deeply this morning.

**Competing Interests:** No conflicts of interest were disclosed.