Small Group Workshop as an Active Learning Strategy for Teaching Pharmacokinetics: Implementation and Outcomes in Undergraduate Classroom

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Abstract

A pharmacokinetics course is offered in most pharmacy curricula; however, it is generally not well received by students due to its basis in mathematics and the difficulty experienced in linking basic concepts with clinical relevance. Therefore, it is imperative to reorient conventional classroom teaching of pharmacokinetics courses towards achieving enhanced outcomes in terms of problem-solving and critical thinking skills of students in clinical practice based settings. In this context, a novel small group workshop approach was designed and implemented to teach a pharmacokinetics course to undergraduate pharmacy students. The course design and delivery were based on active participation and learning by professional students in teacher centric small group workshop (SGW) sessions through practice based learning. Another group was taught with traditional didactic classroom lectures (CRL). Students' assessment was carried out based on grade scores obtained in pharmacokinetic problem solving and answering the given questionnaire in each group. An anonymous written feedback was administered following completion of the course to determine students' perception of the delivery method. The majority of the SGW students reported that they were active learners in small groups whereas only a few from the CRL group believed that they actively participated in the learning process. Students' agreement that they would be able to analyse and interpret given pharmacokinetic data displayed major differences in both groups as evidenced from the feedback response. Further, there was a positive response among SGW students in their perceived ability to apply pharmacokinetic theory to the specific case scenario after attending the small group workshop sessions; paradoxically to the responses such as "Disagree" or "Unsure" about this parameter after attending the traditional classroom lectures. The study findings suggested that small group workshops offer students a tangible method to increase their overall level of understanding, comfort and confidence in the application of pharmacokinetics concepts in therapy. The small group workshop can be utilised as a potential instructional method for active and meaningful learning for the delivery of pharmacokinetics courses.

Key words: pharmacokinetics; pharmacokinetic parameters; small group teaching; workshops; data treatment

ISSN: 2044-3315

Introduction and Context

Education is a process, the main objective of which is to bring certain positive behavioural changes in the learner. There are three important ingredients of education: objectives, teaching -learning activities and evaluation. As a blue print can tell an engineer how the output will look, the educational objectives tell the teacher what is expected from the learner at the end of the process. Teaching involves all such activities and processes, which help the learners to facilitate their learning capability by acquiring skills in thinking, feeling and doing. Teachers have always acted as a source of information and through teaching they transmitted the information in their intellectual stocks to learners. Throughout history, teachers have played an active role in the educational process. But when the emphasis was shifted from the teacher to the learner, the teacher has become less of a transmitter of information and more of a facilitator of learning. With this new role of the teacher, the overall responsibility and functions of the teacher in the educational process have increased tremendously (Ananthkrishnan et al, 2000).

Based on long teaching experience, it was observed that most pharmacy students have considerable difficulty applying pharmacokinetics to patient care, and further, that this limitation is also prevalent among practicing pharmacists. In order to apply pharmacokinetics to patient care, the student or pharmacist must be able to transfer knowledge from the classroom to the patient-care setting. In this context, learning is an individual endeavor that requires teachers to personalise and deliver information in new and creative ways in order to achieve the goal.

Pharmacokinetics utilises new teaching media and methods to communicate pharmacokinetic concepts to students with the goal of reaching each student individually and providing a customised learning experience. Pharmacokinetics aims to describe drug absorption, distribution, metabolism and excretion mathematically as a means of predicting drug behaviour in specific patient subpopulations. A pharmacokinetics fundamentals course is offered in most pharmacy curricula; however, it is generally not well received by students due to its basis in mathematics and the difficulty experienced in linking basic concepts with clinical relevance (Persky and Pollack, 2009).

Traditionally, the delivery of pharmacokinetics education in pharmacy programs has followed a didactic, lecture-based teaching format; a teacher-centered approach, in which information is defined, controlled and directed by the instructor. It would appear that this limits higher levels of student learning (Jones et al, 2012) as students are not encouraged to learn how to gather, analyse or synthesise information and do not develop the skills to analyse the logic of questions and problems (Garside, 1996). It has also been suggested that due to its mathematical focus, pharmacy students find it difficult to apply pharmacokinetics to patient care in the clinical settings. Students and pharmacists need to be able to transfer learned processes from one context to another. This application of knowledge is a key component of deep learning and practising; as in case of pharmacokinetics, this is sometimes overlooked (Dupuis and Persly, 2008).

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However, in a short semester course and busy university schedule, students are expected to be involved in several academic and associated curricular activities. Therefore, it is reasonable to suggest the following approach at undergraduate level: a not completely student-centred approach, which also actively engages students to participate and learn, where students feel free to contribute to face to face interaction, and can actively participate in discussion. This is achieved with minimal burden and stress unlike a completely student-centred approach whereby students are required to prepare study materials by themselves. Consequently, students can better focus on actual understanding and the basics of the pharmacokinetics concepts not only within the context of the syllabus and examination, but also their exposure to clinical data. Further, it has been noticed that conventional lecture based teaching in pharmacokinetics resulted in poor understanding especially in form of assimilating, analysing, interpreting and implementing the pharmacokinetics data to real case scenarios, due to which the actual purpose of pharmacokinetics teaching seemed to be failing in the current educational set up or while handling case studies in clinical settings. Moreover, it was experienced that mere theoretical class room teaching was not productive unless students themselves perform pharmacokinetic data treatment and interpretation of pharmacokinetics parameters.

Thus the intake of knowledge and its reproduction, delivered via traditional models of didactic teaching was found insufficient for pharmacy students (Smith et al, 2010). The converse of the teacher-centered approach to learning goes beyond the simple acquisition of knowledge and comprehension and involves active participation by students in the learning process. It is well known that students who actively participate in the learning process learn more than those who do not (Howard and Henry, 1998; Howard et al, 2002; Fritschner, 2000) and they experienced increased retention of information and learning (Weaver and Jiang, 2005).

In this context, it was realised that the pharmacokinetics teaching should be carried out with a novel teaching method to enhance the learning abilities of the students during their study periods. Before designing and implementing the small group workshop for pharmacokinetic teaching, the advantages of small group teaching methods were considering, which include: learning rigorous academic discourse; knowing each other well in a group which is more difficult in a large lecture theatre; the possibility for the students to interact with the teacher and each other on a sustained basis; working in teams, and thus developing the key skills of teamwork and cooperation. Keeping in view the appropriateness of small group teaching at undergraduate level, this in turn resulted in the concept of workshop sessions in small groups. Therefore, work was undertaken to propose and implement a practical workshop concept in small groups for teaching basic pharmacokinetics and data treatment to undergraduate pharmacy students; and to assess and compare the learning outcomes of students for this new method with that of delivery of traditional classroom lectures.

ISSN: 2044-3315

Literature review

Some colleges and schools of pharmacy use problem based learning (PBL) or case-based learning in their pharmacokinetics courses. Key attributes of the structure of these courses and the present course include delivery of foundational information by student and/or faculty members with application of concepts through case-based problems, followed by a collective review of solutions. Carolyn et al (1999) observed that following the clinical clerkships and pharmacy practice, pharmacy students had great difficulty in applying pharmacokinetic principles to patient care and the problem was hypothesised to be one of contextual transfer of learning. They redesigned and implemented an undergraduate pharmacokinetics course to teach the process of contextual transfer using active learning strategies in an enhanced process for learning application of pharmacokinetics. Persky et al (2007) incorporated games into classroom instructions to develop classroom games as alternatives to traditional pharmacokinetic instruction. Overall, students found the games enjoyable, but some students questioned how much they learned. Mehvar (2008) evaluated the effectiveness of active learning tools and practice opportunities on the ability of students and found that despite being a difficult subject, students achieved mastery of pharmacokinetic calculations for the topic of intermittent intravenous infusion when appropriate active learning strategies and practice opportunities were employed. Thomas et al (2008) developed and implemented a high-stakes assessment approach to applied pharmacokinetics instruction in order to identify instructional and assessment problems leading to pharmacy students' failure to retain pharmacokinetics abilities into the experiential year and develop an instructional methodology and abilities-based assessment tool to address the problem. The study results revealed that both instructional methods and assessment methods improved students' pharmacokinetic skill performance in the direct patient-care environment. Dupuis and Persky (2008) studied the impact of cased-based learning which was implemented in an applied pharmacokinetics course to focus on applying pharmacokinetic concepts, pursuing higher levels of learning, and improving student participation at a distant site. Persky (2008) employed a multifaceted approach to integrate a series of educational strategies ranging from content delivery to assessment, including a change in philosophy regarding the use of in-class time, to enhance the learning of pharmacokinetics.

Persky and Pollack (2008) implemented an "Answer-Until-Correct" and immediate feedback examination format in the core curriculum to improve learning in fundamental and clinical pharmacokinetics courses, in order to determine whether this format assessed pharmacy students' mastery of the desired learning outcomes as well as a mixed format examination (e.g., one with a combination of open-ended and fill-in-the-blank questions). Shawaqfeh (2015) conducted a systematic review, in order to determine the effects of implementing educational games into the pharmacy curriculum. His studies reported that although some students believed that the games did not affect their overall grades, the majority of the students felt they were more engaged and had more preparedness and confidence for real life scenarios as a result of participating in the different educational games.

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Design and Implementation

The study was designed with a total of 47 students divided into two groups. These groups were assigned names 'SGW' (for novel small group workshop sessions) and 'CRL' (for conventional classroom lectures).

The study design was modelled on a classic small group teaching format, with data treatment workshop sessions (SGW) and comparison with traditional class room lectures (CRL). The study protocol was approved by Institutional Review Board and participants' consents were taken prior to initiation of the study. All the students were placed in two different groups; one small group of 10 students (SGW) and another consisting of 37 students (CRL), based on their final grades in previous semester, thus balancing level of academic performance among the groups. With this distribution technique, the semester grade point average among groups varied from minimum ±0.3 to a maximum of ±0.5 based on a 4.0 scale.

The instructor was responsible for designing the object of workshop sessions and a questionnaire, their relevant data and information as well as students' assessment. For designing the workshop objectives, their related information and volunteer data as well as subject related questionnaire, standard text books were referenced (Gibaldi, 1991; Shargeal, 2005; Rowland and Tozer, 2005).

Based on the curriculum, ten workshop objectives were designed with their hypothetical data and other necessary information required (depending on the workshop object) to solve the pharmacokinetic problem. The workshop was held once every week with four hour sessions. After the instructor provided and explained the necessary data and theory, students were then allowed to proceed for the treatment of data as per given instructions. While proceeding for the remedial solution of a given pharmacokinetic problem, students were encouraged to interact with the instructor in case of any doubt or confusion. During this time, the instructor was supposed to be discussing, interacting or helping the students. Moreover, this was the time when the instructor qualitatively assessed students' understanding, interest and enthusiasm for learning. After completing the given pharmacokinetics exercise, same pharmacokinetic practice exercise with new data set was assigned to the students in addition to a questionnaire containing set of at least four basic questions related to the given exercise. Both of these were in turn solved by the student. At the end of session, the solved practice problem, completed questionnaire and students' feedback were collected and assessed by the instructor.

For another group CRL, the same pharmacokinetics topics were taught by the instructor in two consecutive lectures, each of two hours. Further, pharmacokinetic problems and questionnaires given to the students were assessed. For both groups, the instructor was the same and was allowed to use a board and power point presentation for the delivery of information and instructions. The students were permitted to use scientific calculators and MS Excel program as

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and when required but were restricted to use any pharmacokinetics software. The comparison of the assessment was done for both the groups at the end of ten sessions. The ten data treatment pharmacokinetic workshop objects (WO) designed by the instructor are listed in Table 1.

Assessment and Findings

Assessment criteria were mainly divided into two: Qualitative and Quantitative. These two approaches considered the assessment of learning and problem solving skills and the solution of practice pharmacokinetic problems along with answering a questionnaire at the end of each workshop session. The quantitative approach employed the evaluation of given exercises and their respective grades. The students' answers were evaluated out of ten points and different grade scores assigned as A (9-10 points - Excellent), B (7-8 points - Good), C (5-6 points - Average), D (3-4 points - Poor) and F (<3 point - Fail). The qualitative approach utilised judgement of the level of understanding, related skills and interpretation of results of pharmacokinetic parameters, speed of calculation, interpretation and analysis of numerical values of pharmacokinetics parameters in clinical settings, ability to relate derivatisation of theoretical equations to the problem solution, clarity about pharmacokinetics parameters units, expression of results, enhanced confidence for interacting with fellow classmates and the instructor as well as the overall educational benefit of the practical workshop sessions. Data collection of students' assessment was carried out each week whereas written feedback and the open ended survey were conducted at the end of ten weeks.

In the small group workshops (SGW), 80% of students scored an "A" grade and 20% of the students secured a "B" grade in solving practice pharmacokinetics problems, whereas 70% and 30% students secured "A" and "B" grade respectively in answering the questionnaire. Surprisingly, none of the students out of 37 in CRL group scored an "A" or "B" grade in solving the practice pharmacokinetics problem. However, approximately 11% students were able to answer the pharmacokinetic questionnaire. Only 8% of the students scored a "C" grade, whereas 19% and 16% students showed poor performance in problem solving and the questionnaire respectively in the CRL group. The majority of the students in CRL group (73%) failed in solving the practice pharmacokinetics problem (Table 2).

An anonymous written feedback was administered following the completion of the course to determine students' perception of the delivery of the instructional method. Students were asked to assess their experiences and feelings related to functioning within the small group environment, close interaction with peers and finally, their independent performance, and their ability to identify, evaluate and summarise key points applicable to the specific objective of the study. Based on the written feedback from the survey instrument, the students' main concern was regarding their active participation in the learning process despite the fact that the faculty facilitator was present all the time in both the workshop and classroom set up. On the feedback

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survey, the majority of the students in the small group setting (95%) believed that they actively participated in learning, whereas only 19% from the CRL group believed that they actively participated in learning. Students' agreement that they would be able to analyse and interpret given pharmacokinetic data displayed major differences in both groups as evidenced by 85% and 5% from the SGW and CRL group respectively (Table 3). There was a positive response (80%) among students regarding their ability to apply pharmacokinetic theory to the specific case scenario after attending the small group workshop sessions whereas 62% of students were disagreeing and 30% were unsure about this parameter after attending classroom lectures.

In the open ended section of the survey instrument, a high-frequency response utilising the small group workshop for pharmacokinetic teaching and learning was the active and outcome based objectives. While 65% of the students from CRL group believed that they would not be able to analyse and interpret the pharmacokinetic data (Table 3), it was further reflected in their strong belief about the insufficiency of classroom lectures for pharmacokinetic teaching; further seeking some modified class room teaching format to be implemented (Table 4). Interestingly, students were anxious but positive with their existing teaching method in the case of small group workshops, whereas most students were comfortable, but confused and doubtful about information delivered with didactic classroom lectures. Despite this inherent anxiety, the students reported perceived strengthening in their ability to engage higher level intellectual skills such as analysis, interpretation, judgement and problem solving. Students ultimately believed that small group workshop sessions improved their knowledge and concepts to case based scenarios similar to real practice situations in clinical settings, thus fulfilling the main goal of the pharmacokinetic teaching-learning process (Table 4). The overall educational outcomes of the small group workshop format are summarised in Table 5.

Discussion

During the compilation and assessment of the small group workshop sessions, anecdotal feedback from students after final their practice experiences indicated that the proposed data treatment workshop format in small group teaching was capable of combining the benefits of both components of the format, that is, workshop sessions as well as small group teaching method. This proposed method made the students capable of understanding and consequently, performing, the pharmacokinetic calculations comfortably and speedily. The small group workshop sessions further enhanced students' capability to correlate theoretical pharmacokinetic equations to practical problem solving. The most significant benefit students achieved in support of small group workshop sessions, along with solving practice pharmacokinetic problems and answering the questionnaire, was considered to be a highly positive shift in students' perceived ability and learning outcomes to apply theory to case based scenarios.

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While facilitation of pharmacokinetics using the small group workshop sessions requires greater faculty concern and commitment than that for the conventional classroom lectures format, the author believes that the method offers a superior preparation format for highly effective teaching as well as communication and delivery skills by directly exposing students to pharmacokinetic concepts. It also teaches the students how to work towards a common goal in a small group setting without compromising independent working and practising. This provides the feeling of active participation of the learner in an otherwise teacher-centric approach. The format of small group workshop sessions for pharmacokinetics appeared to be comfortable for most students who were accustomed to the conventional classroom lecture set up but at the same time, realising much more active participation of self with other components of the format such as size of group, constant interaction with teacher, on the spot clearance of any doubt, immediate feedback about their own understanding through solving practice problems and answering questionnaires, better guidance regarding expression of results and documentation of data treatment as well as clearer understanding regarding relevance between pharmacokinetic parameters and their clinical implications. Also, the instructor's qualitative assessment based on observations about students working in both groups were different. For the students of SGW, enhanced skills for planning and presenting the results of pharmacokinetic study was noticed, whereas the majority of the students in the CRL group were lacking this ability. One more interesting and major observation by the teacher was regarding students' ability to retain pharmacokinetics parameters derivation and formula, their units and terminology; this was surprisingly higher among SGW students than among CRL students. This fact was attributed to a better teaching-learning format offered by SGW as compared to CRL. Another major advantage of SGW was that, although students were active participants, they were not directly involved in the teaching process and therefore remained stress-free about their direct responsibility of contributing toward teaching to their fellow classmates, unlike in a few active learning approaches such as seminar or presentations. The author believes this is a major credit point of small group workshops which might lead to high frequency positive feedback in open ended responses regarding this method. Further, this active participation in the learning process was found to be a potential format for the short curricular course duration and busy academic schedules. In this way, the specific, concise and highly effective small group workshop session offers students the ready-to-access information, but at the same time, allows the students to work individually, thus providing the opportunity to read, learn and practice more in pharmacokinetics.

The overall results of the studies revealed that practical workshop sessions through small group teaching were extremely useful and helped the students to be thorough in understanding the calculations and modeling in pharmacokinetics which was found to be quite difficult with conventional class room teaching. The proposed instructional delivery format also demonstrated that students' learning ability was focused on their teaching perception which allowed easy access to communicate with the instructor, teacher's attention to individual students with face-to-face interactions, and on the spot doubt clearance with each other and with the instructor.

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Conclusion

Implementing small group workshop sessions to teach pharmacokinetics in the undergraduate classroom reinforces the application of pharmacokinetic theoretical principles to clinical scenarios. In addition, this structure promotes individual and professional skills required to develop a functional foundation of learning fundamentals in pharmacokinetics principles and confidence in individual clinical judgement. The proposed teaching-learning format was found to offer a higher level of potential educational benefits and critical skill improvement in the pharmacokinetic ability of the students upon successful completion of the workshop sessions, compared with didactic teaching through conventional classroom lectures.

Acknowledgement

The author would like to thank professional pharmacy students for participating in the study with a positive attitude and open mindedness.

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ISSN: 2044-3315

Appendix (i)

Table 1. List of Workshop Objects Designed in Pharmacokinetics Course

WO 1. Introduction and study of mathematical fundamentals including use of semi log graph in pharmacokinetics.

WO 2. Determination of absolute bioavailability for given data of drug concentration as a function of time for an orally administered drug using trapezoidal and cut and weigh method.

WO 3. Determination of various pharmacokinetics parameters from given urinary excretion data using rate of excretion and sigma minus method.

WO 4. Estimation of absorption rate constant and other pharmacokinetics parameters and understanding flip flop phenomenon using method of residuals.

WO 5. Assessment of absorption rate constant and other pharmacokinetics parameters by Wagner Nelson method.

WO 6. Study and comparison of different pharmacokinetic modeling using selected examples.

WO 7. Estimation of relative bioavailability of different formulations from salivary excretion data and comparison of various pharmacokinetics parameters by compartmental and non-compartmental approach.

WO 8. Determination of various pharmacokinetics parameters of drug following one compartment open model kinetics, and administered by constant rate intravenous infusion.

WO 9. Determination of different pharmacokinetics parameters for a drug administered by a) intravenous bolus injection and b) extravascular administration following two compartment open model kinetics (Loo Riegelman method).

WO 10. Determination of mean residence time (MRT) for an antibiotic administered by intravenous bolus injection using compartmental and non-compartmental approach.

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Appendix (ii)

Table 2. Comparative Students' Grade Scores in Different Groups

Grade Scores/No of Students*	Small Group Workshops (SGW)[a]		Class Room Lectures (CRL)[b,c]	
	Pharmacokinetics Problem Solving	Answering to Questionnaire	Pharmacokinetics Problem Solving	Answering to Questionnaire
A (9-10 marks-Excellent)	08 (80%)	07 (70%)	00	00
B (7-8 marks-Good)	02 (20%)	03 (30%)	00	04 (11%)
C (5-6-Average)	00	00	03 (8%)	04 (11%)
D (3-4-Poor)	00	00	07 (19%)	06 (16%)
F (< 3-Fail)	00	00	27 (73%)	23 (62%)

[a]SGW consisting of 10 students, [b]CRL consisting of 37 students, [c]tweaked percentage values

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Appendix (iii)

Table 3. Summary of Students' Feedback Results[a]

Item	SGW (n=10)	CRL (n=37)
What do you feel about having the small group environment for learning pharmacokinetics?		
Uncomfortable	5	8
Can't say	5	59
Very effective	90	33
What do you feel about having close and face to face Interaction with teacher during learning pharmacokinetics?		
Uncomfortable	10	11
Can't say	05	16
Very effective	85	73
I feel my active participation in teaching learning process.		
Disagree	00	59
Unsure	5	22
Agree	95	19
I am able to apply pharmacokinetic theory to the specific case scenario.		
Disagree	10	62
Unsure	10	30
Agree	80	8
I am able to analyse and interpret given pharmacokinetic data		
Disagree	5	65
Unsure	10	30
Agree	85	5

[a]Results are given as percentage

ISSN: 2044-3315

Appendix (iv)

Table 4. Open Ended Questions and Students' Common Responses

Questions	**Responses**	
	Small Group Workshop (SGW)	**Class Room Teaching (CRL)**
What do you think being the greatest advantage that you would consider about your existing teaching method?	Good understanding; concept clearance	Learning with comfort
What do you think being the greatest hindrance that you would encounter with your existing teaching method?	Anxious, but positive	Confusion and doubts with information received
What is the major comment that you would give with existing teaching method?	Active participation, practice problem and questionnaire	Absence of active participation, Time gap between lectures
What would you think being active learning and outcome based objectives utilising your existing teaching method?	Excellent	Poor
Should the existing method be continued for the pharmacokinetic teaching?	Yes	No, some modified teaching method should be implemented

ISSN: 2044-3315

Appendix (v)

Table 5. Summary of Overall Educational Benefits of small group workshop sessions

Sr. No.	Parameter
1.	Active participation of students even though teacher-centric approach
2.	Better ability to correlate theoretical pharmacokinetic equations to actual practice settings
3.	Enhanced understanding of theoretical principles to practice
4.	Enhanced skills for pharmacokinetic data treatment and analysis
5.	Increased speed of calculation and concept clarity about pharmacokinetics parameters units
6.	Improved memorisation of pharmacokinetic terminology and writing skills due to workshop training and practice
7.	Enhanced higher level intellectual skills such as analysis, interpretation, judgement and problem solving
8.	Better interpretation skills for pharmacokinetic parameters’ values in clinical settings
9.	Development of specific research skills such as design of pharmacokinetic projects
10.	Enhanced skills for planning and presenting the results of pharmacokinetic studies
11.	Higher confidence level and interaction with fellow classmates and instructor

ISSN: 2044-3315