Alternatives to Animals in Teaching: Experience in an Indian Medical School

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Summary

In the 1990s, the practical classes in pharmacology for the undergraduate medical course in JIPMER, Pondicherry, India included 15 animal experiments. It was mandatory for students to carry out animal experiments to pass the final examination. With the advent of the new curriculum prescribed by the Medical Council of India in 1997, the number of animal experiments was reduced to seven. A set of clinical pharmacology exercises, computer simulated animal experiments, and a few models developed in-house were introduced to replace animal experiments. A CAL laboratory was set up in the last decade, and the CAL packages developed by us were distributed to others. At present, three live animal experiments and five computer simulated animal experiments are conducted. This paper reports the results of a survey conducted among the teachers on the usefulness, acceptance, and barriers with respect to the use of alternatives to live animal experiments as a teaching tool.

Keywords: CAL, alternatives, Indian Medical School, clinical pharmacology exercises, computer simulation

1 Introduction

The Medical Council of India (MCI) prescribes the theory and practical curriculum for all medical subjects taught in the undergraduate medical course in India. Pharmacology for the basic medical degree (MBBS) course is taught for 18 months during the second and third year of the course. Currently, animal experiments are taught to students in the practical classes, and they have to perform these animal experiments to get hands-on experience. Students are evaluated in the summative examination on the animal experiments, and those who fail to clear the practical examination are not promoted. The authors have worked as medical teachers in the Department of Pharmacology in the Jawaharlal Institute of Postgraduate Medical Education (JIPMER) for the past 25 years and would like to share their experiences in developing, introducing, and implementing alternatives to animals in teaching pharmacology to medical undergraduate students in their department.

2 Background1980s

Pharmacology practical classes in the 1980s

In the 1980s, the practical curriculum in JIPMER included 15 animal experiments. The details of species used and the titles of experiments are given in Table 1. Each experiment would be ini-

Tab. 1: The list of experiments taught to medical students in the 1980s

Species	Title of experiments
Frog	Effect of drugs on the frog heart Demonstration of drugs on the frog rectus muscle preparation Effect of saline purgative on frog intestine Effect of drugs on the frog aorta (hind limb perfusion) Effect of drugs on the ciliary movement of frog esophagus Effect of drugs on strychnine induced convulsions Evaluation of local anesthetics using hind limb preparation
Rat and mouse	Evaluation of analgesics by chemical (writhing) and tail flick methods Effect of drugs on locomotor activity Effect of drugs on electrical and chemical convulsions Demonstration of routes of administration
Guinea pig	Evaluation of local anesthetics Bioassay of histamine using guinea pig ileum
Rabbit	Effect of drugs on the rabbit eye
Dog	Effect of drugs on dog blood pressure and heart rate (demonstration only; 3-4 times a year)

tially demonstrated by teachers to 5-7 groups of 4-5 students each, and then the students would be asked to collect data by doing the experiments themselves in groups. The students were asked to perform the experiments in formative and summative examinations. Approximately 200 frogs, 100 rats, 100 mice, 15 guinea pigs, 20 rabbits, and 3-4 dogs would be used every year for teaching a single batch of 60-70 undergraduate medical students.

The problems

In the 1990s the students started protesting that performing animal experiments just to demonstrate the actions of drugs was unnecessary. During this period, the animal rights movement, which started in the West, gained momentum and slowly spread to India. Though there were not many animal rights groups here, and they were less aggressive than their counterparts in the West, they succeeded to some extent in making people aware of animal ethics. At the same time, the usefulness of animal experiments for medical undergraduate students was questioned. The skills acquired from conducting animal experiments were not perceived to be of use to medical students who would pursue clinical medicine as doctors. Very few medical students would end up doing animal research after completing their course. Given the circumstances, the concept of using alternatives to animals for teaching started to evolve, and we began planning to introduce alternatives in the early 90s. In the late 90s, the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) came into existence, and the awareness of animal rights and alternatives became widespread.

3 The solution

It was decided to introduce alternatives to animals without compromising the course objectives. Three types of alternatives were developed in-house, i.e., clinical pharmacology exercises, computer simulations, and models:

Clinical Pharmacology Exercises (CPE)

Ten clinical pharmacology exercises were prepared. The list of CPEs is given in Table 2. Each exercise was formulated with learning objectives, brief explanatory material, and simulated tasks that would be solved by students in small groups. The practical class on CPE started with an introduction of the subject by a teacher. The objectives and the tasks were clearly explained

Tab. 2: List of clinical pharmacology exercises

Fixed dose drug combinations
Adverse drug reaction monitoring
Therapeutic drug monitoring
Effective doctor-patient communication
Essential drugs list
Randomized controlled clinical trials
Rational use of antimicrobials
Medical ethics and informed consent for research
Management of common stings/bites/poisoning
Critical appraisal of drug advertisements

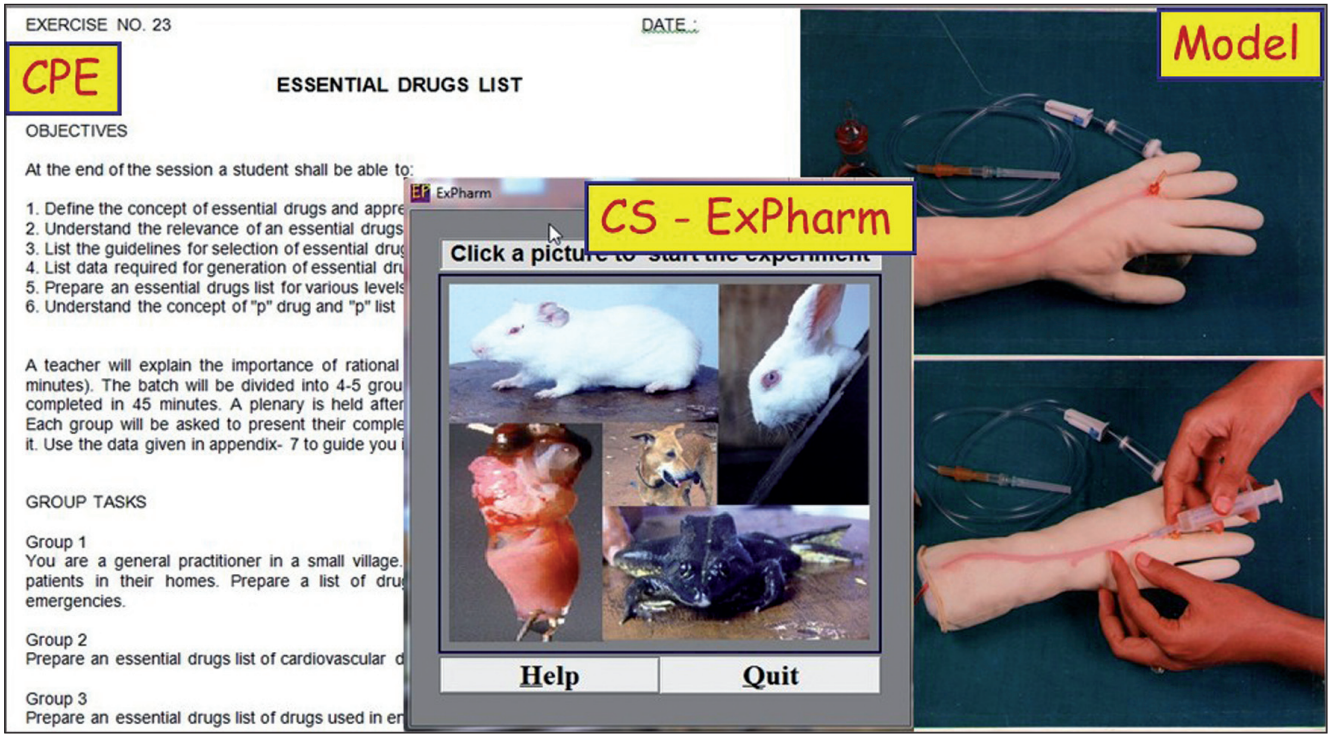

Fig. 1: Alternatives to animal experiments

CPE (clinical pharmacology exercise), CS (computer simulation) and a model

to the students, who would be divided into groups and asked to solve the problem. The plenary included presentation of solutions/suggestions by each group. Other groups were encouraged to ask questions and criticize the solutions presented. The teacher facilitated the session. The CPEs provided the students with the knowledge and skills required by future prescribers.

Computer Simulations (CS)

Five computer software modules were written for the following experiments:

1. Effect of drugs on the rabbit eye
2. Bio assay of histamine using guinea pig ileum
3. Effect of drugs on the frog heart
4. Effect of drugs on dog blood pressure and heart rate
5. Effect of drugs on the ciliary movement of frog esophagus

The design, programming, and development were carried out using exclusive in-house expertise. The software package was named ExPharm. It was made available to other medical and pharmacy trainers, initially through floppy discs and compact discs and later via free download on the internet. The software packages available abroad were not only too costly be affordable but were unsuitable for the practical classes conducted by us in India.

Models

Giving injections intravenously is a relatively difficult task, as compared with other routes, both in animals and in humans. We designed and developed a model (Fig. 1) using commonly available cheap material such as latex gloves, cotton, red ink, and polythene catheters for practicing administration of intravenous (i.v.) route injections. Many of these models were produced, and students were asked to practice on them to acquire and develop i.v. administration skills. We also used oranges as models for students to practice giving intramuscular injections, and we prepared cotton-and-gauze models resembling mice for practicing subcutaneous injections.

3.1 Implementation

In 1997, the MCI announced a new curriculum that provided us with the much-awaited opportunity to change the pharmacology practical scheme. Ten CPEs were newly introduced, and the number of animal experiments was reduced to 7-8 (from 15). All animal experiments that were considered slightly cruel to animals were removed. The experiment on dogs was completely abolished, and a CAL exercise was introduced in its place. Though we have produced five CAL exercises, none could be introduced due to lack of infrastructure and regulatory requirements. The models we produced were put to good use to train students in the skill of administering injections.

In 2005, a computer lab was set up at the institute (Fig. 2), and one more computer simulation (effect of drugs on the frog heart) was included in the practical scheme. Live animal experiments were reduced to five in number. During 2010 and 2011, MCI further relaxed its regulations on animal experiments. CAL

Fig. 2: CAL laboratories in JIPMER
Students performing computer simulated animal experiment.

is now accepted in place of live animal experiments. An exclusive CAL laboratory was set up in our department with 25 personal computers (Fig. 2). All frog experiments were removed. The number of animal experiments was reduced to three and the number of CAL experiments was increased to five.

3.2 Challenges

The development and implementation of alternatives did not come easily. The challenges faced at each stage and how they were overcome are outlined below:

1. Software
   No software was available in India. Software available in the West was very costly, and procuring it was difficult. Hence, we started designing software for various experiments. We coded them and made a package. CPEs were conceived, developed, and improved after many brainstorming sessions with the faculty members of the department.
2. Hardware
   In the 1990s computers and accessories were very costly and acquiring them in large numbers was not possible. In the new millennium, the prices fell, and they became cheap and affordable. This helped us set up a computer laboratory in our institute.
3. Personnel
   The teachers who were not familiar with CAL were given training.
4. Evaluation
   The experiments taught using CAL could not be evaluated in the examination due to lack of computers in the department and university regulations regarding the examination system.
   A CAL lab with 25 PCs was later set up in the department itself, which made evaluation possible. Furthermore, the institute became autonomous (university status was given to the institute), and hence we could modify the examination pattern. It is planned to include CAL for evaluation from the year 2011 onwards.
5. Validation
   Informal feedback from students and teachers was obtained and modifications/corrections were carried out continuously.

3.3 Does it work?

Yes it does, as evidenced by the good feedback received from the students and the teachers. The students stated that they believed CPEs would be useful for rational use of medicines in their clinical practice. The fact that the alternatives instituted by JIPMER are also followed by many other colleges in India is proof of their success. Previously, we could not use the CAL experiments for evaluation, although the CPEs were used. This problem is sorted out as of 2011, and the use of all types of alternatives for evaluating students is now possible.

4 Survey

The CAL package "ExPharm" we produced was put on the internet[1] for free download. Feedback was obtained from those who downloaded ExPharm. The acceptance, usefulness, and barriers of CAL-based education were evaluated using an email questionnaire survey. The results are presented here:

Participants

Approximately 1,050 emails were sent to those who downloaded the software from the website. Sixty nine from India and 15 from other countries responded. Out of eighty four, 63 were faculty members and 8 were postgraduate students. Thirty four were working in medical colleges, 42 in pharmacy colleges, and the remaining in veterinary and dental colleges. Sixty eight indicated they have a computer laboratory at their institute, and 14 said they did not.

Acceptance

53 stated that, given a choice, they would use CAL software instead of live animals for reasons such as: ethics, convenience, concern for animals, to avoid killing animals, and to save time. 13 said they would use live animal experimentation for gaining practical knowledge and a better understanding, as well as to acquire skills and to get a proper perception of animal experiments. 16 said they would use both, since they would use CAL to train students before they move on to live animal experiments.

Tab. 3: Reasons for acceptance of CAL

The figures indicate the no. of participants who gave the rank (n=84; figures do not tally since some participants did not give ranks).

Reason	Rank				
	1	*2*	*3*	*4*	*5*
Concern for animals	35	11	6	3	0
Novelty of CAL method	14	15	8	8	0
Difficulties with animal experiments	14	14	7	7	0
Cheap/free CAL software	2	10	15	8	0
Others (total cost, manpower, ethical problems, better understanding before live experiment, better responses assured in CAL)	5	0	0	2	6

[1] www.indphar.org

Twenty-five participants said their students fully accept CAL, 41 said "to some extent" and 8 said their students do not accept CAL. Similar results were seen with acceptance by colleagues of the participants (fully accept: 20; to some extent: 41; not at all: 14)

The participants were asked to rank the listed reasons for accepting CAL. The results are presented in Table 3. Thirty-five participants ranked "concern for animals" as the foremost reason for accepting CAL. Cheap/free CAL software is least attractive.

Usefulness

The usefulness of ExPharm was evaluated. The software was rated high on all counts except evaluating students (Tab. 4). It must be noted that the experiments in the package do not have separate evaluation modes. The participants were asked how they would rank the effectiveness of methods to teach the actions of drugs. Both live animal experiments and the CAL software were equally ranked as effective methods (Tab. 5).

5 Barriers

Among the barriers, the lack of computers and the lack of enthusiasm of colleagues and staff have been ranked as foremost (Tab. 6). When the participants were asked how they overcame the difficulties, the following responses were received:

1. By downloading/purchasing the software

Tab. 4: Usefulness of CAL

1 – Very useful; 2 – Moderately useful; 3 – Useful; 4 – Slightly useful; 5 – Useless
(n=84; figures do not tally since some participants did not give ranks).

ExPharm (CAL software) is useful to	Usefulness scale				
	1	*2*	*3*	*4*	*5*
Impart knowledge	38	19	20	2	1
Reinforce actions of drugs	43	13	20	4	0
Replace/reduce animals in teaching	49	17	11	2	1
Evaluate students	26	21	15	16	3
Self-learning	47	17	10	5	1
Stimulate interest in learning	41	18	17	1	3

Tab. 5: Effectiveness of methods to teach drug actions

The figures indicate the no. of participants who gave the rank (n=84; figures do not tally since some participants did not give ranks).

Method	Rank				
	1	*2*	*3*	*4*	*5*
Lecture	13	9	8	11	12
Tutorial	9	12	11	13	4
Small group discussion	12	8	14	7	6
Live animal experiments	16	8	4	6	8
CAL software	14	15	12	5	4

Tab. 6: Barriers

The numbers indicate how many participants gave the respective rank (n=84; figures do not tally since some participants did not give ranks).

Barriers in implementing CAL	Rank				
	1	*2*	*3*	*4*	*5*
Lack of computers	18	2	5	1	2
Lack of software	7	11	3	0	4
Cost of software	9	3	4	4	2
Lack of enthusiasm of colleagues and staff	14	5	2	6	1
Lack of enthusiasm of students	3	4	1	1	1
Lack of cooperation from the administrators	4	6	5	3	1
Rules/regulations	2	4	3	1	1

2. By convincing colleagues and administrators
3. Trying to impress everyone involved in teaching and administration about the advantages of using alternatives
4. By encouraging the students to use the CAL software
5. Trying to include CAL-based experiments in the curriculum; Demonstrating the software-based experiments, and generating interest
6. Using the LCD projector for demonstrations in small groups for UGs (to overcome the lack of computers)
7. By creating awareness by conducting workshops

6 Discussion and conclusions

The types of alternatives for animal experiments used in JIPMER, a medical school in southern India, and the implementation of these alternatives were discussed. Computer simulations and clinical pharmacology exercises can fulfill the learning needs of UG medical students to a reasonable extent, with reference to understanding the actions of drugs and its optimal use. While computer simulations help the student learn drug actions and develop analytical skills, clinical pharmacology exercises prepare him for rational use of medicines in clinical practice. Both are effective as alternatives to animals in teaching. Though the computer simulations and clinical pharmacology exercises produced by us were not formally validated, their usefulness and acceptance can be gauged by the fact that these modules were downloaded from our website and used by many medical colleges in India. The software package "ExPharm" is used by almost all medical, pharmacy, and veterinary colleges in India.
The survey results show that
1. CAL is widely accepted.
2. Concern for animals is the major reason for using the alternatives.
3. Teachers would like to avoid using animals.
4. CAL software is useful to teach drug actions and reduce animal use in teaching.
5. CAL is equally effective for teaching drug actions.
6. Lack of computers and enthusiasm by colleagues are the major barriers in implementing CAL.
7. Various approaches are followed to overcome the barriers.

It should be noted that concern for animals is the major reason for acceptance of CAL. The wide acceptance of CAL in India was made possible by many factors, including the affordability of hardware and software, growing awareness, and the restrictions imposed by the CPCSEA. Many teachers said they would avoid using animals if they could, and some of them wanted to use both with the intention of training students with CAL first so that they can perform better with live animal experiments. Though ExPharm, a CAL software, is meant for replacement of animals, we have learned that it is also used for refinement. The various approaches used for overcoming the barriers can be used by the readers when they implement CAL as an alternative to animal experiments in their institutes.

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