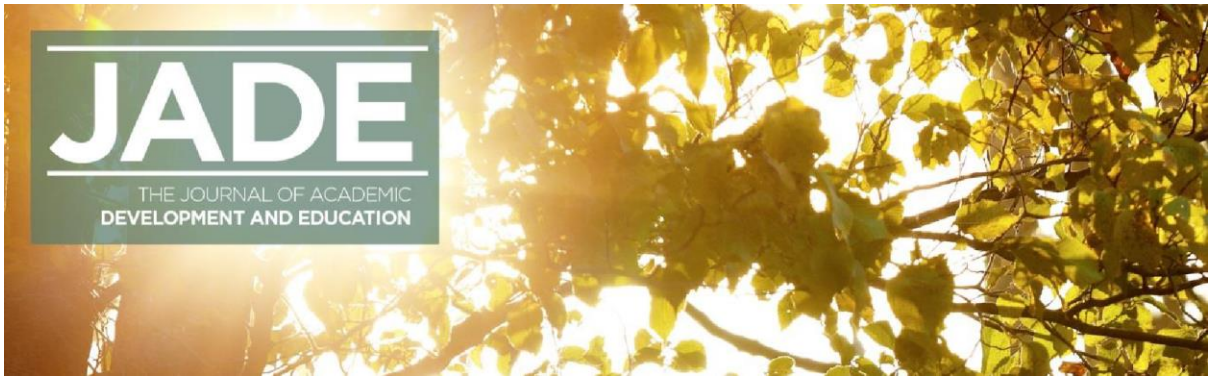

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Article:

CASE STUDY: Re-designing preclinical neuropharmacology teaching to enhance student engagement and active learning.

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Abstract

Group-based teaching can be an effective means of promoting active learning. As part of a medical degree, these sessions often focus on a clinical case. The students work collaboratively to build on previous knowledge and gain a deeper understanding of the pathophysiological mechanisms causing disease. However, a student-led approach can lead to frustration (and consequently sacrifice engagement) if the sessions are not designed with enough guidance to enable students to "scaffold" their learning. This case study is an account of the evaluation, reflection and subsequent re-design of a module in Year 3 of the MBChB course that focuses on the topic of neuropharmacology. The re-design posed unique challenges, as Year 3 acts as a transition phase from pre-clinical to clinical teaching for medical students. The aim of this re-design was to enhance student engagement and promote collaborative, active learning, whilst fostering the problem-solving skills required for clinical practice.

Keywords: Pharmacology, student engagement, group-based learning, active learning.

Context and objectives

The following case study is an account of the critical evaluation and re-design of the third-year module *"Neuropharmacology"* – a module in which I teach as part of the MBChB course. I will begin by describing the module content and placing it in the context of pharmacology teaching across the Keele MBChB programme. I will then critically evaluate the module itself, with emphasis placed on session logistics and student engagement. Finally, I will discuss the re-design of the module, and support this rationale with a reflective account and evidence from pedagogic literature.

This account was written in June 2017 as part of an assignment for a Postgraduate Certificate in Learning and Teaching in Higher Education. Although aspects of the GMC guidelines have now been updated, the pedagogic principles remain valid.

Designing modules for medical curricula

Over the past 25 years, undergraduate medical curricula have undergone dramatic changes. The stimulus for these changes was the publication of the first edition of *"Tomorrow's Doctors"* by the General Medical Council (GMC; General Medical Council, 1993). Prior to this original publication, medical schools in the UK were inconsistent with regards to their core curriculum (Lewington, 2012). As the regulatory body that maintains the standards for undergraduate medical education (Medical Act, 1983), the GMC's more recent "*Outcomes for graduates"* provides a set of standards for teaching and assessments for which all UK medical schools must adhere (General Medical Council, 2015). Broadly speaking, *Outcomes for graduates* highlights three themes/skills for which a graduating clinician must demonstrate to have

acquired through their undergraduate education (Fig. 1). These themes emphasise the importance of promoting independent thought, communication skills, group work and adult life-long learning.

However, although graduates are expected to have the required skills to practice (Ringstead, 2001), medical schools do have the freedom to demonstrate novel and innovative teaching. As teachers we strive to enhance student engagement and facilitation of knowledge, but we must also promote the themes set out in *Outcome's for graduates*. When evaluating a module's success or when addressing module design, medical educators must find a balance between creativity in teaching and the stringent GMC requirements, as well as maintaining student engagement and satisfaction (Carini, 2006; Browne, 2010). The latter of which is becoming increasingly important in the rapidly changing landscape of higher education.

(Insert Figure 1 here)

Module description and context

Pharmacology is the study of the uses, effects and modes of action of drugs. As such, is an essential component of any medical curriculum. Traditionally, medical schools separated 'pre-clinical' and 'clinical' phases of the curriculum, with the former focusing on the basic science or so-called "ologies" (Maxwell & Walley, 2003). However, research has shown that this model did not facilitate the application of factual data learnt in the early years, to the clinical setting in the later years (Coles, 1998). Now, many medical schools have adopted a more integrated design (Fig. 2). At Keele, pharmacology is taught as a *strand* across all modules within the course as part of a spiral curriculum. This facilitates deep learning by allowing students in later years to build on existing knowledge obtained in the earlier years (Bruner, 1960).

(Insert Figure 2 here)

Keele's approach is to balance the ethos of student-led, problem-based learning (PBL) alongside a framework of teacher-led sessions and clinical placements. This blended approach to learning has been deemed beneficial by both students and teachers (Ghosh & Dawka, 2000). Although Keele aims to integrate basic science teaching with clinical context, there is still a dramatic shift between years two and three of the course from a pre-clinical to a clinical emphasis. Medical students often find this transition difficult in terms of understanding their roles and responsibilities, putting their newly acquired clinical skills into practice and applying the theoretical knowledge from earlier years of the curriculum (O'Brien, 2007; Prince, 2000). The third year of Keele's medical curriculum offers a bridge between this gap, whereby four days a week, students spend their time on clinical placement, in clinical seminars or case-based learning (CBL). One day of the week is devoted to

Year 3 *SPINE* at the medical school on Keele campus. On these so-called "*SPINE Days*" (currently every Thursday), students have various teaching sessions including anatomy, tutorials, lectures and workshops (see Table 1) that are similar in format to those in Years 1 and 2.

(Insert Table 1 here)

The "*Neuropharmacology"* module runs in the first semester of Year 3 SPINE, and covers the major neurotransmitter systems (physiology), disorders (pathophysiology) and pharmacological management (pharmacology) of the central nervous system. Run as a series of five, one-hour syndicate-style tutorials, students work through a set of clinical cases and use textbooks, literature, online resources and group discussion to address a series of questions and present their findings. It is assumed that students beginning the "*Neuropharmacology"* module hold a good understanding of basic pharmacology learnt as part of the earlier years of the course. The session objectives therefore employ the principles of Bloom's taxonomy (Bloom, 1956), whereby students are expected to *apply* previous knowledge to clinical scenarios (or cases) used in the tutorial sessions, to both diagnose the patient in question and suggest appropriate pharmacological treatment.

Critical evaluation of the "*Neuropharmacology"* module

Evaluation of group-based learning for neuropharmacology teaching

As stated, the "*Neuropharmacology"* module runs as a series of one-hour tutorial sessions where learning surrounding a neuropharmacology "theme" is supported by group-based, collaborative learning. Each week in which a "*Neuropharmacology"* session runs, the entire cohort (i.e. all current Year 3 students) are split into sets (A, B and C). Each set is then split into two groups (each of which is assigned a tutor), and each group is split further into three smaller groups (of approximately 7 students per group), each working through a series of clinically-themed "mini cases" to guide their learning (Fig. 3). Each week, the three cases focus on a similar theme, which may or may not be aligned to their clinical placements that week.

In terms of timing of the session, students have approximately 35-40 minutes to research the topic using textbooks provided and online resources. Each small group then has approximately five minutes to present their case and answers to the questions. A major outcome of the session therefore is that all the students obtain the knowledge from all three cases, despite having only carried out in-depth research on a single case. This is important, as each case may focus on a different pathology, and a different set of drugs, which all students are required to know in depth. Following this, the session is then repeated for the other two sets (totalling 3 hours teaching for each tutor).

(Insert Figure 3 here)

It is now generally accepted that small group learning methods of teaching are optimal for the promotion of *active learning* (Walton, 1997), with some suggesting that students are more likely to learn when working with others than alone (Michael, 2006). Active learning is the term used to describe student's active participation in learning activities to stimulate higher order thinking for analysis, synthesis and evaluation (Bonwell, 1991). This contrasts with the passive nature of didactic lecture-based teaching (Prince, 2004), and has been demonstrated to increase student performance, particularly in science, engineering and mathematics (Freeman & Eddy, 2014). As a subset of active learning, the term *collaborative learning* describes a scenario where students work towards a common goal, collectively in small groups (Prince, 2004). Graduates of medicine are required to learn continuously throughout their career. It is therefore not surprising that many medical schools now focus on instilling the principles of active learning. Additionally, on an experiential level, small group, collaborative learning creates an active, social environment allowing students to enhance their communication and team-working skills, and aids assimilation of knowledge (Kolb & Kolb, 2005; Walton, 1997). That said, there is a need to emphasise how best to implement small group learning in order that the student experience is both meaningful and productive (Cohen, 1994). In a review on the evidence base for active learning and its application to physiology teaching, Michael (2006) used a set of "rules" (initially devised by Romiszowski, 1999) to promote active learning, and generated specific techniques in which they could be implemented as part of small group teaching. Walton (1997) presented similar suggestions with reference to medical education, specifically. Collectively these recommendations are summarised in Fig. 4 below and have been adapted specifically to the "*Neuropharmacology"* module at Keele. A brief explanation for the pedagogic basis for some of these recommendations follows (full analysis of all the recommendations made are beyond the scope of this article).

(Insert Figure 4 here)

One aspect, which has been highlighted to promote effective small group learning, is to clearly define the learning objectives at the start of the activity (Biggs, 2007). However rather than merely providing these objectives as a list at the beginning of the module, by *demonstrating* the problem-solving process to the students this will illustrate what is to be expected of them – a technique termed "faculty modelling" (Michael, 2001). The first session for the "*Neuropharmacology"* module incorporates this technique. Students are provided with an example case and associated questions to work through. However, at the end of the session, rather than the students presenting their findings, the tutor provides model answers in addition to an explanation of how they approached the problem (e.g. example sources used). Upon

reflection, this session seemed to provide the students with the appropriate guidance of what was to be expected of them in future sessions. However, the session highlighted an additional problem. It became apparent that many of the students were lacking a level of basic pharmacology knowledge on which to build upon in the present module. These basic concepts were taught in Year 1 of the MBChB course; however, the students have had little opportunity to revisit these concepts in Year 2 (Bruner, 1960). Thus, as teachers we had assumed prior knowledge that, due (in part) to the gap between years 1 and 3, seemed to be lacking. It has been demonstrated that prior knowledge is imperative to the acquisition of new knowledge by creating "mental hooks" to anchor new concepts (Campbell & Campbell, 2008). Better methods for activation of prior knowledge early in the "*Neuropharmacology"* module may therefore be required.

Another important aspect highlighted by Michael (2006) is the use of "problems". As well as guiding the learning/investigating process, these problems will act as a goal or target for which the students can aim to achieve. Additionally, it is suggested that students should work through different types of problems, which should be presented from "easy" to "hard". In the "*Neuropharmacology"* sessions we employ a series of questions that the students work through to guide their research. This can be likened to "scaffolded learning theory*",* whereby the level of support and/or guidance given to the student is decreased as the student gains more knowledge and experience on a specific topic (Wood, 1976). However due to session time constraints (see below), students tend to divide the questions between the group members – with one or more students addressing each individual question. This does have the potential benefit of avoiding lack of engagement from quieter and/or weaker students - a potential disadvantage of group-based learning (Walton, 1997). However, by dividing the specific topics that each student addresses, the sessions run the risk of further limiting acquisition of knowledge during the session. Even though all students are expected to have a sufficient level of understanding of all topics to meet both the module aims, as well as alignment to GMC guidelines.

Student engagement and acquisition of knowledge

An important factor that is not currently outlined in the review by Michael (perhaps as it is implicit to the design of any learning activity) is the importance of allowing enough *time* for the students to carry out the assigned task. In their current format, the "*Neuropharmacology"* sessions only allow approximately 35-40 minutes for the students to work through the cases and questions. In my experience the students seemed to struggle to complete the session tasks; due to lack of time or due to lack of engagement (the latter perhaps a consequence of the former). As tutors we often need to prompt the students throughout the session. These feelings were reinforced by verbal feedback from students during the session. With regards to session logistics and timings, as each group only have five minutes to present their findings, group "presentations" were, I felt, inadequate – usually consisting of a single student reporting their findings verbally to the group, often with minimal

enthusiasm. This created an additional problem, in that many students felt a great deal of anxiety, as they were unable to hear what the students were presenting. This was evidenced by verbal feedback from a student. As a tutor it became increasingly difficult to ascertain whether the students had fully understood the concepts being presented. Although board pens are provided in every session, students never used them to illustrate the complicated concepts they were attempting to present. As such, the sessions are unlikely to cater to variations in learning styles and modalities amongst group members (Hawk & Shah, 2007). Specifically, there is a lack of a *visual* component to the sessions, which has been deemed critical for both activation of prior knowledge and acquisition of new knowledge (Roth, 1998) in addition to fostering problem solving and maintaining motivation (Cook, 2006).

Another aspect relevant to student engagement is the placement of the "*Neuropharmacology"* sessions with respect to the programme (as a whole). As discussed previously, the "*Neuropharmacology"* module forms part of Year 3 SPINE which currently run as a single academic day per week, with the rest of the student's time devoted to clinically focused sessions. The percentage of time that third year students spend in scheduled learning activities *vs*. clinical placements is far less than the first two years of the course (Table 2). This is likely to have an impact on the students' engagement with a module which is more similar in structure to the earlier, less clinically focused years of the course. According to Knowles' assumptions of adult learning (Knowles, 1970), adults are more likely to learn ideas and concepts that are relevant to immediate rather than future applications. As such, students that are within a more clinically focused mind-set are less likely to acquire new knowledge from a more basic science perspective.

(Insert Table 2 here)

"Neuropharmacology" module student evaluation

The MBChB course is evaluated by the quality assurance of basic medical education (QABME) to ensure that the content adheres to GMC guidelines. Additionally, however, Keele Medical School use student feedback to evaluate current teaching and content. Current Year 3 teaching is evaluated by students as part of an end of semester questionnaire. The questionnaire is delivered as an anonymous Google form in the last week of March where evaluation of the "*Neuropharmacology"* module is grouped alongside all SPINE sessions. The questionnaire was designed to include a five-point Likert scale (Likert, 1932) assessing the effectiveness of specific sessions run in SPINE. Unfortunately, the questionnaire was designed so that questions are not module-specific, therefore evaluation through the Likert scale was not specific to "*Neuropharmacology"* teaching. That said, the inclusion of free-text comment boxes allow the students the freedom to feedback on specific areas that they felt worked particularly well or not. Indeed, several students

mentioned the "*Neuropharmacology"* sessions as part of this free-text feedback.

Assessing student perceptions of small group teaching activities can be a useful means of session evaluation. For example, a study by Steinert (2004) established that student perceptions of effective small group teaching include (but were not limited to): (i), active student participation; and (ii), cases that promote thinking and problem solving. This is echoed by feedback received on the "*Neuropharmacology"* sessions. Others suggest that the use of student feedback questionnaires as a valid indicator of teaching quality should be addressed with caution (Kember, 2002; Wachtel, 1998). For example, the timing of student evaluations may influence the response rate (Hatfield & Coyle, 2013). The fact that students were given the questionnaire several months after the module had finished ("*Neuropharmacology"* runs until the end of November and the questionnaire was delivered in March) could lead to a decrease in the number of students responding to the questionnaire. Additionally, the students that do respond are more likely to hold particularly strong views (usually negative; Kherfi, 2011) which could influence whether the responses are representative of the entire cohort. For this year's evaluation, even though the questionnaire was delivered several months after the module had run, the response rate was 92%. Furthermore, several students took the opportunity to comment about the "*Neuropharmacology"* module despite having not been asked about it specifically. After reflecting on this feedback, I outline the proposed redevelopment of the sessions as stated in the following section.

Re-design of the "*Neuropharmacology"* module

From this critical evaluation of the "*Neuropharmacology"* module, as well as assessing student feedback, I have identified a number of potential issues which should be addressed in the re-design of the module: (i) individual sessions are currently too short; (ii), lack of [assumed] prior knowledge; (iii), lack of student engagement during sessions; (iv), lack of confidence in knowledge acquisition. Based on this evaluation I have re-designed the sessions with the overall aim to improve student engagement, confidence and knowledge acquisition. In order to achieve these aims, the following changes will be implemented for the 2017/2018 academic year:

(i) Implementation of an introductory lecture
(ii) Alterations of session logistics
(iii) Re-design of clinical cases and associated questions

The re-design of the *"Neuropharmacology"* module will be achieved predominantly by restructuring; with an emphasis on session logistics.

Change 1 - Introductory lecture

The first change to be implemented as part of the Neuropharmacology module is the introduction of a 30 min lecture at the start of the first session. The aim of this lecture will be to remind the students of core knowledge (obtained in the first year of the course) as well as modelling how the sessions will run.

It has been suggested that the greater the amount of prior knowledge the more likely a student will learn something new (Bransford & Johnson, 1972; Schmidt, 1993). Consequently, this suggests that those who lack prior information (or prior knowledge has not been adequately "activated") may struggle to acquire new knowledge. A key objective of the introductory lecture will be to activate prior knowledge surrounding basic neurotransmission and pharmacological concepts. Students should then build upon this knowledge during the "*Neuropharmacology"* sessions. In practice, the lecture will cover the basics of neurotransmission and the various sites at which a potential neuropharmacological agent may act (see Fig. 5). The delivery of information by means of a lecture falls under the umbrella of mass instruction teaching and differs from both small group teaching and individualised instruction (Elton, 1977). Although lectures have been a mainstay of higher education teaching throughout history, their usefulness as an effective means of teaching has been criticised of late. For example, Bligh (2000) suggests that lectures place students in a passive role, as students do not have enough time to analyse, question or reflect on the information presented. This negates the previously discussed emphasis on active learning. Furthermore, long-term retention of information delivered in lecture-format may be poor (Bligh, 2000). Conversely, the use of lectures has also been advocated if the quality and context are justified (Bligh, 2000; Crawford, 2016). Furthermore, the purpose of the introductory lecture is to activate prior information, rather than deliver new content. As a "starting block" to the module, the lecture should orientate the students and demonstrate how the sessions will run – a form of faculty modelling (Michael, 2001). A final justification for the use of an introductory lecture is that it introduces a different format or learning style to the module itself. In its current format, the "*Neuropharmacology"* module consists only of small-group collaborative learning, and the implementation of a lecture may therefore cater to a wider range of learning styles (Hawk & Shah, 2007).

(Insert Figure 5 here)

In addition to activation of prior knowledge, it is anticipated that the introductory lecture may facilitate transfer of "threshold concepts" – i.e. concepts which transform the way in which a student thinks about a topic so that they pass a point of no-return with regards to their understanding (Meyer & Land, 2003; Davies & Mangan, 2007). Specifically, by explaining/illustrating that [virtually] all drugs that act within the central nervous system do so via one or more of a select few target sites, this will hopefully relieve the anxiety felt by some students when faced with the prospect of learning such a difficult topic. The hope is that this will aid their future learning. This will be facilitated by the provision of supplementary material covering the physiology of the

eight major neurotransmitters relevant to the central nervous system. Understanding of neurotransmitter physiology forms the basis of a good grounding in neuropharmacology, therefore this supplementary material can be accessed by the students when they perform their research in small groups.

Change 2 – Session logistics

The second (and perhaps fundamental) change to be implemented in the "*Neuropharmacology"* module is the logistical restructuring of the sessions. In its current format, the sessions leave little time for the students to carry out their research and present their findings to adequately inform the other students. The new module will therefore be reformatted to consist of two sessions: (i) a three-hour tutor-guided case-based group learning session; and (ii) one-hour student-led presentation session (Fig. 6). "Session 1" will be run across three separate weeks - one for each third (set) of the year and will begin with the 30-minute introductory lecture discussed previously. Once the students have been introduced to the module and their prior knowledge activated, each set will be split into two large groups with one tutor per group (in a similar fashion to the current format). Each tutor-led group will then be split into 4 smaller groups of approximately 5-6 students per group, each working on a different case. The groups will then have one hour to research the answers to the cases (see following section) and prepare their presentations – providing the students a 100% increase in time available for this activity. After a 15-minute break, the students will then return and have 15 minutes per group to present their findings to the rest of the class. Again, this will increase the amount of time considerably. Once "Session 1" has been carried out for all three sets, tutors will then release a further four cases for the students to research in their own time. All students will have two weeks for self-study, where they will then return for "Session 2" – a one-hour session where each group will have 15 minutes to present their findings to the class.

(Insert Figure 6 here)

It is anticipated that restructuring the session in this way will address several of the issues raised by both student feedback and my own critical appraisal of the module. For example, longer sessions will allow more time for students to carry out their research in order to answer the questions presented. This should increase student engagement with the sessions, as the task at hand will not seem as intimidating. Increasing the amount of time dedicated to researching the topic could also alleviate the need to split the questions between group members and may foster further discussion to necessitate effective group learning (Walton, 1997). The students should also have more time to prepare effective presentations to deliver following the 15-minute break, and tutors can emphasise the importance of using white boards to draw illustrations and flow diagrams to aid presentation delivery. By encouraging the students to use illustrations to explain their findings, this will

not only aid learning, but also account for variations in learning styles for those students who were not currently researching that topic/drug-in-question. This will facilitate a "multimodal learning environment" – i.e. a teaching session in which the core content is delivered by both verbal and non-verbal means (Paivio, 1986; Moreno, 2007).

Conversely, there may be some disadvantages to increasing the length of the sessions. For example, total session time (for "Session 1") will be increasing 3-fold. Some students may succumb to cognitive or mental fatigue, which has been demonstrated to affect attention, motivation, distractibility and performance (Sievertsen, 2016; Boksem, 2005; van der Linden, 2003). This has been highlighted as an important point in the design of teaching sessions in a medical curriculum (Ramani, 2008). This may prove to be counterproductive in terms of increasing motivation amongst the student cohort. For this reason, the first session has been designed to include a 15-minute break (in-between the 1-hour research time and 1-hour presentation time). Additionally, in order to accommodate the longer, tutor-guided session, the second session (which will include an equal number of cases/questions incorporating novel content) will only be one hour long. This means that students will have to perform the research in their own time, and it is unlikely that students will be able to work as part of a group. Tutors will be required to emphasise the importance of the self-directed-learning element, because if the students do not perform the work in their own time, the second, shorter session will not be able to run.

Along these lines, the longer, tutor-guided first session should form a basis for how students should approach pharmacology learning. Although in the introductory lecture the tutor will *tell* the students how they should approach the cases/questions, the first session will demonstrate this first-hand and thus model the approach for future learning (Michael, 2001). The students can then use the skills acquired in the first session to address the new cases in the second, shorter session. Some of these skills include self-directed learning, research, selection of appropriate resources and communication – all necessary attributes outlined in *Outcomes for graduates*. There are of course some noted disadvantages to self-directed learning, which have been highlighted specifically with regards to PBL-based learning in medical curricula. For example, students are often left frustrated and are unaware of "how much they need to know" (Wood, 2003). This is something I have encountered frequently during my own teaching within the "*Neuropharmacology"* module. As a consequence, the additional emphasis on pre-work has the potential to impact the acquisition of knowledge, as this will be the only opportunity for students to encounter this material within a formal teaching session. Nevertheless, tutor feedback in the second session will allow for any gaps in the student's knowledge to be filled and does address points made in student evaluation of the sessions (Table 3).

Change 3 – Case re-design

The final change to be implemented to the "*Neuropharmacology"* module is again directed to the "student confidence/engagement" aspect of the critical appraisal. In this regard, the questions associated with each mini case will be re-designed with the aim of being more specific to the learning outcome we, as tutors, expect. To ensure that the students approach the questions properly, the first question associated with each case will ask the student to draw a "typical synapse" for the specific neurotransmitter in question. The outcome of this single question will be three-fold: (i) the student will be able to use information provided in the introductory lecture to answer the question ensuring they have engaged with the content; (ii) the inclusion of an "easy" question to start with (as information has been provided to them) will make it easier to address the [subsequent] harder questions. The latter will require the student to build on this knowledge using content/evidence from which they have obtained through research; and (iii) by asking the student to *draw* something, the task is more explicit, and will encourage the student to illustrate their findings for the forthcoming presentation in the second half of the session. This again, will assist in multi-modal learning and alternative learning styles. Following this, subsequent questions will then increase in difficulty, in line with the recommendations made by Romiszowski (1999) and Michael (2006) and outlined in Fig. 6. In this way we will be able to guide the students as to what we want them to learn, and further facilitate the modelled approach to learning.

There are, however, some potential consequences of designing the questions to be more specific rather than open-ended. For example, according to Knowles' adult learning theory (Knowles, 1970), students are more likely to learn if they are involved in the planning and implementation of their own learning. Therefore, if the questions are too prescriptive, it may negate the active, student-centred learning process. However, assessment of student feedback suggests that more guidance on what they should be learning is required.

Conclusion

The purpose of the present article was to critically evaluate the Year 3 "*Neuropharmacology"* module according to relevant pedagogic theory and GMC guidelines, as well as incorporating student feedback. Overall, I felt that the module achieved its aims in terms of content, however, was weaker with regards to structure and logistics of the sessions in which the content was delivered.

It has now been three years since the re-designed sessions were first implemented as an outcome of this evaluation. Having reflected on this process, I feel that the module's re-design has achieved the aim of improving student engagement, and I have witnessed an improvement in student confidence with neuropharmacology topics. In addition, the re-formatted sessions have enabled students to build their skills in team-working, research and communication. These skills are not only required for a graduating clinician but align to "Keele's Approach to Education". As such I believe that

the core principles employed in the re-design of *“Neuropharmacology*” are applicable to other modules striving to improve engagement with student-led, collaborative learning sessions.

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Figures

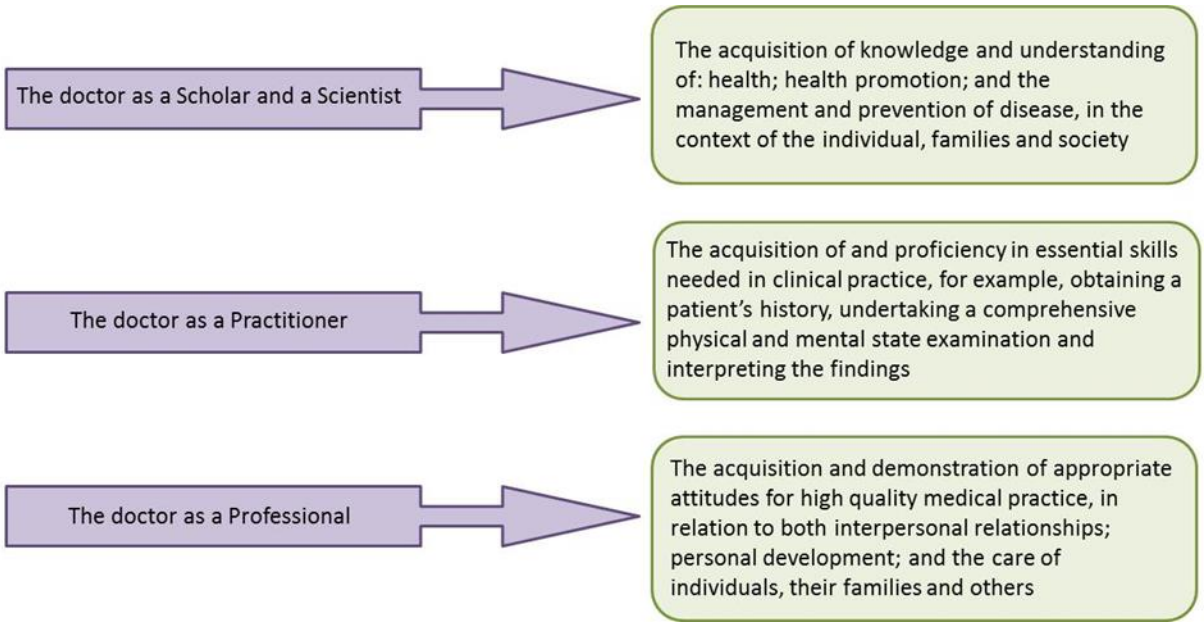

Figure 1. The three themes outlined in the GMC's Outcomes for Graduates formulates the aims of the Keele undergraduate medical course. Adapted from Keele University (2016a).

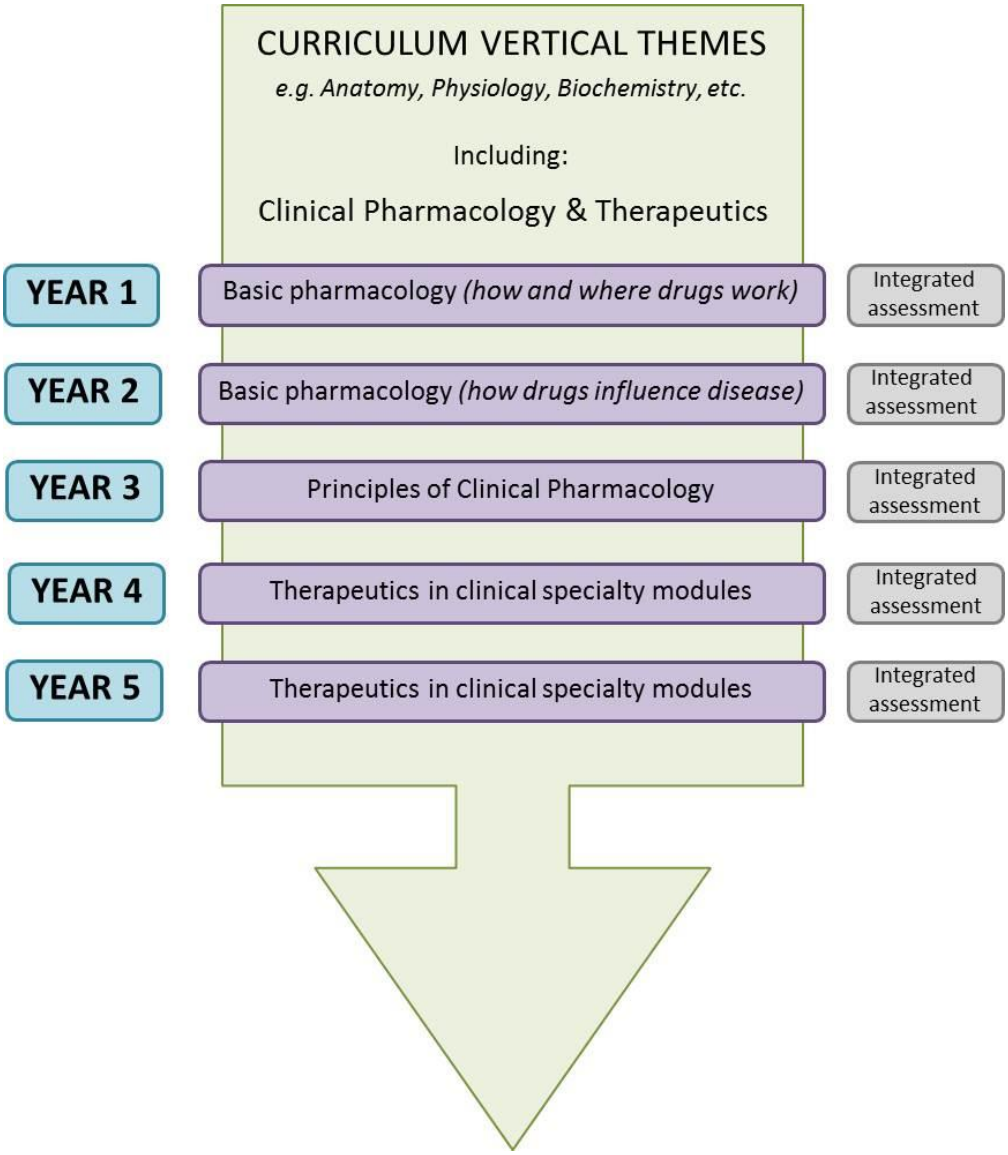

Figure 2. An example of an integrated pattern of delivery of pharmacology teaching in an undergraduate medical curriculum. Teaching of pharmacology in the Keele MBChB programme follows a similar structure. Each year of the course is composed of a series of units (modules) and specialist areas (e.g. anatomy, physiology, pharmacology, behavioural and social sciences, etc.) are taught as strands. The content of the units is assessed by integrated rather than modular exams. Adapted from: Maxwell & Walley (2003).

Week	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5
1	Anatomy	Neuroph *ADHD*			Lecture	Lecture	Seminar	
2	Neuroph *Anxiety*	Workshop	Workshop		Lecture			
3	Anatomy	Neuroph *Psychosis*	Workshop		Lecture	Lecture		Seminar
4	Neuroph *Addiction*	Workshop			Lecture	Seminar		
5	Anatomy	Neuroph *Depression*			Lecture	Seminar		

Table 1. A typical SPINE timetable for a student in the first semester. Students in Year 3 spend each Thursday at the Medical School for SPINE sessions. Weeks illustrated are those in which "*Neuropharmacology*" sessions currently run. Neuroph = Neuropharmacology, ADHD = attention deficit hyperactivity disorder.

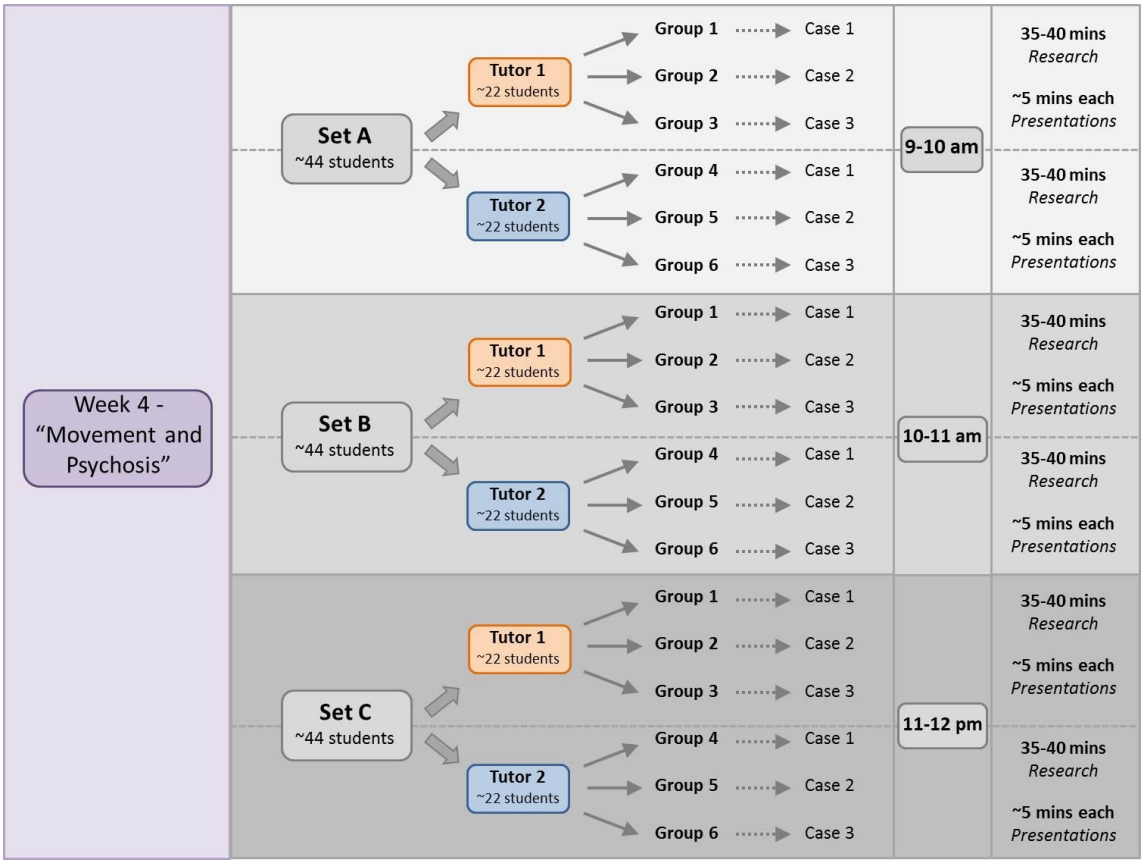

Figure 3. Current format of a "*Neuropharmacology*" session. The example illustrated is for "Week 4 – Movement and Psychosis". Each of the five sessions follows a similar format.

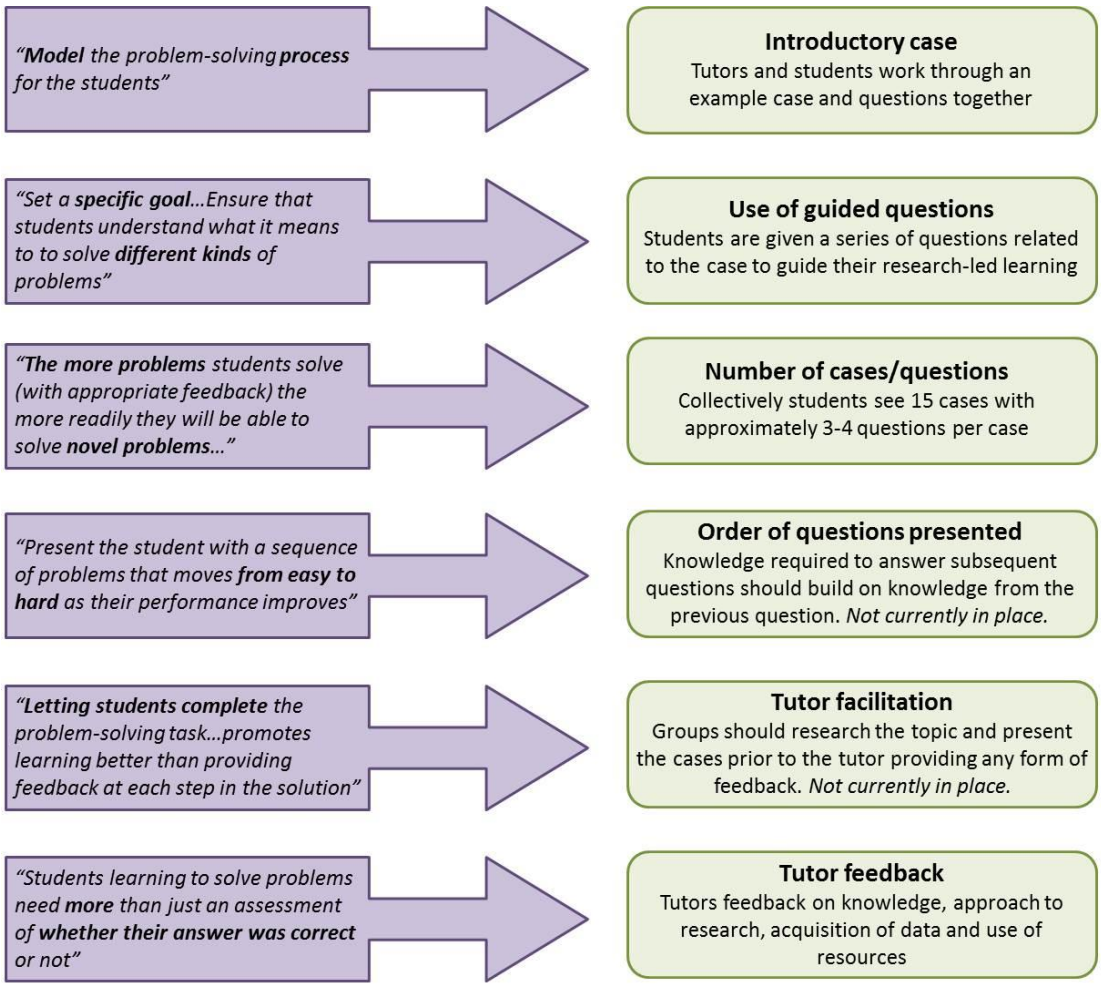

Figure 4. Recommendations to promote effective learning in a small group environment. Purple arrows illustrate the initial "rules" suggested by Romiszowski (1999) and their application which have been adapted from Michael (2006). Green boxes highlight how these recommendations are applied in the "*Neuropharmacology*" module (or where the recommendation is not currently applied).

Activity	Year 1	Year 2	Year 3	Year 4	Year 5
Scheduled learning and teaching activities	43%	43%	29%	27%	11%
Guided independent study	54%	50%	15%	8%	13%
Placements	3%	7%	56%	65%	76%

Table 2. Contact time and expected independent study across the Keele MBChB programme. The "*Neuropharmacology*" module sits within Year 3 of the curriculum (highlighted). Adapted from: Keele University (2016b).

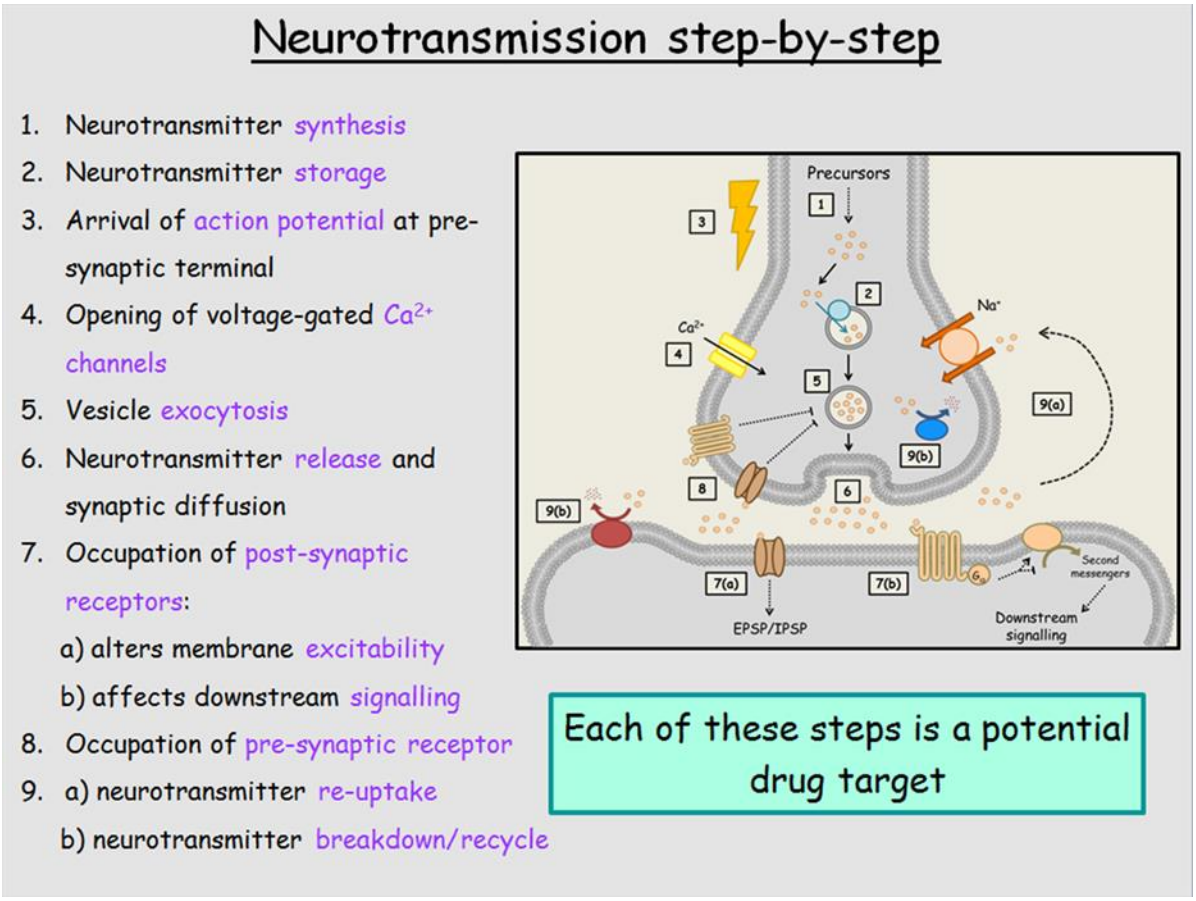

Figure 5 – example slide from the 30 min introductory lecture.

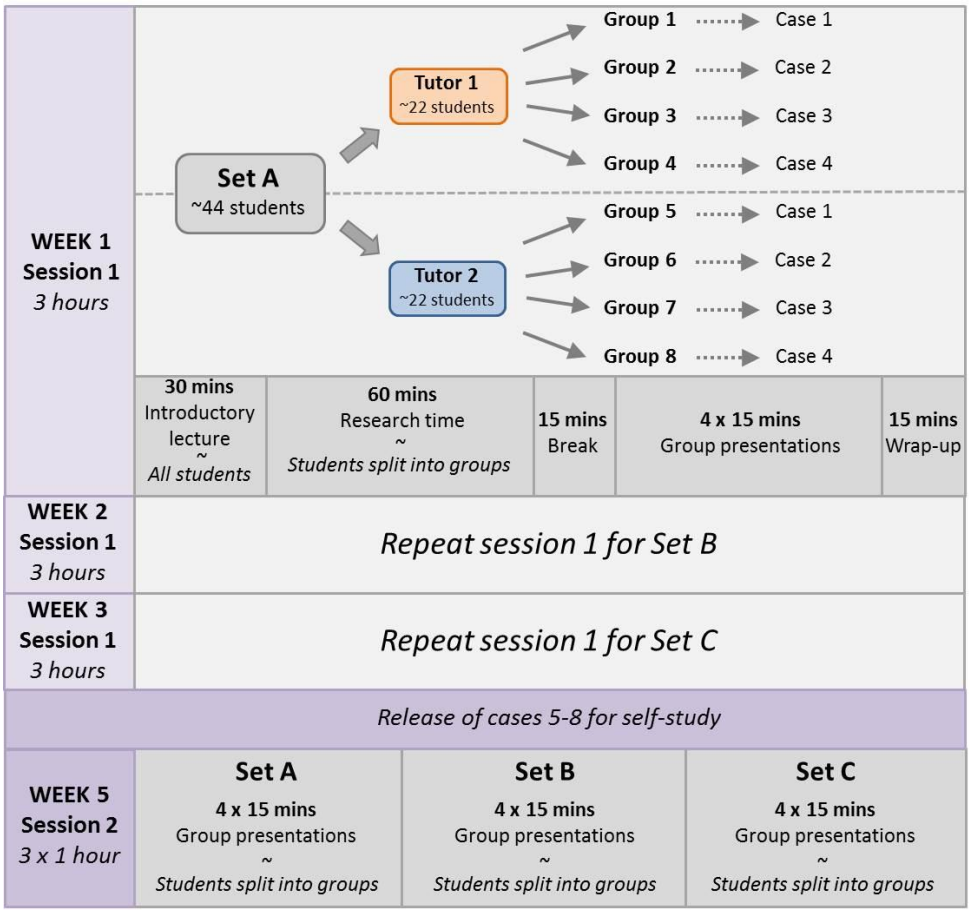

Figure 6. Overview of the new "*Neuropharmacology"* module. For comparison the contact time for each student will be 4 hours (vs. 5 hours in the old format). Total hours teaching for tutors will be 12 (vs. 15 in the old format).