Review

Teaching Pharmacology in 2010 - new knowledge, new tools, new attitudes.

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Abstract. Changes in pharmacology teaching are being driven by various pressures. These originate: from changes in the discipline itself; from government; from professional bodies; from students; from changes in teaching styles and opportunities; from academic staff; from ethical/animal rights considerations; from employers and from higher education institutions. These changes will require an alteration in the knowledge, skills and attitudes of academic pharmacologists as much as they will require changes in the way teaching is delivered and learning is facilitated. Pharmacology courses will be provided in a changed environment and must prepare students to work in a changed discipline as well as being appropriate for students who will take employment in non-pharmacology areas. Change is likely to centre around the curriculum, problem based learning, simulated practicals, peer assessment, use of the internet, information technology and interactive computer based learning, virtual learning environments and integrated medical courses. The most effective strategy to achieve the necessary changes is likely to involve collaboration between pharmacology teachers on a global scale and a general consciousness among current academic pharmacologists that we need to ensure tomorrow’s academics are well prepared for the changed environment in which they will have to work.

Keywords: Teaching pharmacology; education technology; peer assessment; innovative teaching methods; computer aided learning.

INTRODUCTION

Anybody teaching pharmacology will have noticed that things have changed over the last 15 years! These changes, which will continue at a fast pace, have resulted from pressures which are generated:
- from the discipline itself;
- from government;
- from professional bodies;
- from students;
- from changes in teaching styles and opportunities;
- from academic staff;
- from ethical considerations and animal rights;
- from employers
- and from Higher Education (HE) institutions.

While all these pressures are not equally present in every country, many are common where ever pharmacology is taught.

PRESSURES ON TEACHING

Within the discipline of pharmacology there is more information at a biochemical level e.g. on receptors, cytokines and proteomics. The discipline is more embracing of other biosciences (genetics, molecular biology, immunology) and there are more high tech tools. In clinical pharmacology there are more treatment options, the importance of genetics in drug responses has been appreciated and there is recognition of sub groups of patients who may better benefit from particular treatments. Knowledge has exploded and it is no longer possible to teach it all.

Governments are more involved in higher education. In the UK, participation of the age group in HE will rise from 43% now to 50% by 2010. Funding per student has decreased and new priorities have been introduced by government and the Higher Education Funding Agencies (http://www.hefce.ac.uk/stratplan). Institutional performance in priority areas such as
quality enhancement and assurance, widening participation, employability, retention and life-long learning will affect funding provision at institutional level.

**Professional bodies** are more involved in HE. The UK General Medical Council has defined the attitudes, skills, knowledge and attributes required in medical students (1) and inspection visits ensure institutional compliance.

**Institutions** have a greater interest in cost-effective teaching, in improving space utilisation and in living within their income. Imposed targets are passed to teaching units which will compete in the global market. Increasingly, institutions will develop diverse mission statements and will focus on their strengths. Collaboration or partnership between institutions will become closer and the UK is already seeing mergers between previously independent HE institutions.

**Academic staff** will have less time to teach because of the heavy emphasis on research and the need for staff and institutions to demonstrate research excellence if career progression and funding are to be maintained. In the UK, there are moves to enhance the status of teaching but it is unclear what impact these will have. Staff are under pressure from the shortages of technical support and the requirement for professional training as a teacher. There is little doubt that increased molecularisation of pharmacology has decreased staff who can to see the organism as a whole integrated system. Few staff now possess *in vivo* skills and the lack of teaching of *in vivo* skills is a serious problem (2).

**Employers** of pharmacology graduates have become more diverse (Fig. 1) and have changed requirements (3). The increased transience of employment means that flexibility, self-development and career management skills are increasingly valued and the decreasing proportion of pharmacology graduates entering pharmacology related occupations has emphasised the need for generic skills (4).

**Students** have become more numerous, some pharmacology courses graduating 80-100 students each year. Students have greater diversity of ability at entry, more diverse expectations and aspirations and graduates progress to more varied employment. Often less than 50% enter occupations requiring pharmacological knowledge or skills. Students pay more and have higher expectations for what they have bought. Disturbingly, many students are assessment driven and make strategic choices of what work to complete based only on its contribution to their final grade.

**Institutions** are increasingly subject to outside influence which has eroded independence. In the UK the Quality Assurance Agency has introduced Subject Benchmarking Statements, Programme Specifications, the Qualifications Framework and a variety of good practice guides (5). Institutions are more conscious of cost/benefit balances and many know exactly the

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**Fig. 1.** Percentage of honours BSc pharmacology graduates from 4 major UK universities going to different types of employment (1996 to 1998 data).
costs and income flowing from individual modules. The viability of small or expensive modules is under pressure as are expensive teaching methods (e.g. tutorials).

**Teaching styles and opportunities** have changed even over the last five years (6, 7). The use of computers (e.g. simulations and virtual learning environments), the internet and the appreciation that generic skills (e.g. communication, group working, career management, information technology) need to be explicitly taught and assessed within the context of the discipline of pharmacology has engendered enormous change. Distance and flexible learning and global education provision have also made an impact. We can no longer teach it all and there are increasing moves to teach HOW to learn and to prepare students for life-long-learning.

In response to pressures from **ethical/animal rights** issues (8) some universities have closed animal house facilities seriously limiting pharmacology teaching. Others have replaced ‘wet’ practical classes with alternatives involving physical simulations (9), computer based simulations (10, 11) and video material.

**CHANGES IN PHARMACOLOGY TEACHING**

The increasing application of these pressures has ensured a continuing move away from traditional lectures, practicals and tutorials. There will be increasing use of innovative teaching methods and educational technology to cope with the larger number of more diverse students and a smaller resource. Change will continue to involve:

- Assessment based on group and team performance as well as on individual performance.
- A curriculum more selective in knowledge content. The emphasis moving from teaching everything to creating independent life-long learners.
- Assessment moving from being dependent on one set of final exams to incorporating extensive course work, examinations distributed throughout courses and supported by a portfolio of achievement. Degree classes may not survive.
- Generic skills will be taught and assessed alongside discipline based knowledge and skills.
- Educational technology will be embraced in all its forms including mobile phones.
- Instead of students isolated within a course there will be internationalisation of student contact.
- Teacher isolation will change to collaborative development of teaching between institutions and countries.
- Problem based learning and integrated medical courses will increase.

- The problem of mixed ability teaching will come to the fore.
- The focus on efficient use of academic time for teaching will sharpen.

**INNOVATIONS IN PHARMACOLOGY TEACHING**

Some innovations in teaching which will enable us to respond to these pressures and deliver the above changes are worthy of further consideration. Particularly:

- problem based learning;
- simulated (dry) practicals;
- peer assessment;
- use of the internet;
- interactive computer based learning (CBL) including video;
- virtual learning environments;
- integrated medical courses
- and collaboration between institutions.

**Problem based learning (PBL)**

While there is debate as to whether this increases the quality of graduates (12-14) many institutions have adopted PBL methods (15, 16). Development costs are considerable and delivery costs can be greater than conventional courses. Comparisons between institutions are not easy since PBL institutions may be selected by (or may select) students with particular characteristics. The term ‘PBL-based’ covers considerable diversity and may imply exclusivity or a combination in varying proportions with conventional teaching. Some PBL courses have no set expectation of what knowledge students will acquire while others have a clear definition of what core material will be learned by all students. In some institutions the learning resources used by students to solve the ‘problem’ are closely defined which proscribes the material the student will encounter. It is interesting that some institutions now include lectures in their PBL based courses to define the limits to the expected learning. Undoubtedly more outcome information will become available from what has been described as ‘the largest educational experiment ever performed’.

**Simulated (dry) laboratory practicals**

Laboratories are not places where only laboratory skills are developed. Students may spend 50% or more of direct teaching time in laboratories and a long list of diverse items, only some of which involve laboratory skills, are learned or practised in the laboratory environment (17). It is possible that all these learning objectives may not be appropriate for every
A student on a course since 50% or more pharmacology graduates enter an occupation not requiring practical pharmacology skills. Among students of pharmacy or medicine or in first year courses where many students take pharmacology as an elective, an even smaller proportion may need pharmacology practical skills. For these students the laboratory class may be primarily concerned with illustrating theoretical concepts taught elsewhere. Simulations may be appropriate (18, 19) and a variety of pharmacological simulations have been produced including simulations of clinical trials data, ligand binding experiments and several simulations of animal preparations, e.g. Fig. 2 and also the virtual dog lab (20).

A comparison has been made of the academic performance of students using simulations with those doing traditional ‘wet’ practicals. Assessment of the practical write-ups showed that higher marks were obtained by those who did the simulation. In examination at the end of the course there was no difference in the ability of the two groups to answer questions based on the theoretical principles underlying the practical exercises (the important learning objectives) though recall of the details of the practical conditions of the experiment was less (21). Use of simulations helps to address several pressures including the need to teach students experimental design skills.

**Peer assessment**

Peer assessment (students marking other students work) is a powerful technique (22) which offers educational and other advantages (Table 1) and can be used in many different contexts:

- write-ups of computer simulations and real practical work and other computer generated exercises (23);
- oral communications and presentations (Fig. 3)(24);
- poster presentations;
- data interpretation and data handling exercises;
- marking of MCQ, extended matching set questions, short answer questions and ‘fill-in-the-blanks’ exercises
- and, less successfully in my hands, in marking long essays.

Almost anything can be peer assessed but certain features of the work make it easier to use peer assessment with minimum difficulty.

1. There should be an explicit marking schedule with material broken down into small pieces each
of which is associated with specific criteria for marks to be awarded. The work of each student should follow the same sequence of presentation (so all markers come across material in the same order) and contain much the same material e.g. work resulting from following a practical schedule. The same measurements have been made, in the same order and similar data obtained and processed the same way. Certain points will follow in the discussion. Work in year is more likely to fulfill this requirement. Final year work often has so many alternative approaches that peer marking is very difficult.

Don’t think your students are going to enjoy peer assessment! Many believe assessment is the job of the teacher (“don’t you get paid for this?”), many complain that peer assessment is hard work (“you have to think and make judgements”), and that it’s tiring (“I’m really exhausted at the end of a marking session”). Some find it difficult to concentrate for a whole hour. However, peer assessment is a win-win scenario - better learning in students and less staff time spent marking.

Use of the internet

A great deal of material is available through the internet though its quality is variable. As with computer based learning methods it is the effective integration of the material into the course which is crucial. A number of questions also need to be addressed such as:

- Will the material be available tomorrow and next week?
- Will they suddenly start charging for access?
- What happens if the host server goes down?

Use online is complicated by these uncertainties but if the material can be downloaded to a local server then fewer problems arise. Useful material can be difficult to locate but it is possible to find URLs of material utilised by other pharmacologists at www.IUPHAR.org and at www.bps.ac.uk. Other examples of available material are:

- COURSE: Allain: med.univ-rennes1.fr/edud/pharmacolab
- LABORATORIES: Dempster: www.strath.ac.uk/Departments/PhysPharm/index.html

Table 1. The 9 advantages of peer assessment

1. Provides each student with full and timely feedback.
2. Requires students to understand better the material they are dealing with since a better understanding is needed to assess somebody else’s work.
3. Reinforces learning when the material is covered again in the marking session.
4. Develops critical evaluation skills and self-criticism, essential qualities in any scientist.
5. Improves learning since it provides a second look at the material covered and learning is reinforced by feedback.
6. Enables students to see the standard others achieve and where their own work may be improved.
7. Prepares students for a work environment where they will have to assess the work of others.
8. Makes students confront the ‘personal relationship’ issue and learn to make assessments independent of any personal relationship.
9. Saves staff time and effort (I can mark 250 or more practical write-ups in one hour.)
EXERCISES: information retrieval on new drugs (25).

**Interactive computer based learning materials including video**

Normal ‘print-on-paper’ books are portable, inexpensive, easily borrowed, can be dropped without terminal damage and don’t run out of power. The main advantages of the electronic book is that, if delivered over a network, it can be updated easily and that it can offer *interactivity and animation*. These are powerful learning aids but too often authors fail to capitalise on these features. In addition, electronic books tend to cover many areas of pharmacology and are therefore difficult to incorporate into a traditional module which may cover only a small area of pharmacology. For these reasons electronic books generally have not been widely taken up as primary learning aids in pharmacology courses.

Many smaller and more specific interactive software packages (Fig. 4) are available (26) which can be used in a variety of contexts: in tutorial and small group teaching; in lectures; as a replacement for lectures (27); to better prepare students for practical work; as a replacement for practicals; to provide options within a limited course structure (e.g. special study modules for medical students); to supplement lectures enabling students to work at their own pace; to provide ongoing access to self-assessment throughout a course; to aid distance learning; as remedial teaching and to extend the student learning experience in areas which are too expensive or time consuming.

The context of use may greatly influence students perceptions of quality of a software package (28). One computer-based tutorial type learning package was used in 3 universities with students of pharmacology. The approval ratings by students in different contexts of use were:

- 90% when used in conjunction with a workbook which was assessed and a required part of the course;
- 78% when used with MCQ which had to be completed in pairs, were marked and contributed to final module grades;
- 59% when shown in a lecture and provided to stu-

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**Fig. 4.** Screen shot taken from an interactive computer-based learning program on hypertension showing an animation concerned with the mechanism by which diltiazem produced an anti-hypertensive effect.
and 49% when simply made available for voluntary use on an intranet.

Clearly, “it’s not what you’ve got but how you use it” which matters. Integration also influences how many students use CAL materials. Material just made available on an intranet was used by only 12% of students. Showing the student the software in a lecture increased use and telling them it contained material which was examinable and had been left out of the lecture increased use even further. Providing an assessed exercise based on the software increased utilisation to practically 100%.

Virtual learning environments

Virtual learning environments (VLEs) or managed learning environments (MLEs) are being used increasingly to provide students with an electronic environment in which they can interact easily with teachers, with other students and with the variety of learning materials which are provided. It is possible to arrange all the administration of a course through the VLE, including submission and marking of work, monitoring of student progress and even the preparation of formative feedback and its dispatch to students via email or to their mobile phones. The full potential of this development is still being appreciated. Some universities have developed their own environment in house (for example the (virtual) Nathan Bodington Building at Leeds, UK) while others have used commercially available material (Blackboard, WebCT).

Integrated medical courses

Along with problem based learning the provision of integrated medical courses (removing the divisions into disciplines) has probably been the biggest change in medical pharmacology teaching and has had unfortunante consequences for pharmacology at many institutions. Pharmacology content has often been reduced very significantly and the material has been dispersed throughout the medical course sometimes to the extent that nobody knows what pharmacology is actually taught. It has proved necessary to reintroduce a separate basic course in some aspects of pharmacology (e.g. receptors, quantitative and general aspects of pharmacology, absorption, distribution, metabolism and excretion of drugs, pharmacokinetics, drug interactions, prescription writing) which do not integrate easily into a systems based course but which are nevertheless vital knowledge for prospective doctors.

Collaboration between institutions

The globalisation of education has generated a competitive environment between institutions at national and international levels which is in tension with the pressure to develop and share innovative teaching. In the UK the higher education funding bodies are encouraging institutions to diversify their missions, play to their individual strengths and collaborate. While institutions may collaborate locally they remain competitive nationally and internationally. In contrast, pharmacology teachers remain unfailingly collaborative at all levels and willing to share developments at conferences (29), through the International Union of Pharmacology Teaching Section (http://www.iuphar.org (>sections; >section on teaching)), through learned societies (e.g. British Pharmacological Society - http://www.bps.ac.uk) and though the recently funded Learning and Teaching Support Network Centres (for Bioscience http://bio.ltsn.ac.uk; for health http://www.health.ltsn.ac.uk; and for medicine http://www.ltsn-01.ac.uk). These National LTSN Centres have a mission to disseminate innovation and good practice in all aspects of teaching, learning and assessment within the disciplines.

Table 2. Necessary activities in tomorrow’s academic pharmacologist

| Research | globally collaborative, grant supported, interdisciplinary, output measured and assessed, highly competitive but also collaborative. |
| Teaching | professionally trained and qualified, using modern methods, exploiting funding opportunities, quality assessed, less independence and choice over both content and method. |
| Administration | professional attitude, functions across all management activities (space, financial and human resources); complex work-load model and information system |
| Leadership | directs own unit, plans for change, interfaces with public/government, sell success of research group to all stakeholders |
| Entrepreneurial activity | aware of intellectual property, exploits ideas, commercialization of both teaching and research, conscious of power of publicity |
| Professionalism | explicit training in all aspects, clear and effective appraisal |

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with which they are associated.

THE CHANGED ACADEMIC PHARMACOLOGIST

The pressures which will change the teaching of pharmacology will not be without effect on academic pharmacologists. Evolution affects teachers as well as courses. Table 2 shows the characteristics likely to be found in tomorrow’s successful academic though increasing diversity in the mission of universities may not require every academic to possess every characteristic equally. It would be easy to continue to produce academic pharmacologists from the old mold and it is not easy to re-shape the mold so the product better fits the changed environment. In the commercial world however companies which do not respond to changing environments go out of business and our discipline has too much to offer to be allowed to suffer such a fate.

CONCLUSION:

The multitude of pressures bearing on pharmacology teaching will continue to require substantial change in all aspects of pharmacology teaching and in the staff who teach in the discipline. Just as students must be fit for tomorrow’s purpose so must academics. All pharmacologists have a duty to our discipline to ensure that tomorrow’s academics are able to perform excellently in the changed environment in which they will be operating.

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411頁〜418頁: Ian Hughes 教育講演 [日本語要約]
薬理学教育 2010年に向けて -新しい知識、新しい教材、新しい方針-
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要約: 薬理学教育は多様な圧力を受け、変化を余儀なくされている。それらの圧力とは、薬理学の学問体系としての変化、政府から、専門機関から、学生側から、教育体系や教育機会の変化から、教官側から、動物愛護や倫理的考慮から、企業就職者から、また高等教育機関からのものが挙げられる。これらの変化に対応するには、大学の薬理学者の知識、技能、教育態度の変化とともに、教育する方法や自習能力の向上も必要になる。薬理学の教育課程はこの変化した環境のもとで提供され、学生が変化した学問体系の中で学べるように準備されなければならないし、また薬理学と関係のない領域に就職する学生にも適切であることが求められる。得るべきものは、カリキュラム、問題志向の学習、シミュレーションプログラムを用いた実習、学生間評価、インターネットの活用、情報工学、多方向性コンピューター学習、視聴覚教育環境、統合医学教育課程などが中心になる。これらの必要な変革を有効に行う最も大事な戦略は、世界的な枠組みでの薬理学教育者間の協力と、現在の薬理学教育者の間に、明日の大学人は彼らが働くなくてはならない変革した環境に充分適応する準備が出来ていると、一般的な認識を持たせることである。

キーワード: 薬理学教育、教育技法、客観的試験、教育法改革、コンピュータ学習
（著：橋本敬太郎）