

The development of a Pharmacology module for undergraduate medical students

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Abstract

Teaching an experimental subject such as Pharmacology to large student classes represents a major challenge with regard to appropriate content delivery and assessment. A key skill for Medical graduates is to understand the experimental aspects of drug development to aid their decision-making during their professional lifetime. In the University of Galway, we see the 2nd year of the curriculum as being pivotal in laying down the foundations of experimental pharmacology. Within our Semester 1 introductory module, we have developed a curriculum that is underpinned by a blend of face to face lectures, Q&A sessions, practical workshops and regular assessment of learning, which is followed in Semester 2 by a capstone task where students create a team-based presentation profiling a recently introduced drug. In conclusion, we have introduced a range of experimental elements into our Pharmacology curriculum that are valuable in developing skills that are achievable in a large class setting.

Keywords: *Pharmacology; drug development; medicine; experimental skills; large classes*

1. Introduction

The teaching of experimental aspects of Science is very challenging for large classes, from the perspectives of delivery of content, and how it might be assessed in an authentic manner. Over the last 20 years, there has been a global trend of massification of educational programmes. The larger class sizes have demanded a rethink with regard to practical logistics of delivery and that the large class size might be an opportunity to enhance the student learning experience (Hornsby and Osman, 2014). We have spent over 30 years teaching Pharmacology to a range of student groups, including to Medical students. Effective and safe prescribing of medicines is a key skill that clinicians need to employ on a daily basis, but there are concerns that the medicine curriculum doesn't adequately prepare graduates for developing this skill (Geoghegan et al., 2017). In order to prescribe a strong foundation in the principles of pharmacology is essential, and particularly its underpinning in experimental findings using a range of subjects ranging from the test tube through laboratory animals to human subjects. Having an appreciation of the drug discovery and development process thus helps Doctors in deciding whether to prescribe new drugs safely and effectively and which of their patients would benefit most from such medicines. This paper will describe how we have developed our Pharmacology content for Medical Students at the University of Galway, and how the pedagogical principles adopted can have a resonance beyond this field, and thus can have a wider application.

2. Description of the Teaching/Learning Context

The teaching/learning context is within the 2nd year of the undergraduate Medical curriculum in the University of Galway. The 2nd year Medicine class typically consists of approximately 200 students, with 50-60% being Irish students. The class size went through considerable growth nearly quadrupling from 55 students in 1991 to 200 in 2011 and stabilising at this number since then. Thus, our programme has adapted to accommodate these larger class sizes, whilst introducing some pedagogical strategies that will aid student learning.

During the 2nd year, Pharmacology is taught in two modules: Introduction to Pharmacology (MD214) in Semester 1, and Drugs and Disease (MD204) in Semester 2. Thus, the 2nd year of the Medical programme is a pivotal one for the development of foundational knowledge in Pharmacology that will be applied in future years as the student progresses to the clinical stages of their education. This module has gone through considerable development that has coincided with growth in class size, with a particular emphasis on exposing students to the experimental aspects of Pharmacology, providing opportunities for self-directed learning as well as campus-based learning. In addition, the module has responded to student feedback, and regular interaction with the class representatives to generate a productive dialogue. The

main features of the module are summarised in Table 1. The structure of MD214 consists of 4 x 3-week units over the 12-week semester that introduce students to the basic principles of Pharmacology. There is a consistency of approach with each unit following the same design, even though the units may be delivered by different contributors. The series of interlocking features includes both conventional lecture-based and practical workshops, whilst also availing of online options where appropriate, such as in the provision of a weekly online Q&A session. These features provide clear signposting, promote regular engagement and encourage active collaboration in Teams.

Table 1. The main features of MD214 (Introduction to Pharmacology)

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- 4 Lectures in the first 2 weeks of a Unit
 - A practical-based workshop in the 3rd week of a Unit
 - A Unit assessment at the end of the 3rd week (each = 10% of module mark)
 - A weekly Q&A with the Module Lead
 - An end of semester assessment (60% of module mark)
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2.1. Workbooks

At the beginning of each unit, the students can access a workbook that focuses on key stages of the drug development process which the students engage with asynchronously outside of the timetabled session. These workbooks provide a self-directed opportunity that lends itself well to student engagement within the large class setting; there is a workbook linked to each unit (Figure 1). Initially, these workbooks were solely paper-based, i.e. provided as pdf versions that the students would work through. We recently developed an online interactive version using the Articulate Rise 360 e-learning platform, which became available as an authoring tool in our University in 2021. This format was introduced in AY 2021-2022, and is compatible with the Blackboard Learning Management System (LMS). These interactive workbooks provide the students with a number of problem-solving opportunities as they build up their application of their theoretical knowledge of Pharmacology.

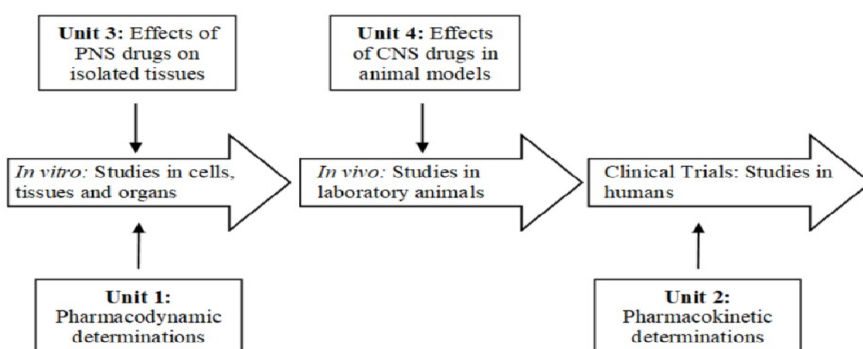


Figure 1. The experimental techniques that the students encounter are associated with key elements of the drug development process, and result in being exposed to the whole range of experimental settings that are used for evaluating drugs through the preclinical stages of drug development. The clinical phase is encountered in the workshops that occur later in the module.

2.2. Practical Workshops

At the beginning of the Semester, the class is divided into 6 “houses” named after leading historical figures in Pharmacology, and the students within the house divided into teams of 5 who work together throughout the Semester; the Workshops take place in Computer suites located across the campus. The organisation into houses helps to foster a sense of community within a large class, as well as getting to know some of the class by engaging in cooperative learning. In advance of the first workshop, students are provided with a drug for which they need to prepare a profile of its properties, including its mechanism of action and therapeutic uses. At the workshop itself, the students work with their teammates whose drugs have some characteristics in common. The students summarise these characteristics in a table, which enables them to compare and contrast their properties. Similar approaches are taken with the remaining Workshops, and are aligned to the content of a particular unit, and thus have a certain flavour whilst maintaining some consistent features. At the end of each workshop, the students submit a single presentation of their findings, which has been

reviewed by the Workshop Tutor prior to submission for any omissions. Currently, the submissions are purely formative in nature, i.e. they do not carry any marks.

Table 2. The composition of the practical workshops

Unit	Purpose
Unit 1: Pharmacodynamics	Teams summarise the pharmacodynamic characteristics of their 5 drugs; select one of the drugs and describe a clinical trial using this drug
Unit 2: Pharmacokinetics	Teams summarise the pharmacokinetic characteristics of their 5 drugs; discussion of a case study that has pharmacokinetic features
Unit 3: PNS drugs	Teams work on an evidence-based profile of a PNS drug
Unit 4: CNS drugs	Teams work on an evidence-based profile of a CNS drug

2.3. Assessment

The introduction of computer-based assessments was primarily a response to the growing numbers of students, but also driven by a disaffection with the written-based format. Within the Blackboard LMS, a number of question types are used, including multiple choice and multiple answer questions, extended-matching questions and calculations that are drawn from experimental data. Although initially challenging, we appreciate how these questions can actually be phrased in such ways that can proceed through to higher levels of Bloom's taxonomy. Students are provided with practice opportunities for both interim and end of semester assessment, which are formative in nature to familiarise themselves with the nature of the assessment questions. The questions have been created to not only assess factual recall, but require considerable interpretative skill, and draw on experimentally-relevant scenarios. This was particularly pertinent during the COVID-19 pandemic, when assessments needed to be conducted in an off campus setting, and where application of knowledge rather than factual recall is emphasised.

2.4. Capstone Activity

At the beginning of the second semester, we have developed an opportunity for the students to apply the knowledge that they have developed with a Capstone Activity, whilst at the same time requiring a deep dive into the research literature. Teams of 6 students prepare a recorded PowerPoint presentation in which they profile a recently introduced drug, preparing a synthesis of evidence. The components of the Capstone Activity are summarised in Table 3. They include identifying the shortcomings of the existing treatments for the disease that the drug has been developed to treat, and how the new drug represents an improvement in the treatment of the disease. The students are required to marshal the skills that they have honed in Semester 1 in order to be able to provide experimental evidence that will support whether the new drug does represent an advance. In order to be able to get a good idea of the impact of a newly introduced drug, the ones that we select for investigation are 5-10 years after being launched, so that there is literature available to assess the post-marketing impact of the drug. The teams are randomly assigned, and a team leader is also randomly selected. A number of roles are identified within the Teams that enable marks to be awarded for the both individual and team-related content, enabling each student to receive their own mark for this activity.. These contributions are identified at the time of submission. The students are provided with a Rubric for this activity, that helps them in identifying the standard that is expected. The students meet as a team on 3 occasions:

- Initial meeting: Organised by Team Leader. Allocation of roles and prepare a plan.
- Midway meeting: Assessing progress, making sure everything is on course.
- Final meeting: Individual panels completed, remaining features of poster agreed upon.

The Capstone Activity is worth 10% of the total mark for this module.

Table 3. The components of the Capstone Activity

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- **Introduction:** An introduction to the disease state; the current treatments and their limitations; the mechanism of action of the drugs and the unmet needs being addressed
 - **Preclinical efficacy:** An inclusion of the relevant animal model literature, at both the *in vitro* and *in vivo* levels (with examples)
 - **Clinical Pharmacokinetics:** A summary of the clinical pharmacokinetics parameters of the drug, including its metabolic pathway and important drug:drug interactions
 - **Clinical Efficacy:** An inclusion of the pre- and post-marketing clinical trials evaluating efficacy of the drug
 - **Clinical Safety:** An inclusion of pre- and post-marketing evidence on all safety aspects of the drug
 - **Case Study:** Drawn from real-life and including all features of the patient's treatment
 - **Conclusions:** Succinct summary of key findings
 - **Overall Presentation and References:** Consistency of style; all references included
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3. Literature Review

When developing a curriculum for large classes, the issue of student engagement is particularly prominent, and thus developing strategies that can make it worthwhile for students to invest their effort in seeing the payoffs from being actively engaged being manifested in the nature of the assessments that are created (Kuh, 2009). In addition, there should be a shift from knowledge recall in such assessments, and movement towards encouraging attributes that will be useful when going out into the world, which have been described as recently summarised as 21st century skills, such as communication, cooperation and problem solving (Allen and van der Velden, 2013). Our module has a considerable team based learning (TBL) element, which, irrespective of the size of a class, provides an opportunity for students to work together in complex problem solving which promotes a deeper learning experience (Michaelson et al, 2008).

For many years, the practical Pharmacology aspects of undergraduate Medical education have been taught using computer-based simulation methods (Markham et al., 1998; Lisha, 2013), with the ethical concerns of the use of laboratory animals that would be required for practical sessions. However, there is also a need for Medical students to be exposed to the breadth of experimental approaches that encompass the drug discovery and development process (Stanley et al., 2005), which means going beyond a narrow definition of the practical applications of Pharmacology. The key component here is realising that Medical students require an appreciation of how these diverse stages of the drug development operate in concert, without the necessity for them to actually conduct these experiments at the bench. The value of Articulate Rise 360 has been successful as a resource for students to learn in an asynchronous fashion (Fuller et al., 2021), and thus complements the blended approach to our teaching of Experimental Pharmacology in the University of Galway, providing both on-campus and off-campus opportunities to develop their skills. The incorporation of deliberate practice assessments provide valuable opportunities to assess and review student's learning (Ericsson and Harwell, 2019), and our module has incorporated regular practice activities within the Workbooks, and the practice assessments that students can take in advance of their credit-bearing assessments. Our capstone project provides an opportunity for higher order learning skills of analysis, evaluation and synthesis to be employed (Bloom, 1956), with the requirement to build on knowledge and skills developed earlier in order to create an evidence-based presentation. Team-based learning is an activity that can be successfully incorporated in a large class setting (Burgess et al., 2020) and the benefits of sharing and working together are very important for students to be exposed to in their undergraduate studies.

4. Empirical Methodology/Data

Figure 2 summarises the student feedback for AY 2022-2023 for MD214. Overall, the feedback has been very positive on a number of elements relating to the organisation of the module, the support of the teaching faculty, and the overall satisfaction with the module. On average, the students devoted 9 hrs/week, which is the amount recommended for a module with a 5 ECTS weighting, based on 20-25 student hours for each ECTS. Aspects that students particularly liked included the regular assessments, the interesting relevant content to Medicine, the Q&A sessions, practice tests, workbooks and the on campus workshops. Areas of improvement included that the on campus workshops should have marks awarded and that some time during the on campus classes ought to be devoted to the workbooks, rather than being completely student-directed.

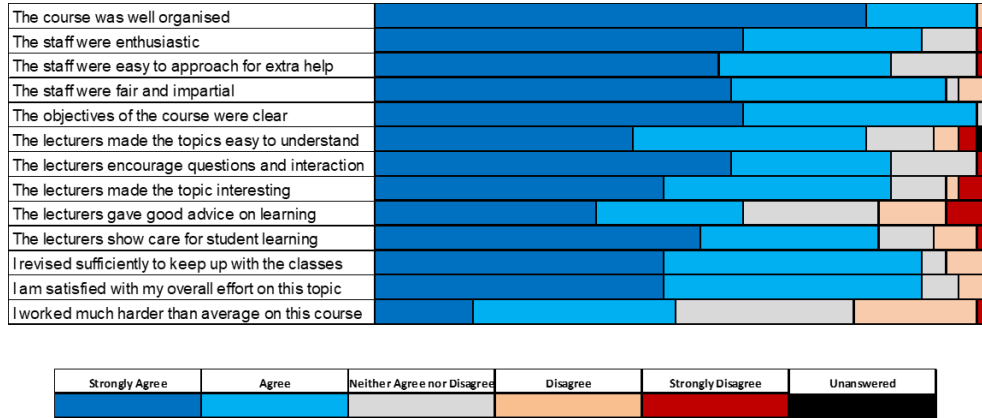


Figure 2. The responses to structured feedback questions in AY 2022-2023 for MD214, conducted at the end of the teaching period, and prior to the end of semester assessment; 45 students out of a class of 192 (23%) completed the survey

For the student evaluation of the Capstone Activity, there was a lower response rate (12%), and the main features are summarised in Table 4. The students did appreciate how the activity built on the knowledge built up in Semester 1, and its relevance to recently approved drugs. The main improvements that the students mentioned revolved around the short duration for the presentation (i.e. 8 minutes) and suggest that this ought to be increased, albeit modestly to 10 minutes.

Table 4. Main student comments relating to the Capstone Activity

What aspects did you like?

- Teamwork/meeting new classmates
- Application of knowledge
- Nature of presentation (i.e. a recorded PowerPoint presentation)
- Learning about a recently marketed drug
- Case Study aspect

How could the activity be improved upon?

- Increase the recording time
 - Increase word count
 - Reduce the team size
 - To be able to choose team-mates
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5. Analysis of/Reflection on/Implications for Practice

We have introduced a number of features to our teaching of Pharmacology to undergraduate Medical students that have been able to develop their skills in the drug discovery and development process, a key component for Practitioners to be able to apply when making decisions about selecting medications with regard to efficacy and safety for their patients. This has been achieved in a large class size and has met with favourable evaluations from the students themselves. In addition, very favourably received features of our teaching include the regular assessments through the semester, and the opportunities to prepare for such assessments with practice assessments. We will continue to further develop our teaching, by taking new innovations into consideration as well as being guided by student feedback.

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