

INSTRUCTIONAL ARTICLE

Learning undergraduate human anatomy – reflections on undergraduate preferences in Singapore: a pilot study

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ABSTRACT

Anatomy education is a principal subject within international medical and scientific curricula. Nevertheless, in more developed countries and with the paucity of cadavers and anatomy instructors, anatomists have had to supplement the current syllabus with multimedia. Using a 5-point Likert scale, we propose investigating the acceptability of learning anatomy through cadaveric prosections and multimedia software as well as considering user preferences. Fifty-six first-year medical students (M¹) (average class size 300) and 80 life-science students (LSM) (average class size 130) from the National University of Singapore (NUS) completed the retrospective survey and were included in this pilot study. Both cohorts were taught using cadaveric prosections and multimedia software. Subsequently, student-feedback results on the 2 different teaching pedagogies – prosections alone, and prosections augmented with multimedia – were analysed. All results were tabulated and the *P* value was calculated using Fisher's exact test. A *P* value <0.05 was considered to be statistically significant. M¹ students preferred cadaveric prosections to multimedia learning for organs and tissue recognition, as well as for comprehension of general physiology ($P \leq 0.001$). Similarly, LSM students preferred cadaveric prosections to multimedia learning for the same objectives ($P \leq 0.003$). However, all students preferred multimedia learning to cadaveric prosections for self-guided independent study and integration with specific physiology domains ($P = 0.001$). It appears that students want the best of both approaches in studying the subject.

INTRODUCTION

To say that using multimedia (a combination of text, audio, and animations) merely adds value to the teaching of anatomy understates its importance. Rather, multimedia has revolutionised the way the subject is being taught in most universities around the world (Sugand, Abrahams & Khurana, 2010). Currently, a typical curriculum includes the use of multimedia instruction to compensate for the decrease of hours in the dissection room, lack of anatomy instructors and

cadavers, and their increasingly expensive preservation (Sugand et al., 2010). Earlier reports (Elizondo-Omana et al., 2004; Nicholson, Chalk, Funnell & Daniel, 2006) have suggested that using multimedia helps students in anatomy to consolidate knowledge and gain higher test scores. Such multimedia tools may be accessible via various platforms such as desktop and tablet PCs and smart mobile devices. Previous literature suggests that the modern revolution in anatomy education started sometime in the 1970s (Welser, 1970; Welser, Lewis & Stockton, 1970). At that time, this involved the use of silent loop films as a substitute for cadaveric dissection. In 1978, at Emory University, medical students studying anatomy were exposed to an experimental multimedia program (audiovisual and computer-assisted), then supplemented with tutorial sessions that used prosections instead of conventional cadaveric dissections (Jones, Olafson & Sutin, 1978; Jones & Sutin, 1978). Both methods allow the students to learn human anatomy adequately with neither showing any superiority. Since then, multimedia-based anatomy teaching has made further inroads in the form of slide presentations, and complex 3D software, simulating human anatomy. There is now a need to understand what all this new information means to students, both in terms of their ability to process it cognitively (Khalil, Paas, Johnson & Payer, 2005) and with reference to the question as to whether there is information overload. In fact, the Peninsula Medical School in the UK has done away with cadaver usage altogether (McLachlan, Bligh, Bradley & Searle, 2004) in favour of multimedia anatomical pedagogy.

Since the early eighties much progress has been made, including the development of a user-friendly multimedia anatomy browser, which incorporated a knowledge base with 3D images (Eno, Sundsten & Brinkley, 1991). At the same time, the program was also designed to quiz students about their knowledge of the subject. Other platforms, such as ATLAS-plus, an instructive multimedia program to assist in teaching histology, embryology and gross anatomy, were also created (Chapman et al., 1992). Significant progress was reported in 1994 when a group from Arkansas in the USA developed a multi-format multimedia platform known as the 'Anatomy Project' (Gest & VanBiervliet, 1994). This entity comprised a series of programs meant for education in the health sciences, merging basic anatomy with clinical aspects in CD-ROM, videodisc and videotape format and covering topics ranging from cardiovascular to neuro-anatomy. In 1996, benchmarking of lectures to Interactive Computer Assisted Learning Packages (ICALP) for the teaching and learning of anatomy was carried out in Curtin University, Australia with some seminal findings (Lee, 1996). The momentum was further encouraged when engineering colleagues developed a web interface for visualising anatomical images that became part of the visible human project (Barker & Young, 1997). In 1998, a report emerged on the successful application of computerised anatomy teaching for a group of nursing students (Thomson, 1998). Further progress was made with the advent of Java 3D for the teaching of

embryology and surgery, as reported by Guttman (Guttman, 1999). Closer to home, at the National University of Singapore (NUS), innovations in pedagogies have also taken place with regard to the teaching of human anatomy (Yip & Rajendran, 2008). The advent of commercial multimedia products from Primal Pictures, A.D.A.M and Pearson has allowed anatomy educators to utilise such new technology and implement it as an adjunct to complement traditional ways of anatomy instruction. Because of the paucity of data on retention of knowledge and translation into better clinical and transferable skills in students' later years, no retrospective study has yet been performed to observe the advantages and disadvantages of student cohorts exposed to both pedagogies. Given this background and the developments sketched above, we sought to explore student perceptions of these innovative teaching methods, and in particular to explore the role of both teaching methodologies (i.e. traditional teaching versus multimedia-augmented teaching).

In summary, the primary aim of the project was to investigate whether learning human anatomy (with respect to visiospatial awareness, physiology and tissue recognition) was preferred using (1) cadaveric dominated programs, or (2) similar programs augmented with multimedia. It was hypothesised that there will be subtle differences between the two pedagogies as well as across the different cohorts of students.

METHODOLOGY

Two different cohorts, namely first-year medical students (M¹) and first-year life science module students (LSM), were enrolled into the study, with significant differences within their first year curricula. A typical M¹ medical student attends a system of weekly lectures (at least 6 hours), practicums (2 hours) and tutorials (2 hours) to understand regional human anatomy, embryology and histology in considerable detail with a view for clinical application in the future. Conversely, a typical LSM student attends weekly lectures (2 hours) and practicums (2 hours) to appreciate systemic human anatomy (no clinical applications needed). A total of 80 M¹ and 100 LSM took part in this retrospective study, conducted over 3 years. These students (55% female and 45% male), ranging in age from 18 to 22 years, were exposed to both approaches under the guidance of their anatomy tutors. Primal Pictures' 3D as well as A.D.A.M's and Pearson's Mastering A&P software programs were utilised for augmentation purposes both during the semester and for students' self-directed learning. Other popular multimedia software programs, such as the BBC DVDs (The Human Body, Brain Story, Superhuman and Womb Collection) and Warwick Medical School Apple App (Aspects of Anatomy), were also recommended as good general resources. These

were shown in tutorials using Apple iPad² devices provided internally by the NUS Centre for Instructional Technology.

All students were contacted retrospectively, that is, at the end of the stipulated period of anatomy instruction – LSM after one semester and M¹ after ² semesters

Table. ¹. All students were asked to fill out two surveys (as shown below): one for prosections alone and another for prosections augmented with multimedia. Students were also asked about physiology and other subject matters to assess if any integration with anatomy had occurred at a higher cognitive order.

Faculty: (1) Med / (2) LSM	Gender: (1) M / (2) F
Approach – (1) Cadaveric Prosection / (2) Multimedia programme	
(1) Regional / (2) System anatomy	If using interactive program, estimated time clocked (1) More than 3 hours / (2) less than 3 hours

Domain	Please shade the appropriate response
	(1) Strongly Disagree (2) Disagree (3) Neutral (4) Agree (5) Strongly Agree
Appreciate 2-D orientation (Laterality)	1 2 3 4 5
Appreciate 3-D spatial orientation	1 2 3 4 5
Facilitate organs/ parts recognition	1 2 3 4 5
Aid your understanding of general physiology	1 2 3 4 5
(1) Very Poor (2) Poor (3) Average (4) Good (5) Very Good	
How much did it help your learning?	1 2 3 4 5
How much did it help your ability to integrate anatomy with the other subjects? (Biomechanics, respiratory + cardiac physiology etc.)	1 2 3 4 5
Do you recommend this education approach for your juniors?	(1) Yes (2) No

(a full year) – to determine which of the two approaches were more useful and in which particular aspects. The data, which were collected via a survey (Table 1), were tabulated and analysed using the Fisher’s exact test. A P value of <0.05 was considered to be statistically significant. For analysis purposes, all votes for “Strongly Agree” and “Agree” were consolidated into one category, while “Neutral”, “Strongly Disagree” and “Disagree” were collapsed into another.

Table. 2. Some notable comments made by students via emails and conversations about cadaveric prosections and multimedia-augmented teaching.

Cadaveric prosections	Multimedia resources
Dictated by tutors and domineering peers, and therefore not able to do self-revision at own timing (no access to prosections ad libitum).	Self paced with the benefit of self-revision later. (access to multimedia ad libitum).
More interactive with anecdotal stories by tutors and instructors.	Less interactive with no human contacts.
More emotions involved.	Less or no emotions involved (dealing with a machine!)
Lecturers and instructors fatigue.	Computer or program fatigue.
Contextual elaboration by teachers are great.	Lack of contextual elaboration.
Teachers may not have all the answers!	“Definitive answers” are available (but not always correct)
If no tutors available, lack of directions.	The quizzes and the e-textbook were good (24 hours accessible).
The smell of embalmed bodies was horrible. Some specimens were not great.	The visuals provided were really helpful in helping me put everything into perspective.
Some variations in answers between different tutors.	It provides clearer and more detailed explanations compared to our lecture notes.
Lack of personal attention due to tutor – student ratios.	A private teacher at your convenience.
Less personal attention from tutors	Your professor and dissection lab brought right to your doorstep.

Additionally, participants were given the opportunity to freely express their likes and dislikes of the two teaching pedagogies. These inputs were then listed accordingly (Table 2).

RESULTS

A total of 56 M¹ and 80 LSM responded to all questions in this study. The cumulative responses over 3 years were approximately 70% and 80% of the recruited medical (56/80) and life science students (80/100), respectively. We noted that local students were not forthcoming in doing extra work for research purposes. They were contented with just the bare essentials and clearing the exams at the end. Some participants left parts of the questionnaire blank, without providing any reasons.

M1 cohort

Cadaveric studies were preferred to multimedia learning for 2D appreciation (laterality; ability to decipher right from left side) ($P = 0.05$; significant), recognition of organs and tissues ($P \leq 0.001$; significant), and understanding of general physiology ($P \leq 0.001$; significant) (See Fig. 1 for raw data). When probed as to which of the two methods helped with self-guided independent study and specific integration with musculoskeletal biomechanics, respiratory and cardiovascular physiology, the students preferred multimedia-augmented to cadaveric dissections ($P = 0.001$; significant) (Fig. 2). Importantly, when surveyed on which of the two approaches they would recommend to their juniors, students preferred cadaveric dissections. In light of the statistical findings, M¹ students prefer cadaveric dissections in anatomy education, especially for organs or tissue recognition and for understanding physiology.

LSM cohort

LSM students, like their medical counterparts, preferred cadaveric studies to multimedia learning, with respect to organs and parts recognition ($P = 0.003$; statistically significant). However, they preferred multimedia teaching for 2D appreciation ($P = 0.05$; significant) and for understanding general physiology ($P < 0.001$; significant) (see Fig. 3 for raw data). As an aid for helping to better understand musculoskeletal biomechanics and respiratory and cardiovascular physiology, students preferred multimedia to cadaveric dissections ($P = 0.001$; significant) (Fig. 4). Furthermore, when asked which of the two approaches they would recommend to their peers, students voted equally for both cadaveric

M1 students

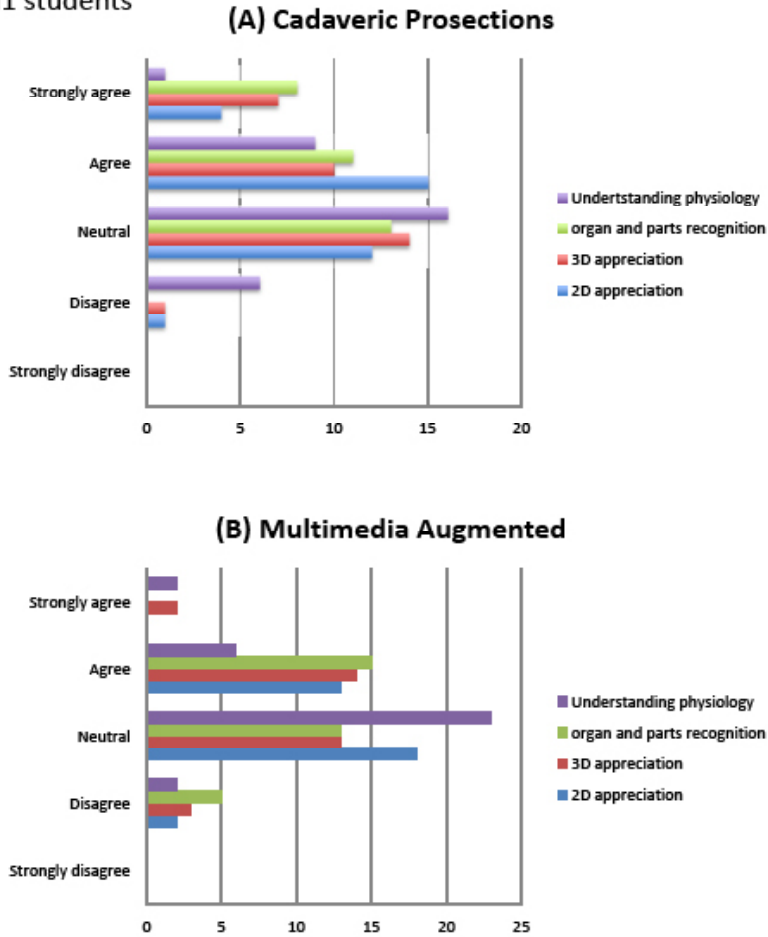
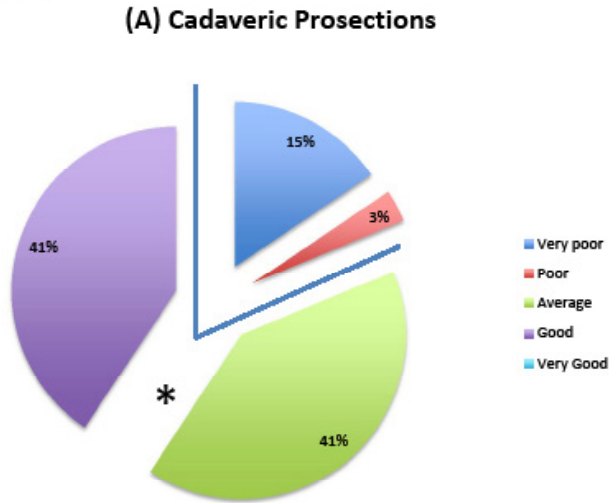


Fig. 1. M1 student’s response to key questions to specific domains with two different teaching pedagogies (A) cadaveric prosections (B) multimedia augmented. For analysis purposes, all votes for “Strongly Agree” and “Agree” were consolidated as one category, while “Strongly Disagree”, “Disagree” and “Neutral” were collapsed into another category. M1 students preferred cadaveric prosections especially for organs or tissue recognition, and for understanding physiology.

M1 students



(B) Multimedia Augmented

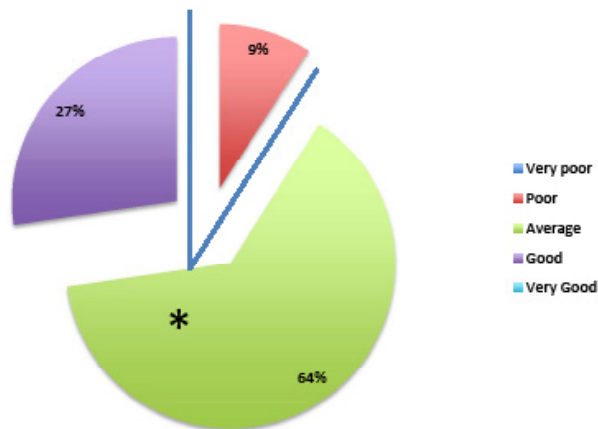


Fig. 2. M1 students' combined responses to the two forms of teaching pedagogies: (A) cadaveric prosections, and (B) multimedia augmented. For analysis purposes, all votes for "Very Good", "Good" and "Average" were consolidated into one category while "Poor" and "Very Poor" were collapsed into another. It was obvious that multimedia augmented was preferred to cadaveric prosections (* $P = 0.001$; significant).

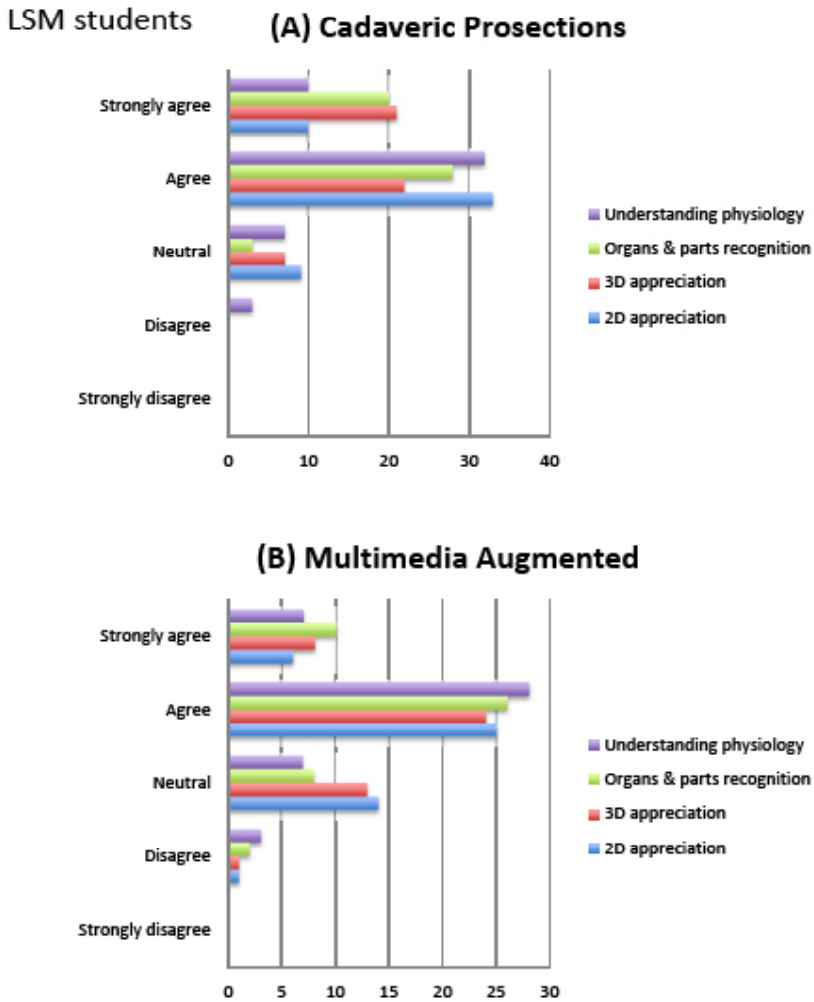


Fig. 3. LSM students' responses to the same key questions concerning two different pedagogies: (A) cadaveric prosections and (B) multimedia augmented. For analysis purposes, the consolidated categories are the same as for M1 students. They preferred cadaveric studies to multimedia learning with respect to organs and parts recognition. However for 2D appreciation and understanding general physiology, they preferred multimedia teaching.

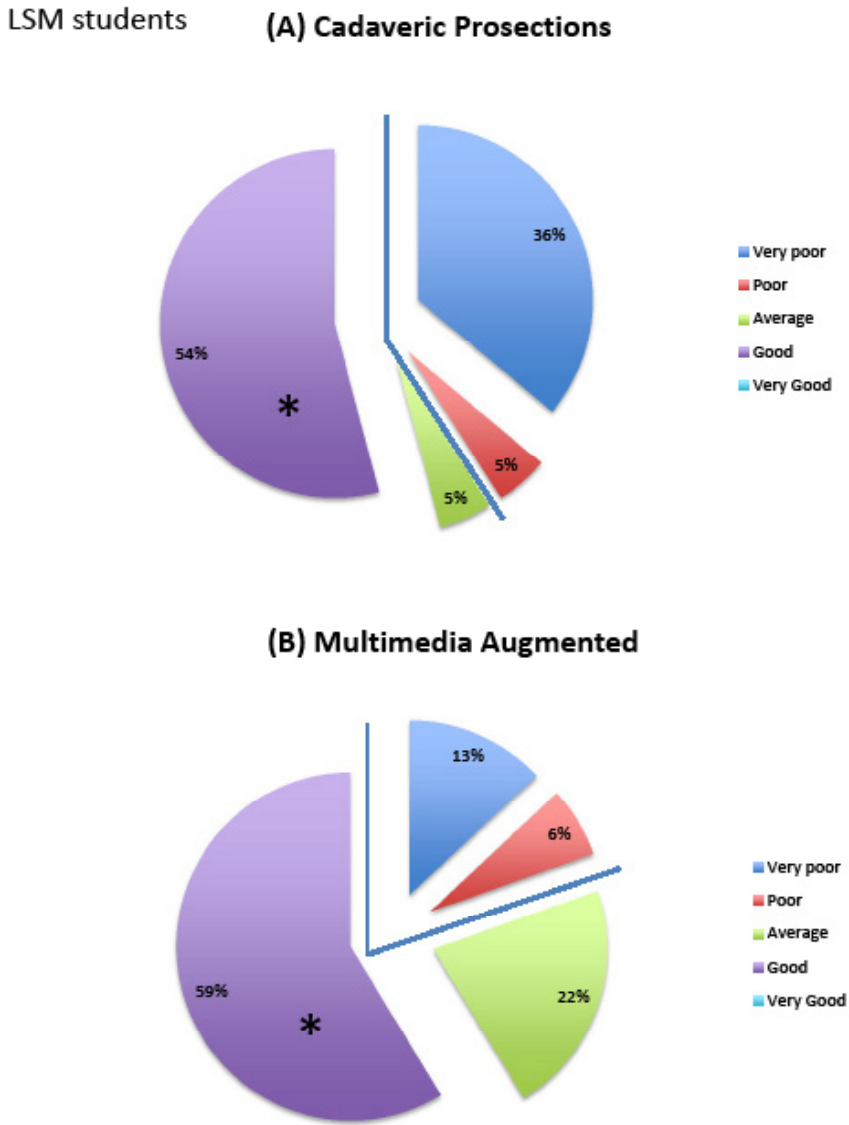


Fig. 4. LSM students' combined responses to the two forms of teaching pedagogies: (A) cadaveric prosections (B), and multimedia augmented. Similarly, all votes for "Very Good", "Good" and "Average" were consolidated into one category while "Poor" and "Very Poor" were collapsed into another. It was equally evident that students preferred multimedia augmented to cadaveric prosections ($*P = 0.001$; significant).

prosections and multimedia. In light of the statistical findings, we conclude that there were no clear preferences for either cadaveric prosections or multimedia anatomy education, except in the case of organs or tissue recognition as well as understanding physiology.

DISCUSSION

The teaching of human anatomy is undergoing a major revamp worldwide (Ang et al., 2012; Sugand et al., 2010). The days of depending heavily on dissection are something of the past at most universities, although this is being retained in some parts of the world (Sugand et al., 2010). It is important that efforts be made to understand the impetus of the shift from orthodox dissection instruction to more contemporary multimedia hybrid alternatives, which are aimed not only at compensating for the logistical implications of cadaveric dissection but also enhancing the learning experience for students. In this study, M¹ students voted overwhelmingly for cadaveric education over multimedia. Results indicated that the use of cadaveric prosections was preferred to multimedia education across the board except for 3D appreciation. The latter is attributed to the functionality of software including rotational features of anatomical parts with the ability to highlight certain structures using colour and conceptual text. Our present findings served to validate existing evidence presented in previous work undertaken in Germany and South Korea (Adamczyk, Holzer, Putz & Fischer, 2009; Chung et al., 2013; Mahmud, Hyder, Butt & Aftab, 2011). More importantly, this study represents an original effort to understand students from a part of the world in which body donation programs are still in their infancy. Furthermore, our survey embraced a broad spectrum of multimedia modalities as adjuncts.

Interestingly, the LSM students preferred the use of multimedia to cadaveric specimens, especially in the domain of 2D appreciation (laterality) and the learning of physiology. The stark difference in preference may be a result of differences in the educational frameworks, since the LSM curriculum does not include a practical examination. An important factor may be that the LSM curriculum does not contain practical components and therefore multimedia education should serve LSM students adequately. Furthermore, multimedia software programs, such as ADAMS and Primal Pictures, include both anatomy and physiology sections, which are appreciated by student-users. An interesting observation is that in the case of the identification of organs, where there is integration of anatomy and physiology, many students (30% to 40%) reported a neutral stance in deciding between the two teaching methods with respect to 2D (laterality) and 3D spatial orientation. We think that this could be due to the fact that these are junior students, and they do not have enough depth of

knowledge to know which is better. This is especially so for the medical students given the fact that they were expected to know more details.

The role of multimedia in complementing orthodox anatomy pedagogy has been attempted and reviewed previously (Sugand et al., ²⁰¹⁰; Tam, Hart, Williams, Heylings & Leinster, ²⁰⁰⁹); in fact, in a large-scale study undertaken some ²⁰ years ago, it was concluded that multimedia could produce results that were comparable to those of mainstream lectures (Lee, ¹⁹⁹⁶). At that time the most glaring disadvantage of multimedia education was the lack of ^{3D} appreciation (Lee, ¹⁹⁹⁶). With improving simulation, however, ^{3D} rotation of the structures is now possible with current software. Given this development, it will be most interesting to see if a multimedia approach now holds an advantage over conventional approaches. A quick literature review suggests that there is some evidence that modern mobile technologies are equally engaging for students in the anatomy laboratory (Mayfield, Ohara & O'Sullivan, ²⁰¹³). Nonetheless, with regard to which of the two methods is truly superior, one cannot categorically determine this, the reason being that they both have unique benefits (Adamczyk et al., ²⁰⁰⁹). Further analysis involving multiple centres should be performed to confirm whether there is a universal trend within the M¹ and LSM student cohorts.

Another possible confounder in this study is that students cannot accurately demarcate cadaveric from multimedia software since they are not mutually exclusive; instead, a mutually synergistic relationship between both methods can be established. Furthermore, the sight and smell of embalmed bodies inevitably could have contributed to the dislike for cadaveric prosections over multimedia forms of education. The outcomes from the survey also suggested some unexpected trends in that a few students (^{5%}) felt that both forms of education did not additionally contribute to their learning of human anatomy at all. In addition, students who used multimedia to augment their studies reported a summative-clocked time of less than ³ hours in total for the entire module. This amount of time is hardly significant compared to the number of contact hours for lectures and tutorials (between ⁴ and ⁸ hours per week). These are alarming findings and will warrant further investigation using thematic analysis in qualitative research. It is time to recognise other means of educational approaches to improve the quality of anatomy education and empower students to take more responsibility for their education as adult learners. One possibility might be the use of team-based learning (TBL) (Nieder, Parmelee, Stolfi & Hudes, ²⁰⁰⁵; Vasan, DeFouw & Holland, ²⁰⁰⁸) or problem-based learning (PBL) (Khaki et al., ²⁰⁰⁷) as practiced in some universities. Interestingly, TBL is able to achieve all objectives in a shorter period of time (Cook, Kamei, Soh, & Chow, ²⁰¹²). All things considered, it is still recommended that current practices continue

since feedback from students have been good; however, educators should remain open-minded to consider alternative adjunct teaching modalities. In the larger scheme of things, anatomists should also understand that the needs of medical students are different from those of surgical residents. It is almost a certainty that the latter cohort will want to learn human anatomy through clinically and technically relevant cadaveric dissection and prosections rather than through multimedia software, even though there are current data that suggest a number of benefits of the latter, such as speed of learning (Das & Mitchell, ²⁰¹³).

Some important observations from this study included:

- All students prefer adjuncts to anatomy instructions (i.e. cadaveric prosections coupled with multimedia software). A hybrid system of cadaveric and computer software programs could be developed.
- M¹ and LSM looked at the subject of anatomy differently and identified different strengths and weaknesses of the proposed methodologies.
- For students reporting on multimedia usage, all indicated clocking less than ³ hours in total for the entire module.
- Comments made by the students at the end of the study (Table ²) should be further examined.

One of the limitations of this pilot study is its low statistical power. Only ⁵⁶ M¹ and ⁸⁰ LSM students participated in this survey, which may not be truly representative of the whole student body. Further, this is a retrospective survey on how students perceive and accept two different approaches. This study cannot and does not make claims concerning the superiority of either of the two methods; nevertheless, a positive synergistic value of implementing both methods has been significantly established. Future studies should focus on determining which of the two is more influential in improving examination results and retention of knowledge.

CONCLUSION

Our M¹ cohort preferred learning from the cadaveric prosections in most subjective metrics and would recommend this teaching method to their junior peers, while LSM students were open to both pedagogies as their principal teaching method. This suggests that it would be optimal to include a multimodal teaching strategy (Pearce & Evans, ²⁰¹²) in the contemporary anatomy curriculum, rather than depending on a traditional framework of lectures and practicums provided solely by teachers.

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