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The Evolving Role of Technology in Physiology Laboratories

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ABSTRACT

Advances in technology have led to the replacement of animal based laboratories with computer based simulations. This pedagogical approach has the advantages of being less costly in terms of time and money, more accessibility for self study, repeatability of the intervention, ability to alter variables in isolation and needing less expert time for implementation. As medical educators we need to look beyond benefits of this intervention in terms of cost or time required for implementation and look closely at the educational impact of this change. This paper looks at the educational advantages of computer simulations on the basis of the principles of teaching and learning

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Introduction

Laboratory observation forms the roots of physiology, which by its experimental nature is just beyond being a mere body of facts. Courses in physiology continue to rely on laboratory observations which offer a platform for practical testing of the students' knowledge, ability to interpret data and integrate the basic principles of these courses with the observed reality.

Live animals have traditionally been used in undergraduate laboratories to illustrate concepts covered during the lectures in health sciences education. However over the years a variety of concerns have been cited regarding the use of animals. Over the same period of time rapid advances have been made in the use of information technology (IT) in teaching and learning. As we look at the advantages and concerns regarding this replacement, the educational impact of this change also needs introspection.

Animal use-the downward trend

Animals have been extensively used in pharmacology and physiology courses in a number of courses including biology, medical and health sciences and veterinary sciences. For the past four decades a steady decline has been noted in the use of animals in laboratory instruction and an increased replacement of animals by computer simulations has been in progress. In the UK even with an enormous increase in number of students in biological sciences, the use of animals in instruction has fallen year-on-year from its peak in 1989 (~12,000) to a low in 2005 (~1600) [1].
The Association of American Medical Schools undertook a survey to analyze the trends in animal laboratory usage in medical physiology courses from 1983 to 2000 and confirmed this downward trend [2].

In the past few years, with the Medical Council of Asian countries like India advocating the view that animal experiments can be replaced with suitable alternatives, complete replacement of animal experiments in teaching are in progress [3].

Causes of the trend

The decline in the use of animals resulted from many factors; cost being the most predominant one. The cost of procurement of animals, equipments and supplies and maintenance of animal house in compliance with the requirements of animal welfare oversight, are of major concern. Apart from the monetary aspects, increased cost in terms of allocating research space and cost in terms of the instructional time for faculty, lab assistants and other staff involved in the animal lab based pedagogy, has also been responsible for the decline in animal use in labs[2].

Ethical issues regarding animal usage are of grave concern. International and national legislations have been put forward governing the use of Animals in Higher Education. Campaigns of enormous publicity organized by People for the Ethical Treatment of Animals and the Physicians Committee for Responsible Medicine have played their part as well in this transition [4, 5].

A decline in the number of faculty with skill for this pedagogical approach has been noted over time. The attitude of the students towards animal use in laboratories has changed, with majority of them objecting to animal use in principle [6].

Medical curriculum has been becoming increasingly crowded and the class size becoming increasingly big. With advances in medical education, curriculum committees have been established and burdened with a need to justify the time and resources intensive activities of animal laboratories. The hurdle of demonstrating with affirmation the contribution of animal experiments to student learning has further contributed to the decline [2].

Advances in technology resulted from a major cultural and economic momentum, with computer-assisted learning (CAL) showing demonstrable advantages in the late 20th century.

This includes usage of slides, videotapes, computer assisted instruction and more recently computer simulations. Meta-analysis of studies done on CAL provided an evidence base for incorporation of this new medium into education extensively [7].

Computer simulations vs. Animal Experiments

Active learning approaches such as student laboratories are often costly in terms of time and resources. Educators must be able to explain clearly to administrators and to students the benefits obtained from laboratory experiences in the context of the educational goals for the course. Considering the hopes that are pinned to simulation as a means of improving learning while at the same time meeting the learning outcomes, an exploration of why computer simulation, rather than live animal usage in experimental physiology, works as a learning strategy is warranted.

Computer simulations have the advantage of being less costly in terms of time and labour. The development of alternatives can be expensive in some cases but owing to its ability to be used repeatedly, it is more cheap in the long run than procurement and maintenance of animals [8].

Information from the short term memory is transferred to the long-term memory only if that information is rehearsed. If rehearsal does not occur, then information is forgotten, lost from short term memory through the processes of displacement or decay [9]. Given that physical dissection is typically conducted in one day because of issues such as specimen decay and student safety, the opportunity for additional learning opportunities and their resultant effects on retention are minimal. However, because computer simulation circumvents a number of these issues that hinder providing additional learning opportunities, students could repeat a simulated experiment to improve retention.

Complex learning is enhanced by challenge and inhibited by threat associated with helplessness and fatigue .Optimum learning takes place when the learner is relaxed and engaged, not alarmed, fearful or in terror [10]. When fear – including fear of failure – is present, the brain downshifts into a more primitive function and encoding into long term memory becomes problematic. The treat of failure and loss of experimental specimen usually outweighs the challenge of doing a live animal experiment and can inhibit encoding. The computer simulator does not share the "emotional overhead" of the animal demonstration [11].

Emotions are critical to patterning. Learning is not a purely cognitive function. Learning tends to be better if the method is enjoyable. Emotions play a significant role in encoding and retrieving information. Students may not favour the use of live animals in laboratory instruction and raise issue of ethical conduct in such work. This would affect the receptivity of such a portion of student population to the knowledge imparted with a consequent decrease in efficacy of such a teaching aid. When the question of efficacy arises in such a situation, the grounds for mortality of animal use become debatable [12, 13].

Learning is developmental. All learners do not learn and progress at the same rate. There are individual differences in which each person falls in a novice to expert continuum. Categorizing all learners in one group may hence not help in optimal learning for all. Computer simulations can be used to adjust to accommodate the appropriate level for each individual learner if it is scalable in its objectives. This may seldom be possible with live animals where there is a complex interaction of variables and may need a higher level of cognition [12]. The computer model has the ability to separate out individual physiological effects. This is difficult or impossible to do in an animal experiment. Likewise, the progress of a computer laboratory can be paced for optimal learning, whereas animal experiments have physiological constrains over timing including the stability of the preparation [14].

Phenomena which may not be normally observable in animal experiments can be easily

demonstrated with the use of modern software which engage higher order thinking skills and thus improve learning [7].In this context, the views that simulations are based on a series of simplifying assumptions are rather artificial and do not add new information to the learning experience, hold no validity [15, 16].Computer simulations or alternatives of the kind can also be used for students to judge their achievement of staged learning objectives, as they can have built in self assessment [17].

Each brain is uniquely organized**.** While constructivism establishes that each person has a unique experience, Caine and Caine stated that each learner also has a unique system for learning. Individual learning styles must be addressed whether it is a relatively simplistic approach such as the VAK learning style set (visual, auditory, kinesthetic) or more complex learning styles sets such as Gardner's multiple intelligences [18]. Simulation invokes a variety of senses as it presents material and as such, it offers multiple ways for the learner to access information [14].

There is adequate literature in support of the fact that the knowledge acquired using computer simulations was well in par with using animals and that the learning objectives were equally well met [19,20]. They also conclude that with CAL many learning objectives could be met and there was increased student teacher interaction [21].

Guidelines to select the pedagogical approach

The pace of replacement of animal experiments with computer simulations seems to be slow in spite of rapid advances in technology. Identifying the reasons behind this and guiding the implementation of this better pedagogical approach is to be emphasized in this scenario. The replacement of animals with simulators will require an initial investment of fund which is likely to pay off in the long run. However, without adequate planning and training of staff, the consequences may prove to be disastrous [22].

Convincing the teachers about the benefits of simulations and addressing the concerns causing their resistance to change from traditional methods .Dissemination of information about existing alternatives and their educational benefits, among faculty via electronic databases, publications, websites and workshops and conferences, makes it easy to persuade them to adopt it [23]. Teachers need to re examine the learning objectives for the laboratory sessions and choose the suitable simulation that can meet them as far as possible. Avoiding technological redundancy and development of soft wares which could be customized according to the needs to the teacher would help the teachers make a right choice [24].

Different learning methods provide different experiences. Effective science teaching requires a diversity of strategies and approaches [25]. Diversifying the types of learning experiences in a course helps engage a larger number of students. Different learning methods provide different experiences. The same students also differ in their educational needs; diverse student learning styles call for diversity of learning experiences. When selecting laboratories that do and do not use living organisms, instructors must bear in mind that students may differ in their educational preferences, that is, some students may be uncomfortable with instructional activities involving animals while others find these activities inspiring and particularly beneficial. Students exhibit a variety of learning styles and characteristics. Their cognitive preferences can affect their performance in different subject areas; and students receive higher grades when their learning style is complementary to teaching style of the instructor [26].

If there is sufficient instructional time, computer simulation and live animal experiments together could likely produce better learning outcomes than either would individually; given that students would be given the opportunity to learn, and possibly on multiple occasions.

Meeting the learning objectives of the laboratory course may not be entirely possible with the use

of alternatives. In such cases effort should be made to reduce the number of animals needed. Model suggested that the "most effective way to help students understand physiological interactions on a systemic basis is to first use technological approaches to proceed from simple to more complex models and then to test the hypotheses based on model behaviour in an investigative experience with a living preparation" [27].

Conclusion

The past four decades have seen a steady decline in the use of animals in laboratory instruction and an increased replacement of animals by computer simulations in the laboratories for Health sciences education. Computer simulations have become a highly favourable pedagogical approach because of their repeatability, accessibility for self study, ability to separate out individual physiological effects and being more enjoyable learning experience when compared to inhumane animal experiments, while effectively meeting the learning objectives. For effective implementation of this technology, awareness and support needs to be provided to the teachers, who should then tailor the learning objectives and the technology used for instruction to optimize the learning experience.

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