Solve your own problems! Peer designed and student led methods for transition through the threshold concepts of pharmacokinetics.
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ABSTRACT: Pharmacokinetics is concerned with understanding what the body does to a drug and is a model-based approach to understanding and predicting dose, metabolism, and excretion of drugs. As a critical, threshold concept in undergraduate and postgraduate pharmacology degree programmes, pharmacokinetics represents a genuine student challenge. As a discipline with its roots in mathematics, the use of equations, graphs and data-modelling moves the student considerably outside their comfort zone, which makes visualisation of the core pharmacological concepts and how they inter-relate difficult for even the most astute. Feedback suggests current teaching approaches are ineffective; students rarely reach an appropriate level of competence and confidence with the subject. The underpinning rationale focused on designing engaging ways in which students could enhance appreciation of the subject and this was best achieved by employing students with recent experience of the subject area to lead the design i.e. a resource created by students, for students.

The problem with pharmacokinetics

Pharmacokinetics is a strand of pharmacology that is used to mathematically describe how the body processes a drug and is essential in understanding and predicting the dose, distribution, metabolism and excretion of a compound. This forms a key threshold concept within the pharmacology disciplines, which provides a very important link between theoretical aspects of drug design and administration and actual vocational use of pharmacological therapeutics.

Traditionally, students find this very difficult and on average achieve lower grades in pharmacokinetic assessments compared to other areas of the degree programme at both undergraduate and postgraduate level. The underlying reason is attributed to a lack of understanding of the concepts, difficulties with numerical manipulations, confusion over the processes that transform raw data into clinically meaningful values and a general lack of appreciation of what the values actually mean in pharmacological terms. This shortfall in understanding is reflected in feedback from students, staff and graduate programme supervisors and is a skills shortage that needs to be addressed. By failing to link these aspects together, a critical element of the programme is being overlooked, with serious impact upon graduate prospects impacting on clinical, pharmaceutical, pharmacy and research employability.

There is a need for more effective contextualised learning to be built into pharmacokinetic teaching, so students can attain the necessary understanding for working with data of this type. Furthermore, by designing exercises in a case study style, then the applied relevance
and true pharmacological meaning would be reinforced and developed.

Current ineffective teaching approaches are dry and didactic in nature, and one of the key aspects of this paper was that the design and content of the teaching and learning resources produced was primarily led by students with very recent experience of the pharmacokinetics areas of the curriculum. Employing students as partners in this manner helped derive more meaningful exercises that were aligned carefully with student needs and expectations. Indeed, this informed student led/peer designed approach has proved critical to the success of these strategies.

Project 1: Creation of a pharmacokinetic spreadsheet database

The rationale which informed the design of project 1 was the fact that there are fundamental concepts associated with the pharmacokinetics subject matter that must be learned, appreciated and understood to permit further grasp of the subject. These are heavily interlinked and co-dependent, thus making comprehension more challenging. Additionally, this was reportedly not helped by some of the jargon-heavy texts and teaching available to support acquisition of this troublesome knowledge (Biggs, 1999; Perkins, 2008).

A solution to this was to produce a repository of pharmacokinetic materials in one system that was written in student-friendly language and that made the interlinked nature of the topic evident and navigable. Indeed the fundamentals feeding into this design are represented in figure 1:

![Diagram](image)

Figure 1: The key interwoven aspects of the repository design.
The simplest approach to this involved hierarchical connectivity of digestible spreadsheets complete with definitions, summaries, examples, clinical links, helpful tips and sample tests that would allow student to command their own progress and learning through this complex topic. The authoring of these information sheets was student-led and the presentation of material designed to be attractive and not intimidating. Furthermore, the careful hyperlinking of these sheets together into a logical and negotiable network of resources ensured students could easily navigate towards and through their own learning objectives.

All aspects of the specific taught pharmacokinetic materials (6 sub-topics) were covered in the project and example screenshots in figure 2 and 3 show how effectively the materials were presented to the students.

![Figure 2: Screenshot showing presentation of definitions and fundamental equations](image)
Figure 3: Screenshot showing information screen from the pharmacokinetics repository (note hyperlinks, related sheets that enhance navigability).

A key aspect of implementing this resource related to presenting it to students, and this was best achieved by making it freely available to them to support their learning through the University IT system. This facilitated use of the tool as personal development, consolidation or revision tool and reports suggest that an undergraduate cohort of around 50 students accessed the folder a total of 735 times throughout the semester when pharmacokinetics was taught. Such usage was mirrored by a postgraduate taught cohort of 27 students that accessed the device 460 times. These figures alone demonstrate the importance of this resource as an integrated component of student learning within this conceptually demanding area. Furthermore, its simplicity further enhances its appeal on account of how it can easily develop and mature with the passage of time, demonstrating clearly how sustainable this adaptable and evolving resource is.
Project 2: Feedback loops to develop pharmacokinetic data handling skills

Following the success of the above project in enhancing student navigation through the pharmacokinetic quagmire, reports of student struggles continued. However, these were less focused on the materials of the course and instead suggested there was limited comprehension of what to do with a set of pharmacokinetic data in raw form e.g. what type of graph to draw, what values to extrapolate from the graphs, what equations to use to determine subsequent parameters, what do these values mean?

With this in mind, this project addressed these issues by student-led development of a resource through Questionmark (an assessment authoring software package), which presents students with a variety of pharmacokinetic case studies showing how and where data is derived, and then leading them through the manipulation and vocation-specific use of this data. At each stage, the Questionmark functionality is exploited to provide intuitive feedback, reinforcing correct concepts where the answer is correct and providing encouraging and structured guidance in the event of an incorrect answer. With the latter, students are returned to the original question after receiving this helpful feedback. The creation of this looped feedback approach leads students through specific, contextualised scenarios, and effectively drives their learning of the practical, applied, vocational relevance of the subject. A variety of different case study scenarios were developed to cover key employment areas e.g. clinical, pharmaceutical (including drug discovery and design), pharmacy and research. This simple approach creates links from pharmacokinetics to defined career outcomes, making the importance and meaning of pharmacokinetics less tacit and equipping students with more developed applied skills for employment across a variety of career paths in the sector. The screenshots shown in figure 4 and 5 demonstrate the provision of interactive case studies, punctuated with feedback and driving experiential learning of how to manipulate and accurately process pharmacokinetic data.

Figure 4: Screenshot showing reinforcing feedback relating to graphical exercises being presented (text above the graph).
By embedding these looped assessment case studies into the virtual learning environment (VLE), exercises are accessible, easily monitored and flexible, which further expands their appeal and curricular impact. Indeed, the authors have adapted this model into a variety of learning contexts with success and this specific iteration is no exception. These exercises were accessed 170 times by the undergraduate cohort (50 students) during the first phase of utilization and is predicted to increase in future years. However, this still represents significant uptake into student learning practices. Therefore, this second project also demonstrates impact in terms of supplemented learning and adds a further tool to teaching and learning pharmacokinetics.

**Measurement of success?**

The development of this suite of resources and strategies to enhance and improve the student learning experience associated with pharmacokinetics has clearly engaged the students, who have participated and used these products widely based on the metrics described above. However, a true measure would relate to the actual graded achievements of the students compared to previous cohorts. While this comparison involves a blend of uncontrolled variables, there was on average a 10-15% increase in pharmacokinetic grade, equating to 3 grade points and a full degree classification category. Furthermore, there was also a marked reduction in the tails associated with the grades in that far fewer students were associated with a low tariff tail. Despite these very encouraging indicators, the true impact will only be apparent after these strategies have become fully integrated into the teaching and learning approaches of staff and students.

A more informal indication of success is student feedback and some examples that typify student opinions on this suite of pharmacokinetics resources are captured in table 1.
Table 1: Feedback from students who have used the pharmacokinetics resource suite.

**Conclusion**

The above projects provide a combinatorial approach to the threshold concept that pharmacokinetics represents and as such helps overcome student difficulties with this subject area. Part of the attraction of these measures is their flexibility and adaptability in terms of how they are used i.e. as a study tool, in class, as an assessment. The outputs from these projects can be delivered in a host of different ways and this extends their usage potential.

The student input interwoven within the project also adds value as it is written for students, by students, which increases relevance and compatibility. The nature of these resources is also such that they are sustainable, evolving, flexible and accessible, which help them to overcome many of the challenges associated with pharmacokinetics, in which they have had a demonstrable impact.

Innovative developments like this help create a more dynamic and flexible approach to teaching, and the informed student driven process engaged to create these make them more applicable and aligned to student expectations. Integrated approaches like this represent an advancement of strategy, where a blended approach that uses peer-designed methods and interactivity to enhance student learning is infinitely more effective. Embracing students as partners in the design of such learning initiatives is a crucial part of transition management elevating students to a new level of comprehension (Meyer and Land, 2003).

**References**

