5.3 Global challenges in research and strategic planning

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Health sciences research is experiencing dramatic progress. How can dental schools throughout the world best make these research advances relevant for dental students, as well as providing them with the means to assess and utilize the research advances that will occur in the future? This complex question presents a critical challenge to the dental educational community. Research is clearly integral to the mission of dental education. By providing dental students with active learning strategies, dental educators can inculcate the ability for independent scientific thinking and thereby develop reflective as well as technically competent practitioners. However, there is a shortage of well-trained individuals to fill faculty and research positions in certain parts of the world. Global networks for mutual information exchange are imperative to overcome resource limitations in individual institutions, as is dedicated funding for research in the dental educational setting.

Key words: health sciences; lifelong learning; research; scholarship.

Introduction

The charge to this Section is to address the following question. How can dental schools throughout the world best make research advances relevant for dental students, as well as providing them with the means to assess and utilize the research advances that will occur in the future? Research in the health sciences is experiencing dramatic progress and new knowledge is being acquired at unimagined rates (1, 2). It is anticipated that many of these advances will lead to improvements in oral healthcare if they are utilized by dentists or other clinical care providers (3). For example, in the past 2–3 years, a number of remarkable biomedical landmarks have been achieved. First, there has been the widely publicized sequencing of the human genome (4). Additionally, stem cells, progenitors capable of regenerating intact, well-differentiated organs, have been isolated from many adult tissues (5, 6). Bioengineering advances have led to the development of approved, clinically useful artificial tissues (skin, cartilage) (7). The first successful human gene therapy experiment, enabling immunosuppressed children to thrive in the natural world, has been reported (8). Novel methods to develop drugs, such as combinatorial chemistry, have dramatically changed the way pharmaceutical companies now conduct their research (9). Such methods are yielding newer, more specific and more powerful therapeutic agents. Although biomedical research represents just one facet of the health sciences research affecting dentistry, the recent progress in biomedical science has been truly extraordinary (10, 11).

Dental educators appear to be facing a significant dilemma (12, 13). They are challenged by the seeming necessity to provide adequate training for students in the health sciences, given the already full course load and demands to acquire technical skills necessary to provide restorative, prosthetic, periodontal and other dental services. This circumstance, for example, has been made especially problematic, given the extremely rapid rate of progress in biological sciences (14). Basic health science courses consume a substantial portion of curriculum hours in dental schools. Additionally, in these schools, many faculty members are engaged in health sciences research. Regardless of the strength of the research programme, and the number of curriculum hours devoted to teaching the health sciences, it is
unfortunate that, for the most part, there appears to be little lasting impact of science on dental students as they enter clinical practice (15).

Perhaps initially it is most important to ask if dental students in fact need to know about and understand modern health science developments (16). Do dental students need to have a research experience? Will dental students use the tools being generated by modern biotechnology and informatics in their training and in their future practice? If the answers to these questions are ‘no’, then there really is no dilemma for dental educators. However, from our viewpoint, the answer to each of these questions is unequivocally ‘yes’. If dentists are to be the primary health practitioners responsible for the oral cavity, then knowledge of the health sciences is integral to providing high quality care for their patients (17). There is an abundance of data to argue that oral health is essential to general health (18, 19), that in the words of the old dental school adage, ‘the mouth is connected to the rest of the body’. Thus, the biological mechanisms operative in, and behavioural mechanisms affecting, oral tissues are the same as those operative and influential elsewhere in the body. Consequently, it is fair to suggest that any scientific developments related to the human condition will have an effect on oral as well as general aspects of health (14). This effect will likely be uneven, affecting some areas of clinical practice to a different degree than others. The issue for all of dentistry is clearly not whether, but rather when, and to what extent.

Dentistry will not be practised in 30–50 years as it is today. A major factor affecting the future of dentistry arguably will be biology (14). A hint of what is coming can be seen from some recent research findings. For example, a synthetic small peptide has been shown specifically to block the *in vivo* adhesion to human teeth of *Streptococcus mutans*, the principal caries causing bacteria (10). Also, a genetically re-engineered form of the commensal bacteria *Streptococcus gordonii*, which is able to secrete a candidacidal single chain antibody, can stably colonize mucosa and prevent mucosal candidiasis (11). Maybe, because of combinatorial chemistry, effective and inexpensive mouth rinses that can efficiently disrupt dental plaque will be developed. Possibly, natural antimicrobial proteins and growth factors will be used to treat carious lesions, i.e. providing a biological restoration in a tooth. Equally, progress in health promotion and public health research may significantly alter the pattern of dental and oral diseases which could have a fundamental impact on dental education.

While the problem of making the health sciences practical and relevant for dental students is significant for all dental educators, the dimensions may vary within and between countries. In emerging countries, there may be much more pressing concerns – notably, the provision of ‘simple’ primary and preventive care to all citizens. How do dental educators in these and industrialized countries include biology while training technically competent practitioners? In industrialized countries, dental students take many health science courses. However, the knowledge gained typically is not used clinically. Most dental students have little or no reinforcement of the health sciences, regardless of the extent of their coursework, during their years of clinical/vocational training (15). Completing their science courses has become merely a rite of passage for most dental students. Thus, paradoxically, while dental students in industrialized countries have numerous technological advantages over their counterparts in emerging countries, benefit from the sciences is not among them.

The central problem for this Section is to find ways to make the health sciences relevant for all dental students, wherever they live. Progress in science will lead to better health and health care. If dentistry lags behind the rest of medicine in using biotechnological, behavioural and public health advances, then it is at risk for becoming unimportant to providing primary health care (14, 18).

**Parameters within which the Section decided to work**

1. Modern cell and molecular biology has had little impact on the practice of dentistry.
2. Progress in science is too rapid to teach everything that is important and relevant to students during dental school.
3. Biological processes occurring in the mouth are mechanistically the same as similar biological processes elsewhere in the body.
4. Progress in all health sciences (i.e. biological, behavioural, social, public health) will lead to changes in dental education and practice in the near (10–20 years) future.
5. There is only one standard for scientific inquiry.
6. Scholarship is an essential activity for university-based dental educators.
7. Dental schools should teach students to use the methods of scientific inquiry when addressing clinical problems.
8. Dentistry as a scientifically based, university-trained profession will move closer to medicine through advances in biomedical science, behavioural and social science, and public health research.
9. Easy internet access to current scientific literature is essential for all dental students and dental faculty members.
10. Partnerships between research scientists and educators throughout the world will benefit everyone.

**Best practices and innovations**

The overall aim is to translate research and research findings into dental education, and train the students to apply this new knowledge in a context relevant to their particular practice. The accumulation into dental courses of the knowledge explosion would require a rapid exponential growth of the dental course which would be impossible to achieve. The solution lies in the promotion of lifelong learning allied to the acquisition of a research mentality by the student. In this sense, the dental education programme extends to a professional lifetime of which only the first 5 years are spent in dental school (20, 21). Thus, the key element in any dental school programme should be to teach the student how to learn and how to discern what needs to be learnt. This is augmented and facilitated by inculcating a research orientation that pervades all aspects of their learning and clinical practice (22). It is epitomized by the constant application of the question ‘Why?’.

- The first example of best practice is found in educational methodology. Learner-centred activities, such as problem-based learning (PBL), offer at least one solution to this problem, particularly if augmented by specific training in research methodology and group involvement in project work.
- The second instance is within the area of institutional benchmarking, consisting of the continuous application by the dental schools of internal and external monitoring. The networking of groups of schools with a broadly similar practice environment for their graduates will reinforce this approach. Examples are: the Universitas 21 scheme and the recently developed network of Australian and New Zealand schools, the so-called ANZDENTAL scheme (Australian New Zealand Dental Education Network for Teaching and Learning) (20, 21).
- The third instance of best practice is to ensure the translation of the research orientation into clinical-practice education by appointing clinical leaders who themselves have a demonstrably rigorous scientific training in fields applicable to dentistry. In practice, the first step would be to apply this to the heads of clinical units since they are most influential on the curricula and attitudes of students. However, ideally, all faculty/staff should be so equipped. The application of the research assessment exercise in the UK is currently making this a reality in that country.

Arguably, the conduct of high quality research, basic, clinical or both, is in itself a ‘best practice’ for a dental educational institution. With a high quality research operation in place in the faculty, training opportunity, involvement in curriculum and cultural values for research are all within reach (15, 23, 24). Without ongoing faculty research activities, all become difficult if not nearly impossible to realize. A strong ongoing research programme in the faculty does not guarantee that transfer to students will happen, but it does enable this transfer if desire and facilitation are also present.

Therefore, a further instance of a best practice is that research is dependent on competitive auxiliary funding (e.g. the NIH in the USA, or the Medical Research Councils in the UK, Canada and Sweden). In the USA, a substantial one-time infusion of support in a receptive setting has had lasting effects, and perhaps should be emulated when it is possible to do so. The five institutions that were the recipients of an initial funding push by NIDR to attract researchers from other fields to the oral health research field have generally maintained a leadership role over a 40-year period (the original ‘Dental Research Institutes’ at Univ. Alabama, Univ. North Carolina, Univ. Michigan, Univ. Pennsylvania and Univ. Washington).

**Impact of information and communication technology**

Science research and technology transfer should be included early in the curriculum. A worldwide database could be developed with the aim of reaching general consensus. The latter could be a discussion forum from where information can be drawn by educators and students alike (e.g. DentEdEvolves). The greatest changes resulting from information transfer will be that access to scientific knowledge will be available to all and the volume of information will continue to increase at an exponential rate. Teachers, students and patients will have access to new, unproven and unverified scientific knowledge at exactly the same time. It will be very easy to access other departments, research institutions, scientists, authors, etc. to ask questions and generally to become more directly involved. For example, students and researchers will be able to do this without consulting or seeking help from their own faculty. As the electronic communication
grows, the world scientific language will very probably be English and all research of international calibre will, at the very least, have English summaries. This will provide a much broader view of many topics, because the developed and developing world differ in epidemiology, treatment needs, philosophy of care, scientific philosophy and methodology, etc. Rapid global communication will also break down both national and cultural barriers and promote transnational and/or cultural projects.

How to converge towards higher global standards

There need to be recognition and acceptance of the core values listed below, with adaptations as needed to the society in which the school exists.

Important regional and continental differences

The curriculum of each institution should reflect the societal situation, norms and values in which its graduates will function (see core values). There are important regional and continental differences. Among them are: language; level of educational preparation prior to admission to dental school; resources available; cultural values in the population and within higher education; political realities influencing admission and graduation; disparities within the population served (e.g. rural vs. urban). Such differences lead to the necessity of having variable components of curricula to supplement a basic core curriculum which can be more universal.

The core must include the ability to understand health management and communications research, education in professional social responsibility, and the scientific method and terminology. The variable or optional components should address the local and regional needs, and will vary accordingly. Some should be defined by the institution and some should be at the preference of the student. The core curriculum, supplemented by optional components that vary by region, may need to be complemented by methods to accommodate movement of professionals (e.g. from one country to another), or significant changes of a population within a region (e.g. by mass immigration). Such methods may include additional education, or qualification by re-examination. Research, at a more advanced level, may be one of the optional components of the educational environment, such as beyond the basic core of scientific method and terminology, in accordance with the resources and values in the region.

Considerations not otherwise covered

Examples of major advances in health sciences (basic, clinical) that have occurred in the past few years: human genome sequence and also that of several important oral pathogens (4); molecular messengers, i.e. growth factors (25), cytokines, chemokines, receptors; foetal stem cells and adult stem cells; plasticity of neuronal function and related advances in neurobiology; molecular markers for cancer development (26), progression and prognosis; understanding apoptotic pathways; human gene therapy (27); nanotechnology (28); DNA vaccination technology (29); structural biology and drug design; proteomics; socio-psychological and behavioural aspects of health; advances in computer technology and informatics; aspects of bioengineering related to imaging, biomaterials (30, 31), implants.

Implications and potential for emerging countries

1. There are more pressing problems in providing fundamental primary and preventive care.
2. Educational systems, and the existing research ‘culture’, may not encourage questioning by students or junior researchers, i.e. the essence of science. Thus, students do not learn the skill of asking precise questions, which is critical to being a good diagnostician.
3. Students have little exposure to modern biomedical research journals.
4. Students (may) have limited internet access.
5. Students (may) have limited exposure to medicine.
6. There is limited integration of science (research findings) into clinical training. Indeed, ‘science’ and the clinic may be kept wholly separate in some countries.
7. Faculty members do not generally conduct ‘cutting edge’ research, and thus do not keep current with research advances.
8. There are insufficient funds to support high quality faculty research and, thus, high quality research experiences for students.
9. There are insufficient funds to support faculty to travel to attend top-flight scientific meetings. This limits faculty exposure to novel ideas and prevents faculty from having their existing ideas intellectually challenged.
10. There is an insufficient number of junior staff for small group tutoring.
11. Insufficient knowledge of the English language may prevent students and staff from using internet information.
12. Existing limitations, however, should not stop epidemiological and health survey research, plus collaboration with national and local health services.

Core values applicable to all

As a scientifically based profession, we must remain flexible towards new knowledge and its applications. As an example and application of this, we note that: Truth changes. Thus, periodontal disease was once thought to be due to calculus, i.e. we have changed from a mechanistic concept to realization of an infectious disease. Previously, caries was thought to be caused by *Lactobacillus* – now *Streptococcus mutans*. Application of the above core value requires problem-solving skills.

*Example/application:* This skill does not necessarily come from PBL, but it could come from PBL.

Clinical practice should be evidence based.

*Example/application:* Replacement of a single missing posterior tooth in most instances is not necessary.

Students need the ability to assess scientific literature.

*Example/application:* A student could graduate from some dental schools without having ever read an original scientific paper.

Application of new approaches to teaching must be based on evidence that the approach is effective.

*Example/application:* Does the use of evidence-based dentistry in the curriculum enhance clinical competency over traditional teaching methods?

Does evidence-based thinking transfer into practice after students graduate? Research applicable to dentistry should encompass the full range of research applicable to the human condition.

*Example/application:* Research in the humanities (including ethics and jurisprudence), engineering, etc.; qualitative studies of the effectiveness of teaching; and health services research.

Dental education and, as an extension, dental research must be culturally and socially relevant to the society in which they take place. Oral research must be seamlessly linked to the mainstream of science.

*Example/application:* Development of biological bonding materials originated in materials science, i.e. an interflow with dental materials science; biofilms.

Dental education requires investment in access to the knowledge base.

Example/application: PubMed/Medline/electronic textbooks.

Conclusions

- Research is integral to the mission of dental education.
- The practice of dentistry has not taken advantage of the advances in modern cell and molecular biology (14, 18). This may have arisen from a translational problem in relation to the rapid scientific development.
- Active learning strategies are useful to inculcate the ability for independent/scientific thinking in dental students – the reflective practitioner (20, 21).
- The shortage of manpower to fill faculty or research positions in certain parts of the world will be a barrier to achieving the above (23, 24); data on this problem are lacking from a major part of the world.
- Global networks involving dental educational institutions for mutual information exchange are imperative to overcome resource limitations in individual institutions.
- Dedicated funding for dental, oral and craniofacial research in the dental education setting is useful for advancing the research integration into the educational environment.

Building and growing a thematic network

We should build on existing structures where possible, rather than creating new ones. Dental education is in the fortunate position of having already established a thematic network within which further development can take place. That framework is the International Association for Dental Research. The Australian and New Zealand dental schools have come together to share teaching and learning resources within the Australasian context. Dynamic web-based PBL and sharing of resources/problems are valuable.

Recommendations, realistic goals and a time frame

1. Dental schools adopt an educational methodology that promotes critical, analytical thinking and lifelong learning in the context of the continually changing knowledge base.
2. The curriculum of each institution should reflect the societal situation, norms and values in which its graduates will function.
3. Institutional, local, national and international agencies responsible for dental education and health care delivery should make strategic investments in oral health research. Such investment is essential for the development of dental education and evidence-based care.

The realistic goal for recommendations 1 and 2 would be that a criterion for a dental school’s monitoring process should be to demonstrate the educational methodology used to achieve those recommendations.

The goal for recommendation 3 is that dental schools bring this recommendation to the attention of the relevant authorities.

The time frame for recommendations 1 and 3 is 2 years; for recommendation 2, it is 2–5 years.

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