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Teaching and Research: Opposite Faces of the Same Coin?

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Many would view teaching as the primary occupation of a university lecturer, but I consider research as being equally important, as the two are opposite faces of the same coin of "knowledge". This is because teaching is the dissemination of knowledge, concepts and facts, and the stimulation of ideas in younger people to help them to develop their minds and their skills. On the other hand, research is the gathering of new findings, which contribute to the global knowledge base. Research not only provides the information that teacher depends on, but may also have many potential applications that lead to improvement in the health and wellbeing of mankind.

For many staff, teaching and research compete with each other for the available time. But, there is a proverb of unknown origin, which says that "He who does not research has nothing to teach". Thus, research strengthens teaching by keeping the teachers up-to-date and mentally active, and providing them with novel ideas, materials or approaches, gained through personal experience. Indeed, many years ago, when the California Institute of Technology wanted to revise the first year physics course to make it more exciting, they invited Richard Feynman (Nobel laureate in Physics, 1965) as lecturer[1]. The two-year course (1961-63) was taped and later written up as the Feynman Lectures on Physics[1], which gained renown as an excellent introduction to modern physics. Conversely, teaching is beneficial to researchers in making them weigh the importance of conflicting ideas in the field, and organizing their thoughts and concepts in a logical coherent sequence, suitable for dissemination to students. In addition, interaction with students can often raise interesting questions, worthy of future research. Most importantly, research is an excellent method for teaching, not only for postgraduate students, but also for advanced undergraduate students. This is because research helps the student develop various capabilities, such as solving problems, keeping up-to-date with recent advances, thinking in a critical and creative manner, and learning how to learn.

Not only that, but it is also possible to do research on teaching. I will take some examples from the work of my colleague, Dr. Bhinyo Panijpan and myself, which started in the late 1970's. At that time, equipment was still limited in provincial universities, so, when many former postgraduate students became staff at a provincial university, they were disheartened to do research by poor equipment and facilities. Consequently, we tried to show how one can do research, at least on teaching, with limited resources and equipment, and still publish in international journals. One such activity was the design of new laboratory experiments for students using little or no equipment. An example of this was an experiment on enzyme activation and inhibition, which could be performed with just pineapples (as source of bromelaine enzyme) and low-fat milk (as source of substrate). This experiment was first published as an article in the journal *Biochemical Education*[2], and was later included into textbook collection of laboratory practicals[3]. It is not only less expensive and suitable for departments with limited budgets, but also increases the relevance of teaching by making use of locally available materials for student laboratories.

Another activity was to discuss conceptual errors that are common to several textbooks[4]. Subjects like biochemistry are very broad, and not only cover many concepts, but include even more detailed information, so it is difficult for any one author or even a group of authors to be expert over the whole field. Thus textbook authors may make conceptual errors in areas where they do not have personal experience, which may be detected by someone who has personal experience through doing research in that area. Understanding such errors teaches the student to read with discretion, not to believe everything that is written, and also shows them that the truth is learned through research. Of course, it also helps the teacher provide the correct concepts and information to students, rather than perpetuating the errors to future generations.

A related activity is to discuss novel concepts, which

have not yet reached textbooks. New knowledge and concepts take time before they are accepted worldwide, and even more time before their importance is fully appreciated. Yet, a teacher sometimes needs to explain such concepts or techniques to students before they are discussed in textbooks. Thus, we published a paper explaining the concepts behind SDS-polyacrylamide gel electrophoresis[5] in 1977, ten years after the technique was first described, six years after this author used it, but still years before it was described in textbooks. Gratifyingly, a search of the worldwide web shows that our paper is still used as reference reading in some laboratory courses overseas[6]. All this shows that research not only helps the teacher to know the correct information, but lets him/her have access to that information before others.

We have also taken surveys of the status of biochemistry[7] and course content in biochemistry[8] throughout Thailand. This was initiated by the increase in the numbers of degree programs at all levels at various universities in the early 1990's. Some of us at the Biochemical Section of the Science Society of Thailand wanted to know the status of biochemistry teaching throughout Thailand, in terms of the B.Sc., M.Sc. and Ph.D. degree programs and the staff available for teaching them[7], so as to gauge the assistance needed by emerging departments. This led to a survey of the course content of basic courses in biochemistry for science and medical students[8], to try to determine what knowledge should be required for a "core course" in biochemistry. Such work increased awareness at all biochemistry departments, and I hope, increased networking among them. A major emphasis in all this teaching-related research was to publish in international journals to demonstrate that it is possible to do research at international level with rather simple facilities. While the above description has tended to emphasize the benefits of research to teaching, many of the questions actually arose from teaching. Thus, the need to develop inexpensive laboratories of local relevance led to a search for simple enzyme assays that required no instruments, followed by further research on how this assay could be used to demonstrate various concepts in enzymology. Similarly, textbook errors were detected during the course of reading textbooks, while preparing to give lectures.

Personally, I have spent more time in teaching postgraduate students than undergraduate students, since our department does not run an undergraduate degree program in biochemistry. Since Thailand still has a shortage of qualified research scientists, many postgraduate degree programs have been started in recent years. In addition, various schemes have been initiated to support these degree programs, such as the Thailand Research Fund Golden Jubilee Program, the Asian Development Bank Postgraduate Education and Research Training Program, and the Commission on Higher Education's Postgraduate Education Development Programs and the Collaborative Research Networks. However, since more degree programs are now being offered by many universities/departments with varying degrees of academic and research capability, it is important to maintain the quality of the graduate students being produced, particularly with Ph.D. graduates, since they will become the research leaders of the future. In this connection, the International Union of Biochemistry and Molecular Biology (IUBMB), concerned about the proliferation of Ph.D. degree programs worldwide, have produced an excellent monograph on the *Standards for the Ph.D. degree in the Molecular Biosciences*[9], which draws upon the experience of some 100 biochemists from more than 50 countries, including Thailand. The philosophy behind these guidelines is generally applicable to Ph.D. programs in most areas of science, and as the current Dean of the Faculty of Graduate Studies at Mahidol University, I would recommend anyone involved in producing Ph.D. graduates to read them.

The IUBMB guidelines are too detailed to be summarized in this short space, but the key is that "a holder of a Ph.D. in the Molecular Biosciences should have the knowledge, skills, perspectives and understanding to be capable of self-directed scientific work of a quality satisfactory to others in the field"[9]. This should, of course, include performing work publishable in an international journal. In Thailand, I am pleased to note that publication in an international journal is now required in all Ph.D. programs in science. But acquiring a Ph.D. is just the start in the career of a researcher or university academic. As argued above, university staff should not only teach, but also do research. Eventually, as they become more productive, staff will advance in their careers, and be promoted to Assistant Professor, Associate Professor, and Professor. During this time, the staff member gradually develops his/her research, becomes more independent, and establishes his/her own research group, eventually becoming an authority in the field. Researchers at institutes will tend to develop in a similar manner, except that they are likely to be exempted from teaching duties, but at the same time, forego the benefits of academic positions.

This transition from research student to independent investigator is not an easy one. Overseas, before obtaining tenured positions, many new Ph.D. graduates will work for a few years with more

established investigators, often in other countries, to broaden their perspectives in research and obtain additional experience, as the final preparation to develop into independent investigators. This postdoctoral training may also be regarded as a form of teaching, although it is more implicit, rather than explicit teaching. However, in Thailand, since there are so few Ph.D.s, most will readily obtain permanent positions upon graduation, so that there are few postdoctoral researchers in the same sense as abroad. But starting a high-quality research program in Thailand is often difficult, since resources and infrastructure for research may still be limited. That is why mentorship of young Ph.D.s is so important, in my opinion.

Some funding agencies, such as the Thailand Research Fund, have established postdoctoral level research grants, for which young Ph.D. graduates may apply on the condition of having a senior scientist as a mentor. Presently, I am a mentor to 17 Ph.D.s in my Thailand Research Fund Senior Scholar Grant, including 12 young Ph.D.s from 8 different universities. To my mind, the role of the mentor is to help young Ph.D. graduates settle down, establish their own laboratory and develop into independent investigators. Mentors may help the young researchers in various ways, for example in developing a grant project, by suggesting possible research strategies, providing small laboratory items or money to hire a research assistant, by making laboratory facilities available, by helping with specialized analyses, by critical analysis of research done and manuscripts written, and by writing letters of recommendation for grants and travel fellowships. Thus, mentorship of young Ph.D.s is another form of teaching, teaching by advice and example. In this way, the postdoctoral researcher sees how the mentor works and solves problems *in the context of Thailand*, and assimilates the "knowledge, skills, perspectives and understanding" of the mentor, which helps nurture him/her into a productive independent investigator.

In this article, I have tried to accentuate the linkage between teaching and research, so that staff and administrators should not think that teaching and research are contradictory elements, but that they mutually reinforce each other. I hope that as Thailand develops, higher proportions of university staff will do research and produce more work publishable in international journals. Thailand is now more productive in research than before, and in 2005, was 2nd in ASEAN, 7th in Asia and 43rd in the World in terms of international publications listed in Institute for Scientific Information–Web of Science databases[10]. However, we still need to strengthen our scientific infrastructure and increase our research efforts to keep up with the rapid advances in the world, otherwise we will be no longer be competitive with other countries[11]. With the many local Ph.D. programs, as well as government scholars sent to study for Ph.D.s abroad, more young scientists will graduate each year. It is vitally important that these young people can start research within 3-5 years after graduation, otherwise they will never return to research. Administrators at universities, faculties and departments must ensure that young people are freed from administrative duties and supported to do research, in addition to performing their teaching duties. Senior established investigators are also needed to provide encouragement, advice and help as mentors. Scientific research is essential for our country to compete in this knowledge-driven world, so we must mobilize the young researchers in our country to do research. Otherwise, we will waste the most valuable resources of any country, its people.

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