Review Article

A review of computer assisted learning in medical undergraduates

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ABSTRACT

Laboratory based practical classes, have been the corner stone of undergraduate pharmacology learning. Ethical issues with the use of animals and rapid development of information technology has led to newer trends in teaching and learning such as computer assisted learning. Computer assisted learning (CAL) software includes computer based packages, focusing on interactive instruction in a specific subject area, collection of animal experiments that encourage students to understand concepts in pharmacology. CAL offers a number of advantages to both students and teachers; most important being meeting the learning objectives. Few disadvantages and pitfalls to implementation in medical schools are also associated with CAL sessions. This article reviews the trend of CAL in pharmacology, advantages, disadvantages and pitfalls to the implementation of CAL.

Key words: Animal based practicals, computer assisted learning, medical pharmacology, pharmacology teaching

INTRODUCTION

Pharmacology, as a discipline, is the study of how drugs exert their effects on the living systems. It involves understanding the properties of drugs and their actions, including interactions between drug molecules and receptors and how these interactions elicit an effect. Laboratory based practical classes, which includes the demonstration of drug effects on tissues or on whole animal, has been the central feature of undergraduate pharmacology learning.[1] In the recent years, the undergraduate training in pharmacology has been revolutionized with the adoption of several innovative teaching approaches such as small group discussions, role plays, computer assisted learning (CAL), use of audio-visual aids, clinical and community pharmacology studies.[2] The use of animals for teaching and learning of basic sciences has shown a downward trend over the last decade.[1,3,4] Laboratory based sessions are replaced by computer assisted learning which is now being used as an effective teaching and learning tool.[5,6] Increasing ethical concerns with the use of animals for undergraduate training and the development of information technology in the early 1900's contributed significantly to this trend.

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Computer assisted learning consists of a range of computer based packages, which focuses on providing interactive instruction in a specific subject area. CAL in pharmacology includes collection of animal experiments on course software package which helps in understanding concepts and techniques in pharmacology.[7] CAL has now become an integral component of the pharmacology curriculum in the medical schools. A number of studies from various medical schools have documented the effectiveness of CAL in terms of knowledge acquisition and meeting learning objectives.[1,8-11] CAL in medical education has been increasingly adopted by several medical schools across the world (India,[1,2,7,12-14]),

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United Kingdom[3,8,9,11,15-17] Canada,[18,19] United States,[20-22] Australia,[23-25] Germany,[26] Balkan countries,[27] Malaysia[28] and Korea.[29] CAL in medical education has been implemented by 95% of medical schools in the United States and 100% across medical schools in Canada and United Kingdom.

This trend review on CAL in undergraduate pharmacology curriculum considers nature of the trend, factors leading to this trend, advantages, limitations of CAL and pitfalls in implementation of this trend in the medical curriculum.

Search strategy

To find evidence of examples of CAL in undergraduate medical pharmacology, a search was carried out using PubMed (Medline), ProQuest, Cochrane Library, Medscape and Google Scholar search engines from January 1990 to December 2009, since 1990's reflected the beginning of wide spread interest in CAL in pharmacology teaching. The search terms included "Computer assisted learning and pharmacology", "Computer based learning and pharmacology learning", "CAL and undergraduate pharmacology", "CAL and pharmacology teaching", Computer assisted instruction and pharmacology, Computer simulations in pharmacology learning and "Computer based alternatives and pharmacology". The types of articles included in this review are original research, review papers and editorials from various medical schools across the globe. Both abstracts and full text articles were identified and reviewed. All the articles focusing on the factors leading to the trend, advantages, disadvantages and hindrances to implementation were included. Articles published in English language and English abstracts of articles published in other languages were included. A total 23 studies were included, 15 of them were research articles, six were letters to editor and editorials, and two were review articles. The details from 8 articles are given in Table 1

Factors leading to this trend

Although laboratory practical classes are invaluable, eventually they are only a vehicle for effective teaching and learning of laboratory and animal handling skills.

Concerns were raised with regard to use of animals for undergraduate training as compared to that for research. The practical sessions in pharmacology training involving animal experiments were perceived to be unnecessary by medical students educationists as the learning objectives of these practical sessions primarily focus on observational, analytical and interpretative skills, which are components of the cognitive domain and not psychomotor domain.[11,30]

Furthermore, the use of animals has reduced due to ethical concerns, practical problems associated with the animal experiments such as availability of animals, cost of purchasing animals and maintaining animal houses. Animal experiments are often time consuming and associated with practical difficulties. It is often difficult to demonstrate minute details to large numbers of students and only limited number of drugs can be tested at a given period of time.[1,7,16,17,31]

One of the major problems with animal experiments is the biological variability in the response and non reproducibility. This aspect can affect student learning and have an adverse impact on their motivation. Several published reports from the medical schools have documented that CAL can be an effective replacement for these practical sessions to overcome these limitations.[1,4,12-17,26,27,31,32]

With widespread use of computers among medical students and the abundance of computer based resources available for supporting teaching and learning in the medical sciences, there was a perceived need that medical graduates need to be both familiar with and have competency in information technology and computing skills.[31] CAL can also help to achieve a greater theoretical understanding of the experiments as simulations mimic the actual experimental set up in the laboratory.[1,33]

Nature of the trend

Until the 1990's laboratory based practical classes had been the central feature of pharmacology teaching. The use of animals for educational purpose declined since then when many academicians suggested that the need for using animals for education and training is small as compared to that with research.[11] Around the same period, the use of computers and e-learning were increasingly incorporated in the medical schools and subsequently and increasing trend of CAL in pharmacology teaching. Large number of high quality computer simulations of animal experiments in pharmacology were developed by many medical schools and also made available for teaching and learning.[33]

CAL in pharmacology consists of various softwares with demonstrations of animal experiments. These softwares mimicked the actual experimental set up in laboratory and include illustration of methods of anesthesia, dissection and mounting of tissues. Computer simulations and interactive interface in pharmacokinetics and pharmacodynamics and clinical pharmacology of various drug classes help in reinforcing the theoretical knowledge of different drugs acting on various organ systems in the body. CAL software has also been developed to promote rational and evidence based medication utilization among the medical students.[5,30,34] The majority of the CAL software includes self-assessment tools such as multiple choice questions.

Advantages of computer assisted learning

CAL has a number of perceived advantages to both students and teachers. Modern computers with multimedia capabilities

and presentational benefits can provide an interactive and personalized learning experience and thus promote active and self-directed learning[6,7]; it offers the students the advantage to learn at their convenience and pace of learning; it can save faculty time as well as resources.[32]

The most important advantage of CAL is that they meet the majority of the learning objectives. There is supporting evidence from many medical schools that CAL is the best suitable alternative to practical laboratory classes and successfully meets the learning objectives of the sessions.[8,9,25,28,30,32] The

Table 1: Summary of findings from studies on knowledge assessment and students' opinion of computer assisted learning in medical undergraduate teaching

Parameters	Comparative studies							
	Govindaraja *et al.*[28] (Malaysia)	Kuruvilla A *et al.*[1] (India)	Brain S *et al.*[32] (United Kingdom)	Sewell RDE *et al.*[33] (United Kingdom)	Badyal DK *et al.*[14] (India)	Leathard HL *et al.*[9] (United Kingdom)	Dewhurst *et al.*[31] (United Kingdom)	Wang L *et al.*[25] (Australia)
Number of students	127	141	78	99	47	156	6	75
Knowledge assessment in CAL (mean (%))		(65+76)						
Pretest	64.36±18.04%		58.0±14.4				16.3%	
Post test	75.41±17.09% (Higher post test scores $P<0.05$)		83.8±10.4 (Higher post test scores $P<0.01$)				70.2% (Higher post test scores)	
Outcome								
Good	83.3%	99%	Yes	Yes	40/47	NM	NM	100%
Acheives learning objectives	70%	NM	Yes	NM	NM	<50%	Yes	98.7%
Improves understanding	75%	NM	Yes	Yes	35/47	Yes	Yes	98.7%
Enjoyable/interesting	75%	100%	NM	NM	NM	NM	NM	100%
Recommend CAL use	70%	96%	Yes	Yes	Yes	>66%	Yes	100%
Advantages								
Repeated observation without animal loss	90%	9%	NM	Yes	Yes	Yes	NM	NM
Many students can observe at same time	>80%	13%	NM	NM	NM	NM	NM	NM
Less time consuming	NM	100%	NM	NM	18/47	>66%	Yes	NM
Many experiments performed	NM	100%	NM	NM	NM	NM	NM	NM
Difficult experiments demonstrated	>80%	24%	NM	NM	NM	NM	NM	NM
Avoid use of animals	>50%	51%	NM	NM	Yes	NM	Yes	NM
Learning at their own pace	NM	NM	Yes	Yes	Yes	>66%	NM	NM
Better visualization of drug effects	70%	46%	NM	NM	NM	NM	NM	NM
Accurate results	60%	3%	NM	Yes	NM	>66%	Yes	NM
Easy to use	NM	NM	Yes	NM	NM	>50%	Yes	NM
Better teacher student interaction	NM	NM	NM	NM	NM	>50%	Yes	NM
Disadvantages								
Laboratory skills are not learnt	NM	NM	NM	NM	NM	<50%	Yes	NM
No hands on experience/interaction with animals/live tissues	>80%	22%	NM	Yes	NM	<50%	Yes	NM
Real sense of experiment is lost	>80%	4%	NM	Yes	NM	<50%	Yes	NM
Prefixed doses	>80%	18%	NM	NM	NM	NM	NM	NM
Variation in drug response not observed	>80%	7%	NM	NM	NM	NM	NM	NM
Animal experiments easier to remember	70%	16%	NM	NM	NM	>66%	Yes	NM

NM=Not mentioned, CAL=Computer assisted learning

learning objectives addressed by CAL include the cognitive domain (understanding the pharmacological effects) as well as skill components such as handling the data and communication skills. CAL increases the understanding of the theoretical concepts when it is applied in the setting of simulated experiments.[33] CAL can also supplement lectures and enable students to learn better in their self-study; it can extend the learning experience into fields which are too costly or time consuming and also staff expertise may not be available.[34]

The drug effects can be clearly visualized in simulations; time consuming and difficult experiments can be demonstrated very conveniently with the help of CAL. Biological variations observed in the animal experiments may lead to discouragement among students and also waste faculty and student time, while animal simulations in the CAL session provides results that are reproducible. These experiments can be observed repeatedly without the loss of animals as well as experimental errors.[1,7] The students can observe the effects of drugs at varying dose ranges which would be time consuming when performed on animals. Large number of students can perform the experiment at the same time at their respective stations and their individual computers, whereas the animal experiments are usually conducted among groups of students and depending on the availability of animals the group size varies. Reduction in expenses involved with use of animal experiments is a definitive advantage.[1,31] Studies have documented that computer simulations of animal experiments are more cost effective than establishing and maintaining animal houses.[1,7-9] Leathard HL *et al.* study reported the total cost of carrying out sessions on the GI motility with CAL was around £320 and £860 with tutor demonstration of animal experiments.[9]

Dewhurst DG *et al.* study results revealed that the cost of conventional teaching method with animal experiments ($540) was five times greater than that of CAL ($2598).[8]

CAL is an innovative teaching method and primarily focuses on increasing the understanding of the subject rather than psychomotor skill acquisition. The assessment methods for CAL sessions are those used for assessment of the cognitive domain, unlike the conventional methods where in the evaluation is based more on animal handling skill and to lesser extent the knowledge. The advantage of these assessments is that the higher levels of cognitive domain such as application and analysis can also be tested. Communication skills can also be assessed with the use of interactive multimedia softwares.[9]

Disadvantages of CAL

Despite all the benefits of CAL, there are few associated disadvantages. In a virtual laboratory environment, there are certain skills that cannot be adequately taught, which pharmacology teachers consider essential in pharmacology training. These include making up of drug solutions in varying concentrations, setting up and use of experimental equipments, administration of test drugs and monitoring of the physiological signs.[7,11,31]

CAL limits the direct interaction with the living tissue and observation of variations in responses in living tissue. The practical knowledge and experience of a real experiment is lost. Despite all the benefits that CAL may bring, it is often easily forgotten in comparison to traditional animal experiments.[1] The virtual experiments and simulations have prefixed doses which hinder students to observe biological response at desired doses. CAL is expensive in the initial stages of implementation in the curriculum. Dependence on computers and technical problems arising during class are other disadvantages with CAL. Technical snags are commonly encountered during CAL learning session which can be precluded with good technical support.[28] Development of CAL software is labor intensive, requiring appropriate hardware, backup and frequent upgrading. Many teachers have little expertise in developing software and require the support of information technology staff.[35]

Pitfalls in implementation

Any change in the existing system is encountered with resistance and challenges at multiple stages. These include difficulties at the academic, administrative, financial and logistics level. Appropriate software programs need to be developed based on the learning objectives and the programs should be modified to meet the local educational needs. Faculty resistance to change the traditional animal experiments to CAL is another stumbling block. Many teachers consider CAL inferior and introduction of technology based learning methods a retrograde step.[11] Also, many of them are less inclined to use electronic resources due to lack of computer literacy.[35] Many teachers are unwilling to use software packages, particularly those which are developed by other universities.[32] Persuading teachers and convincing them to use CAL is critical and requires strategies to raise awareness in this direction. Faculty should support the integration of CAL into pharmacology teaching and devise suitable steps to overcome faculty resistance.[11]

Faculties often lack time to develop the skills to integrate this new method of teaching into the modules and learning strategies.[16] Teachers should be informed regarding the availability of CAL softwares and also its integration into the mainstream teaching.[34]

Many of the existing CAL software was developed in the early 1990s; rapid changes in the technologies that were used have rendered it difficult to use and in many instances the software has become obsolete despite the content being still valid.[36] Initiatives should be taken to develop software at the

institutional level based on the local needs and also enable faculty to modify content, educational approach and avoid technological redundancy. In addition, a dedicated information technology staff is necessary to provide practical advice and maintenance of the software and hardware.[34]

It is insufficient to just develop computer based learning material available to students. Like a laboratory class, it must be fully integrated into the modules to obtain the desired benefits.[36] Students should be guided on how to learn from computer-based learning materials as well as to incorporate this learning tool in their learning strategy.[34]

CONCLUSION

In conclusion, computer assisted learning is a feasible and very effective teaching and learning method in pharmacology with huge potential to change the way of learning as it meets the majority of the learning objectives. In the medical curriculum, where teaching and learning is delivered and facilitated in a rapidly changing environment, computer based learning methods have the qualitative and quantitative potential to raise teaching standards to new levels of sophistication. However, there is a need to invoke awareness among the teachers of the advantages of this method of teaching.

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