The Future of Chemistry in the MPharm Curriculum – addressing the New Education Standards

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Introduction

Chemistry is a core subject area in the Master of Pharmacy (MPharm) degree programme. The indicative syllabus (GPhC, 2011) specifies chemistry directly, for example, drug design and discovery, pharmaceutical chemistry and analysis, drug identification and drug synthesis. Chemistry is also indirectly linked to many other specifications including prediction of drug properties, metabolism and formulation. Without a solid chemistry foundation, pharmacy students are unable to fully integrate the pharmaceutical importance of drug structures, drug interactions and side effects which is critical in terms of ensuring patient safety.

The General Pharmaceutical Council's Education Standards for future initial education and training of pharmacists will drive future Master of Pharmacy (MPharm) curriculum development in all UK Schools of Pharmacy. The New Standards and approval criteria will apply to any university applying for accreditation or re-accreditation of an MPharm degree or Overseas Pharmacists' Assessment Programme (OSPAP) in the 2010/2011 academic year. These Standards will each have an individual set of associated criteria and also require evidence from a training provider to demonstrate that the standards have been met to a satisfactory level. In the area of Curriculum Development it will be important to structure learning opportunities in order to provide an integrated experience of relevant science and pharmacy practice. The science components of the MPharm form the basis of effective pharmacy practice and hence are central to patient safety (as examples see: Driver, Lee and Baxter, 2010; Lam, 2009). The importance of scientific expertise in pharmacy is a topic of discussion particularly with the current structural changes to a new professional body and the General Pharmaceutical Council (Craig and Lawrence, 2010).

So how can Schools of Pharmacy integrate science with pharmacy practice particularly in the first year of the MPharm in order to meet this requirement? This is a concept which was considered during the design of the MPharm curriculum at the School of Pharmacy, University of Hertfordshire. This resulted in the integration of science and pharmacy practice between modules in a year of study (horizontal integration) and also linking modules of different years of study (vertical integration). Chemistry is a subject which underpins pharmacy and this article will outline how the contextualisation of chemistry (and science in the broader sense) effectively integrates chemistry with pharmacy practice.

Contextualisation of Chemistry

Contextualisation is the use of real life applications as a starting point to introduce or study a scientific concept. Contextualisation helps to answer the '*why?*'- *why* this is relevant, *why* should one learn this information? Pharmacists are responsible for patient safety through their expert knowledge on drugs, for example, pharmacists understand how drugs work, the mechanism of action, possible side effects and contraindications, all which are vital information when counselling a patient. Consider that aspirin should not be stored in a bathroom cabinet (moisture and heat), what is the basis for this advice? The chemical structure of aspirin contains an ester functional group which is degraded in the presence of moisture and heat due to ester hydrolysis. This process results in the formation of salicylic acid and acetic acid. A physical indication that ester hydrolysis had occurred would be the detection of a vinegar odour due to the production of acetic acid. This is a somewhat simple illustration yet its purpose is to show the role of fundamental scientific knowledge informing a pharmacist's clinical knowledge.

Students entering pharmacy must have a chemistry background in A-level or an equivalent level qualification. In the first year of the MPharm there is a strong emphasis on fundamental science which sets the ground work to build further knowledge in subsequent years. Integrating this scientific knowledge with real life examples that pharmacists meet in their careers is essential in order to apply scientific principles to effective pharmacy practice. It is easier to contextualise chemistry in later years of the MPharm as topics relating to drug discovery and specific therapeutic areas have been covered, however this approach is essential right from the start in order to ensure students integrate and apply scientific principles to clinical approaches. A model for contextualisation of chemistry in Pharmacy is illustrated in Figure 1. Within a chosen therapeutic area the chemical concepts underpin the safe and effective use of specific medicines and this overlaps with the relevant clinical advice from the pharmacist.

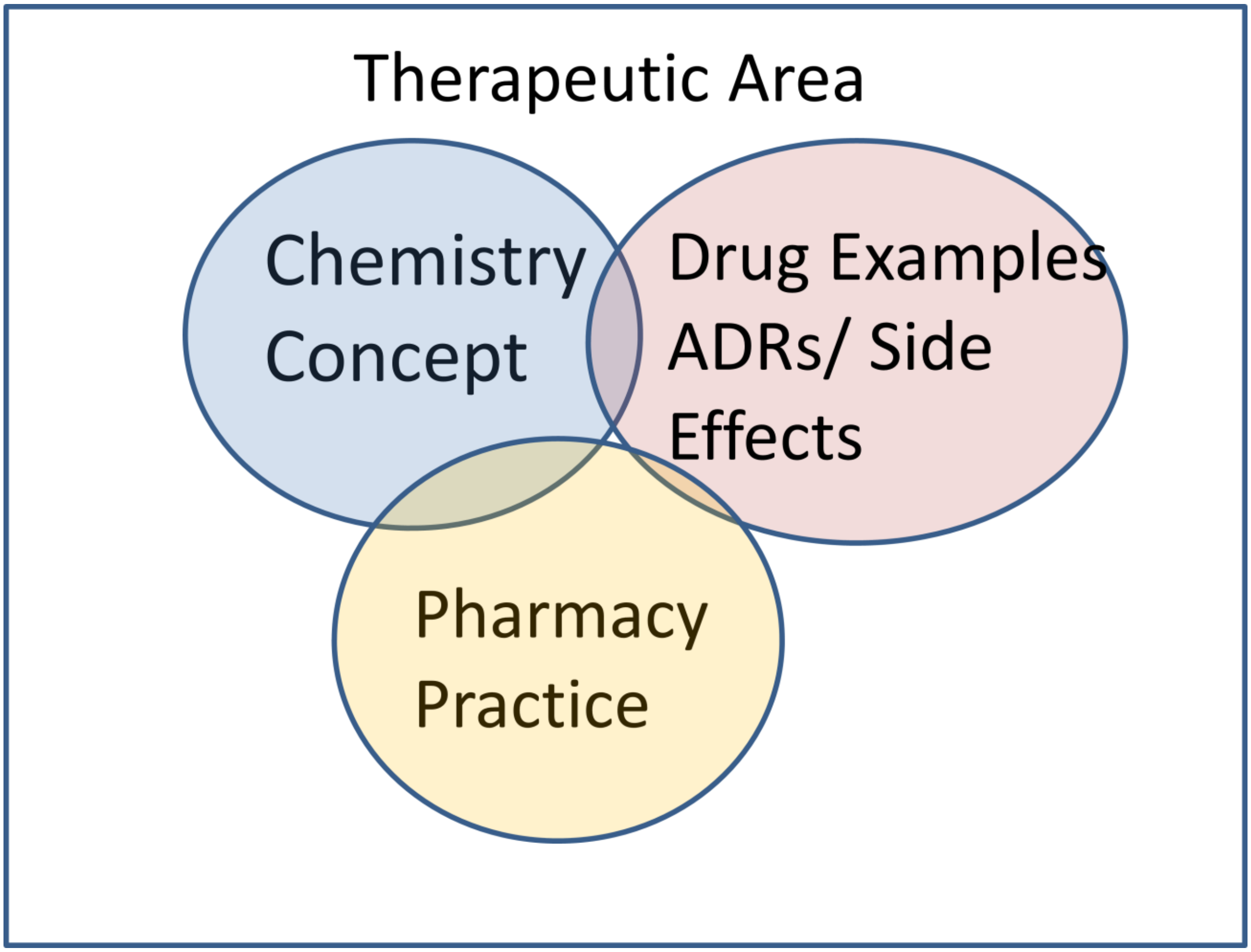


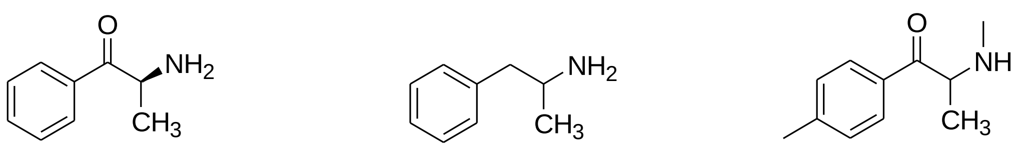
Figure 1. Model for Contextualisation of Chemistry in Pharmacy

An example of how scientific principles are central to patient safety is illustrated in Box 1 where drugs derived from a natural product source are available as cheaper alternatives to other illegal recreational drugs.

[BOX 1 BEGINNING]

Khat is an evergreen tree or shrub found in a region extending from Southern Africa to the Arabian Peninsula. In these parts, the habit of chewing fresh khat leaves is a common tradition with reports that 80-90% of the male adult and 10-60% of the female adult population in East Africa consume khat on a daily basis (Feyissa and Kelly, 2008). The effects following khat consumption include euphoria, excitation, anorexia, increased respiration, hyperthermia, logorrhoea, analgesia and increased sensory stimulation similar to those observed with amphetamine.

The major active alkaloid constituent in fresh khat is *S*-(-)-cathinone. Cathinones are analogues of amphetamines as shown in Figure 2. Due to its high lipid solubility, this facilitates access of the molecule into the central nervous system accounting for the induced psychostimulation. The major metabolites of cathinone; cathine and norephedrine are less lipophilic and posess weaker central stimulant properties.



S-(-)-Cathinone   Amphetamine   Mephedrone

Figure 2. Chemical structures of *S*-(-)-Cathinone, Amphetamine and Mephedrone

Synthetic derivatives of cathinones have produced psychoactive substances, one such derivative which received immense media attention during 2010 is mephedrone (4-methylmethcathinone) with other popular code names including ‘ ‘Meow Meow’, , ‘Meph’, ‘Bubbles’, ‘Spice E’, ‘Charge’, ‘M-CAT’ and ‘Rush’ (Schifano *et al.,* 2010). Mephedrone has been available to purchase via internet sources and in head shops and attention on this drug grew when reported fatalities associated with its consumption were highlighted. The National Addiction Centre in London reported mephedrone as the sixth most popular drug amongst clubbers, after tobacco, alcohol, cannabis, ecstasy and cocaine. The Advisory Council on the Misuse of Drugs published a report on the cathinone derivatives and as a result, mephedrone was classified as a controlled drug (class B) on the 16th April 2010 (ACMD, 2010). Prior to its ban many people considered mephedrone not to be harmful because of its appealing legal status (Ramsey et al 2010).

The structure of mephedrone (Figure 2) contains a single chiral centre resulting in two enantiomeric forms, *S*- and *R*- mephedrone. For cathinone, the *S*-(-) enantiomer is more potent than the *R*-(-) enantiomer, and this may be similar in the case of mephedrone. The major concern in terms of patient safety is that little is known about the pharmacology of mephedrone. It is expected to act as a central nervous system stimulant by promoting the release of monoamine neurotransmitters and likely inhibiting their reuptake (Feyissa and Kelly 2008). Cathinones similar to amphetamines bind to noradrenaline, dopamine and serotonin transporters (Nagai *et al*., 2007), but with a different relative binding potency. The potency of cathinones are mainly lower than those of amphetamines, this again is explained from their chemical structure as the beta-keto moiety imparts a reduced ability to cross the blood-brain barrier (Nagai *et al.,* 2007).

Immediately after the mephedrone ban, novel synthetic compounds appeared on the market, such as naphyrone for example (also known as naphthylpyrovalerone, ‘Energy 1’ or ‘NRG-1’). The active ingredients in such legal highs purchased from internet sources are not confirmed and hence there is an increased risk to individuals purchasing such consumer products which actually may end up containing a controlled drug.

It is evidently clear that the strong interdependent relationship between science and clinical practice is crucial in order to assist healthcare professionals to address this current issue of legal highs and ensure effective understanding of this phenomenon. [BOX 1 END]

Case Study Approach to Contextualisation

Case studies have been used in the teaching of chemistry with first year undergraduate pharmacy students at the University of Hertfordshire. Is there any research evidence to show that this approach helps to make chemistry more relevant? The answer is *yes*. Bennett *et al.* (2007) have extensively reviewed context-based approaches of science teaching in secondary schools from 17 experimental studies in eight different countries. Their findings support an improvement in attitude to science and that the understanding of scientific ideas is comparable to that of more traditional approaches.

Our approach is to use case studies in order to highlight the link between the science and pharmacy practice. A more interactive use of case studies enables the students to develop their problem solving skills and apply their knowledge.

At the University of Hertfordshire, School of Pharmacy a contextualised case study on Antihistamines was presented to Year 1 students. The students discussed the topic in small groups followed by a general discussion of the case study:

> *A taxi driver comes into the pharmacy with seasonal allergies. He asks for advice on what to take and needs an antihistamine that won't cause drowsiness for his job. You have Benadryl one a day ® (cetirizine) and Piriton ® (chlorphenamine) as your options.*

(a) Provide a rationale for your choice considering the chemical structures of both choices.

(b) Considering the structural features of cetirizine and chlorphenamine where (stomach or intestine) will each drug be best absorbed?

(c) What other treatments are available for seasonal allergies taking into account the routes of administration?

Feedback from the students included:

> *"Case studies help relate the chemistry with real life situations including medicines and drugs"*
>
> *"I found it useful as you are able to apply your knowledge"*
>
> *"It's best if theoretical learning is linked directly to everyday life events. Makes it clearer and much more understandable"*
>
> *"It allows you to develop a better understanding of chemistry because you get to see why we study it"*
>
> *"It's so much easier to learn chemistry when it's made directly relevant to our future careers"*

This has been very positive in terms of student learning and it enables students to apply problem solving skills to a real life situation.

Contextualisation and the Education Standards

The outcomes in the Education Standards are derived from the competence and assessment hierarchy known as Miller's triangle (1990). At every stage the underlying level is the building block for the next level (Figure 5).

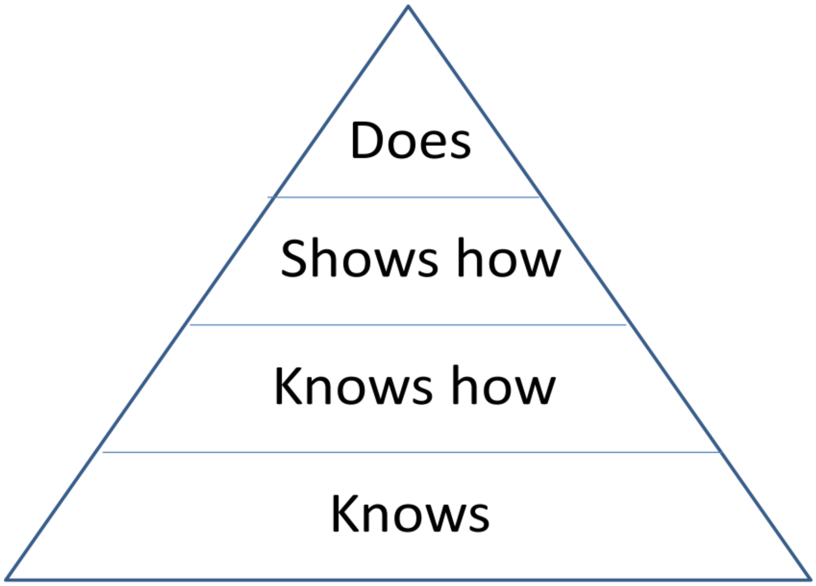


Figure 5. Miller's triangle: assessment of clinical skills/competence/performance

Shown in table 2 are the items from the GPhC's Indicative Syllabus (GPhC, 2011) used for UK pharmacy degree courses which are covered by the contextualised model of teaching and learning. Year 1 students are building on their knowledge and the 'know' level of competency increasing this in certain key learning outcomes.

Table 2. Mapping of Model for Contextualisation of Chemistry against Indicative Syllabus.

Learning Outcomes	Contextualised Model	Year 1 and 2	Years 3 and 4
The unique role of the pharmacist in ensuring that the patient benefits from pharmaceutical intervention	✓	**Knows**	**Shows how**
Health and Illness: definitions and perceptions	✓	**Knows**	**Does**
Theory and practice of personal and inter-personal skills, including written and verbal communication skills and study skills	✓	**Knows how**	**Does**

The ideas and approaches of compliance or concordance in health care provision, particularly as they apply to medicines-taking	✓	**Knows**	**Shows how**
The pharmacist's contribution to the promotion of good health and disease prevention	✓	**Knows how**	**Shows how**
Normal and abnormal bodily function: biochemistry, genetics, microbiology, nutrition, immunology, physiology, pathology, pathophysiology and infective processes	✓	**Knows**	**Knows**
Symptoms recognition and management, the principles of different diagnosis, important diagnostic tests, and medical terminology	✓	**Knows**	**Shows how**
Disease management and care planning, including application of clinical guidelines, prescribing and medication review	✓	**Knows**	**Shows how**
Molecular basis of drug action and the actions of drugs within living systems; molecular, cellular, biological and physical aspects	✓	**Knows how**	**Shows how**
Clinical therapeutic uses of drugs and medicines in man, including contraindications for adverse reactions to and interactions of drugs and their relevance to treatment	✓	**Knows how**	**Does**
Drug absorption, distribution, metabolism and excretion and influences thereon, including formulation, route of administration, dosage regimen, ageing and	✓	**Knows**	**Shows how**

disease			
Clinical evaluation of new and existing drugs and medicines, and post marketing surveillance. Good clinical practice	✓	**Knows**	**Shows how**
Prediction of drug properties, including chemical compatibilities from molecular structure	✓	**Knows how**	**Does**
Public Health and the role of the pharmacist	✓	**Knows**	**Does**

The Model for Contextualisation of Chemistry in pharmacy presented demonstrates a pathway to the successful integration of science and pharmacy practice in accordance with the General Pharmaceutical Council's Education Standards. We have shown how students appreciate this style of learning from an early stage of their degree programme. It is necessary to foster this approach of science and pharmacy practice integration from year 1 so that our future pharmacists 'know' and 'know how' to link both aspects from an early stage in their career building towards the 'shows how' and 'does' levels of competency. This holistic approach to learning therefore benefits patient care and strengthens the education training of future pharmacists.

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Additional photographs which may be used in article

MEPHEDRONE

http://www.erowid.org/chemicals/show_image.php?i=4_methylmethcathinone/4_methylmethcathinone_powder__i2008e1484_disp.jpg

KHAT PLANT

http://khatchat.com/page_1245534669671.html