INCREASING STUDENT ENGAGEMENT IN LEARNING CARDIOVASCULAR PHARMACOLOGY USING SIMLATION BASED SOFTWARE

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INTRODUCTION

The use of high-fidelity, manikin based human patient simulation (HPS) is well established within clinical and healthcare settings for clinical skills training in the education of nurses, paramedics, physician associates and students of medicine and dentistry. More recently, HPS has been applied to teaching clinical pharmacology to year 5 medical students (Arcoraci et al 2019) and suggested as a training tool for clinical pharmacists (Lloyd et al 2018). Application of HPS, to the teaching of basic science pharmacology is more limited, with some reports of its use in the early or preclinical years of an undergraduate medical (Pereira et al 2019) or pharmacy degree (Bielby-Clarke 2015).

We report here the use of high-fidelity simulation based approach to facilitate cardiovascular pharmacology, to year 2 medical (University of Bristol) and year 2 Applied Science undergraduate students (University of West England, Bristol) in the Drugs and Disease module. Unusually for this type of simulation teaching, we based our session on the observation of changing physiological parameters, without the need for interaction with the manikin. The simulation session was delivered to a large class (n=70). Our rationale for using the simulation methodology over didactic teaching was evidence based. Poor student performance in formative assessments, suggested that students may have difficulty understanding mechanisms of drug action owing to information overload in traditional lectures. We felt that didactic teaching was not sufficiently student centric nor did it provide opportunities for experiential or active learning (Schmidt et al 2015). This style of teaching could have been the reason for our observed lack of student engagement or an over reliance on uploaded lectures on the virtual learning platform, which could be accessed anywhere, anytime.

Given the importance of safe prescribing for newly qualified medical graduates (Ross & Maxell 2012, WHO publication accessed 24 May 2020) we hypothesized that the use of HPS in early years medical education would provide an understanding of safe presribing and adverse reactions to drugs. In addition, the HPS could be used to demonstrate the mechanisms of drug action, provide an experiential learning experience through simulations of real life scenarios and simultaneously enhance student engagement and achievement.

METHODOLOGY

Design principles

In redesigning our traditional pharmacology lectures to simulation based teaching, we gave regard to the Learning Outcomes from Tomorrow's Doctors (General Medical Council , UK 2018): *The graduate will be able to apply to medical practice biomedical scientific principles, method and knowledge relating to anatomy, biochemistry, cell biology, genetics, immunology, microbiology, molecular biology, nutrition, pathology, pharmacology and physiology.*

To enable students to apply scientific principles to their future medical or healthcare practice, we integrated physiological and pharmacological concepts of the cardiovascular system using the HPS (see below). Based on

discussion with clinicians, we chose examples from different categories of cardiovascular drugs that are used in intensive care or other chronic heart conditions, We also referred to educational articles published in pharmaceutical journals (Berry and McKenzie 2010, Nair and Hunter 2004) in deciding what key principles to address.

The choice of drugs helped us to facilitate the teaching and learning of cardiovascular variables like preload, afterload, systemic vascular resistance, central venous pressure, and the mechanisms of drug action, mediated via muscarinic and adrenergic receptors of the autonomic nervous system. The effects of drug action in relation to the regulation of blood pressure, inotropy, dromotropy, chronotropy and lusitropy would also be simulated. Additionally, this would provide opportunities for discussion of therapeutic doses and safe prescribing using the HPS (Bielby-Clarke 2015).

The simulation session and learning resources

We chose not to base the session on case studies in pharmacology, instead we used a guided learning approach to enable students to understand the fundamental mechanisms of cardiovascular drugs. The session was designed using the simulator instructor and patient interface CAE Muse (CAE Healthcare, Fl, USA) normally used with the iSTAN patient manikin. Muse allowed application of selected cholinergic and adrenergic drugs and display the effect on a range of physiological variables. Class I-IV drugs used in the treatment of cardiac arrhythmias were additionally used and the effects on cardiac rhythms shown.

The simulation was used to teach a large class of students (n=70). Data were presented to students using a large display screen allowing the whole class to observe changes in real time as drugs were administered. In this study there was no emphasis on examining the manikin - the simulation was software-based. However we designed the learning to be interactive to engage students

Learning resources and student engagement

Students were provided with structured worksheets (Fig. 1) and worked in teams of n=7. They recorded responses to each pharmacological intervention, displayed on large screens in real time (Fig 2). Physiological parameters including ECG, heart rate, systolic, diastolic blood pressures, and systemic vascular resistance were monitored and recorded and values for mean arterial blood pressure and total (or systemic) peripheral resistance were derived using equations provided.

Feedback and consolidation session

One week after the simulation session, the student teams gathered to provide feedback to the class on the observations of drug actions and their effects on heart rate, cardiac output, mean arterial pressure, system vascular resistance and other parameters. The worksheet was designed to challenge students to problem solve how drugs could change blood pressure, in terms of the simulated parameters. The worksheet also challenged students to explain Frank Starlings' mechanism in normal and failing hearts. The feedback session also explored safe prescribing and adverse drug reactions.

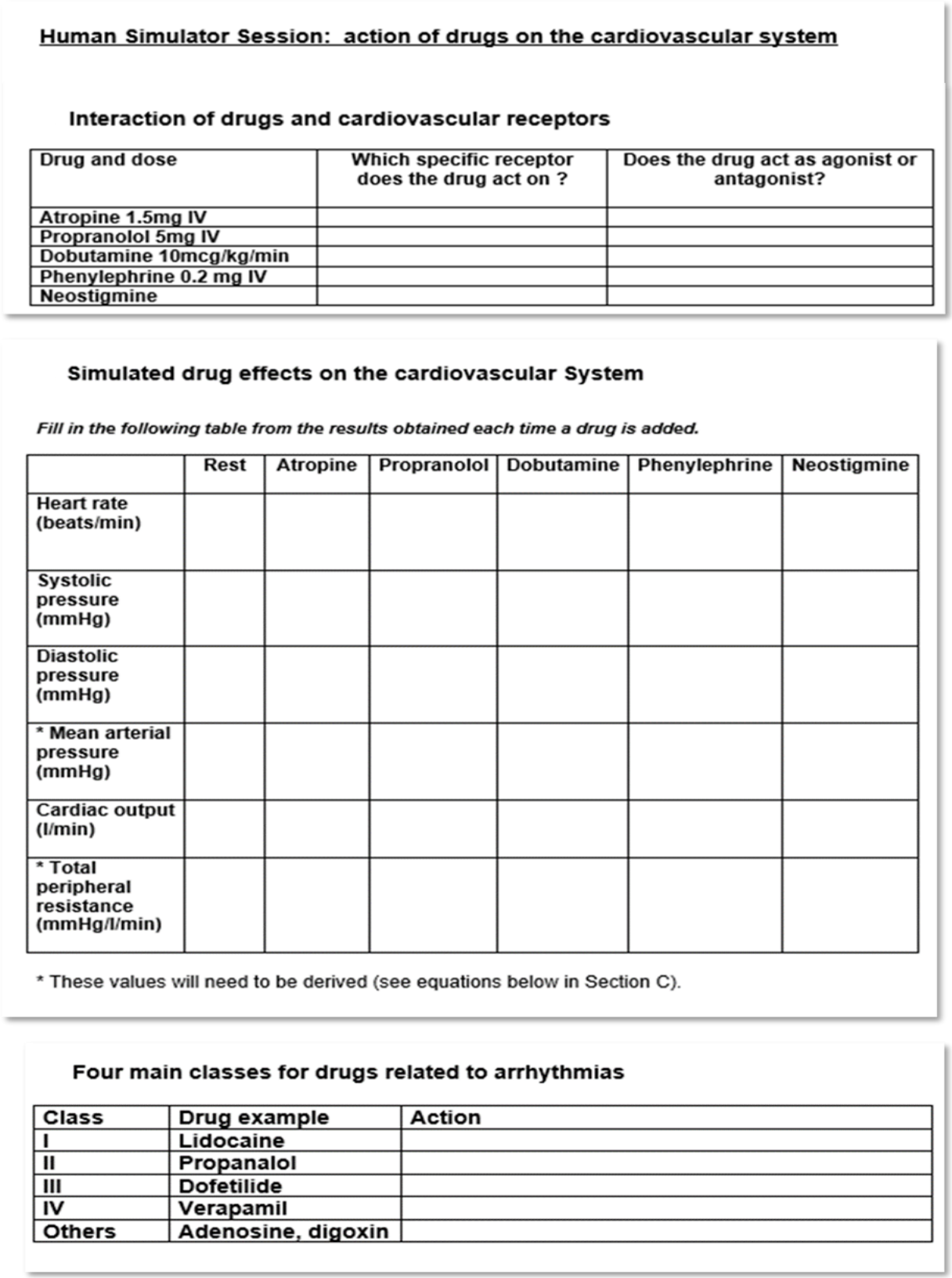
Student evaluation of simulation based teaching

All students completed a satisfaction questionnaire following the simulation session (Fig 3).

Assessments:

Following the simulation session, students had to complete formative assessments by answering 25 multiple choice questions. Turning Point Software was used to administer the formative assessment. Three months

later, the same students had to sit witten summative assessments as part of the summer examinations series (Fig 4).



Human Simulator Session: action of drugs on the cardiovascular system

Interaction of drugs and cardiovascular receptors

Drug and dose	Which specific receptor does the drug act on ?	Does the drug act as agonist or antagonist?
Atropine 1.5mg IV		
Propranolol 5mg IV		
Dobutamine 10mcg/kg/min		
Phenylephrine 0.2 mg IV		
Neostigmine		

Simulated drug effects on the cardiovascular System

Fill in the following table from the results obtained each time a drug is added.

	Rest	Atropine	Propranolol	Dobutamine	Phenylephrine	Neostigmine
Heart rate (beats/min)						
Systolic pressure (mmHg)						
Diastolic pressure (mmHg)						
* Mean arterial pressure (mmHg)						
Cardiac output (l/min)						
* Total peripheral resistance (mmHg/l/min)						

* These values will need to be derived (see equations below in Section C).

Four main classes for drugs related to arrhythmias

Class	Drug example	Action
I	Lidocaine	
II	Propanalol	
III	Dofetilide	
IV	Verapamil	
Others	Adenosine, digoxin	

Figure 1. Excerpt of student worksheet used to record cardiovascular parameters in the simulation session

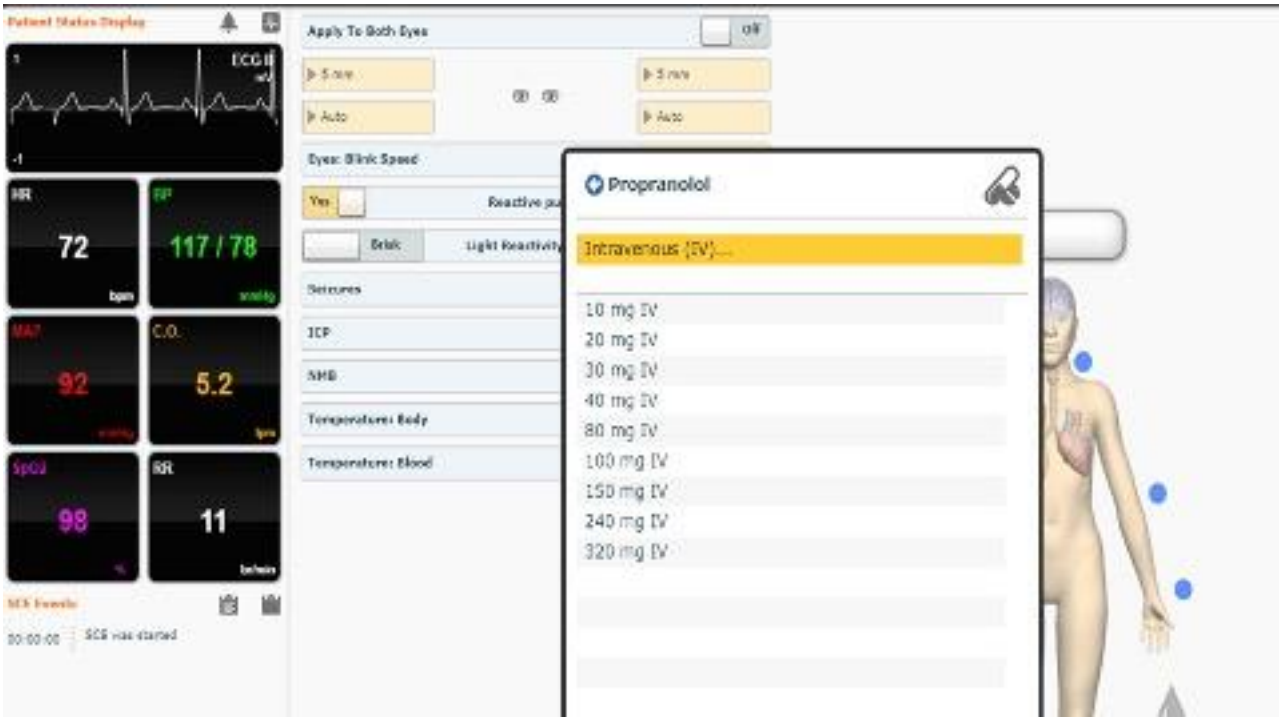
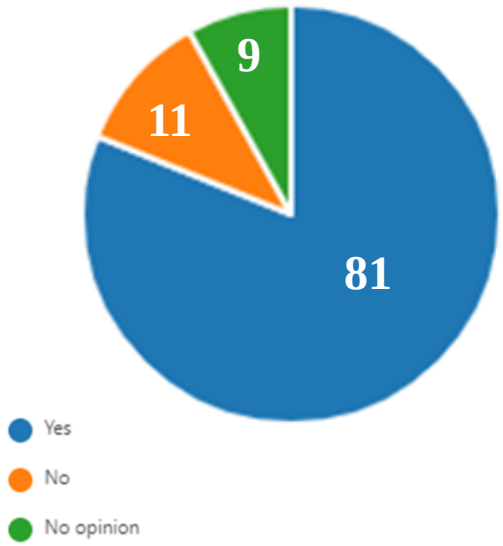
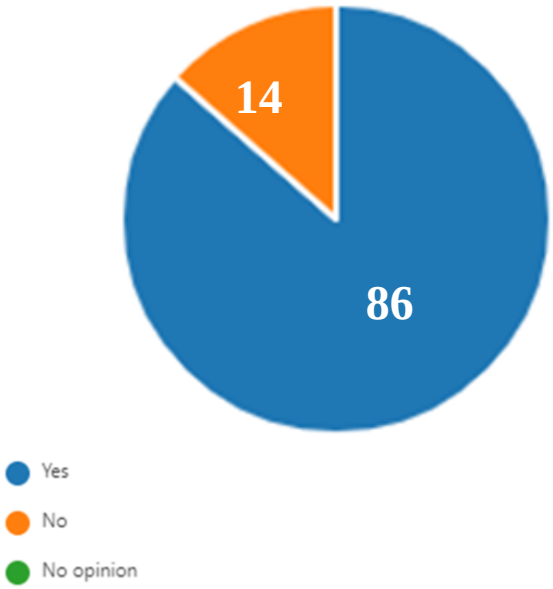


Fig 2. Data display of cardiovascular parameters during drug administration in the simulation session.

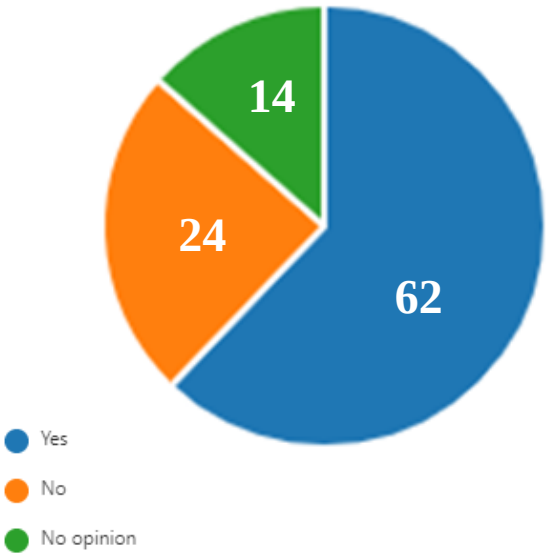
Do you enjoy learning in sessions that use human patient simulation?



Did using data from the human patient simulator enrich your learning experience?



Did human patient simulation session give you a greater confidence in approaching topics compared to those without associated simulations?



Were there concepts that were difficult to understand from lectures and other classes that the human simulation session have helped with?

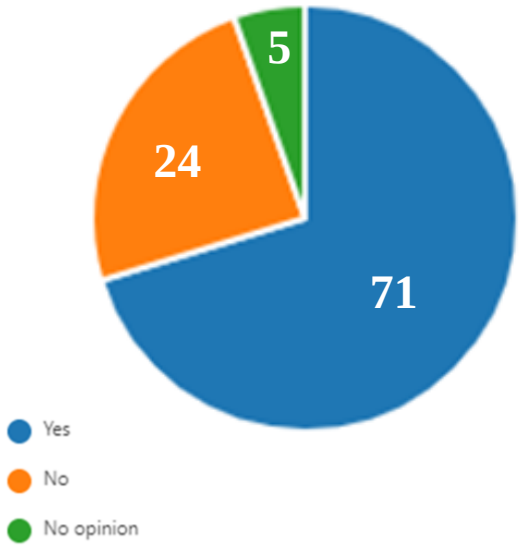


Fig 3: Student evalution survey of the simulation session (results in percentages).

RESULTS

An evaluation survey completed by all students (n=70) immediately following the simulation session was overwhelmingly positive (Fig 3). A written exam in the Drugs and Disease module, conducted 3 months after the simulation session, showed that student performance for this particular topic was higher (79%) than for any other topic (47%) which used didactic lectures in the module (Fig 4). As this was a preliminary study designed to test the effectiveness of simulation based teaching of cardiovascular pharmacology, its ability to enhance student learning and long term retention, we did not perform any statistics. We will need to valid our findings for reproducibility in the future.

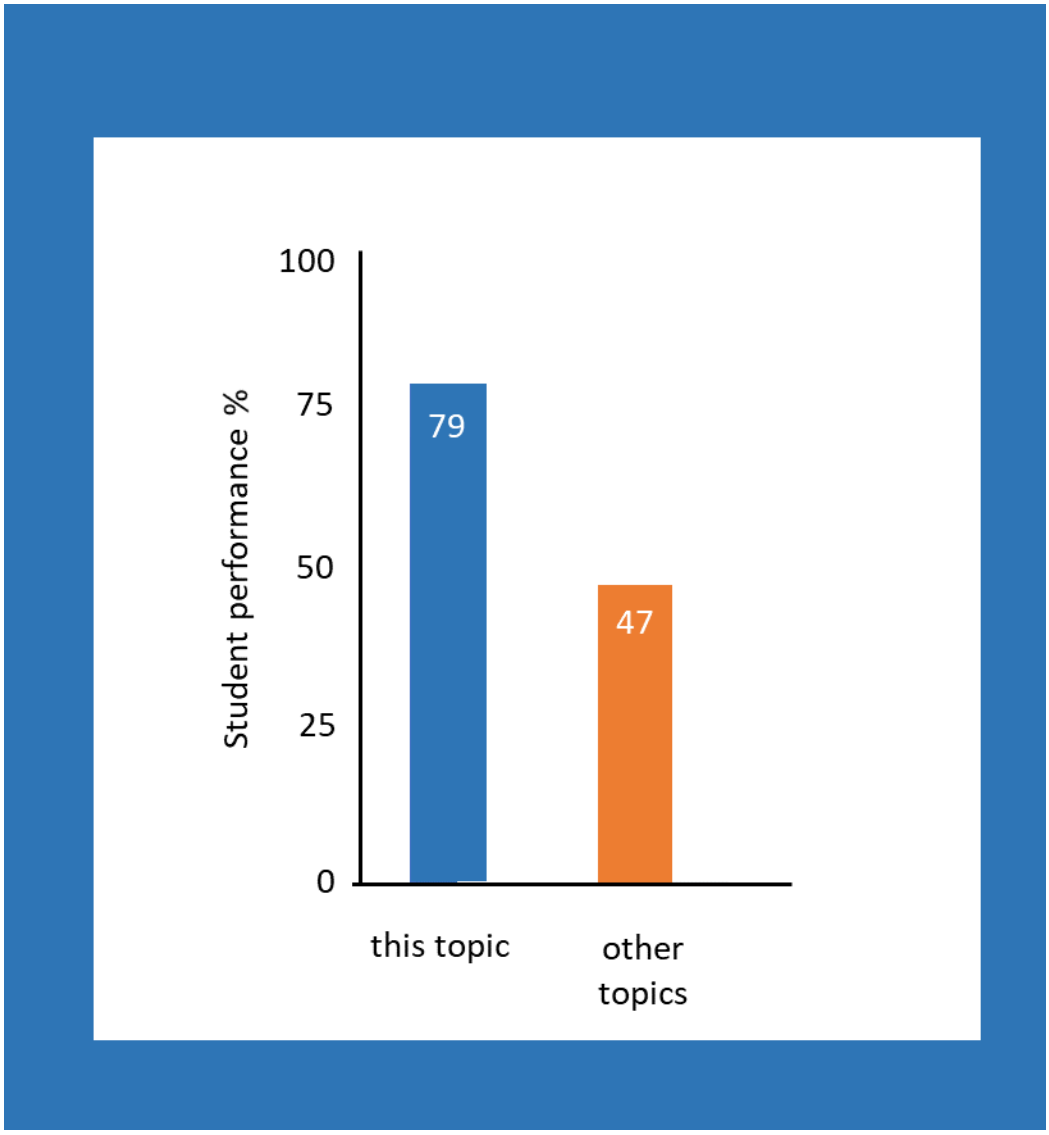


Fig 4: Results of summative assessment following simulation session

79% answered questions on cardiovascular pharmacology questions better after simulation compared with same lectures from didactic teaching in the same module.

CONCLUSION

Our prelimainary data have suggested that the use of high fidelity simulation software was effective in teaching the fundamental principles of pharmacology as a basic science to both medical students and applied science students. We utilised the simulation software in combination with a guided learning approach. This was reflected in the enhanced student engagement observed and evidenced by overall student satisfaction (Fig 3). Although it has previously been reported that high fidelity manikins have been used successfully for the physiology teaching by Helyer & Dickens 2016, Harris et al 2011, Maskell 2008 and many others, we believe that the integration of both physiology and pharmacology to teach early years medical students is unique to this study. This integrated simulation based approach to teaching pharmacology appears to be one way forward to providing experiential learning (Ross and Maxwell 2012) to early years medical students and to design and map the curriculum to the learning outcomes of Tomorrow's Doctors (GMC 2018, Ross and Maxwell 2012).

Simulation based teaching also appeared to increase student performance and help with long term knowledge retention. Students showed approximately a two-fold increase in achievement following this teaching strategy, three months after the session (Fig 4). We found that the structured worksheets encouraged deeper learning and were useful in discussing the principles of safe prescribing and adverse drug reactions. Finally, by using simulations, it was possible to apply the biomedical scientific principles of physiology to future medical practice, through pharmacological interventions. We aim to extend and expand simulation based pharmacology teaching into later clinical years, by collaborating with anesthesiologists, clinical pharamacists, other clinical specialists and general practitioners to design an effective medical curriculum.

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