Student Perceptions to Teaching Undergraduate Anatomy in Health Sciences

Ryan S Anderton[1,2], Li Shan Chiu[1] & Susan Aulfrey[1]

[1] School of Health Sciences, University of Notre Dame Australia, Fremantle, Western Australia, Australia

[2] Institute for Health Research, University of Notre Dame Australia, Fremantle, Western Australia, Australia

Correspondence: Ryan S Anderton, Senior Lecturer | Biomedical Science, School of Health Sciences | University of Notre Dame Australia, Australia

Received: June 30, 2016 Accepted: July 19, 2016 Online Published: August 16, 2016

doi:10.5430/ijhe.v5n3p201 URL: http://dx.doi.org/10.5430/ijhe.v5n3p201

Abstract

Anatomy and physiology teaching has undergone significant changes to keep up with advances in technology and to cater for a wide array of student specific learning approaches. This paper examines perceptions towards a variety of teaching instruments, techniques, and innovations used in the delivery and teaching of anatomy and physiology for health science students, and asks whether active learning through more progressive methods of teaching is beneficial for students across health science disciplines. In total, 138 health science students consisting of 32 biomedical science students, 52 exercise and sports science students, and 54 health and physical education students completed the retrospective study. Biomedical science students were least receptive to progressive teaching modalities, preferring anatomical dissections to laboratory workbooks (p <0.05) and body painting (p <0.05). In comparison, students from health and sport related degrees responded significantly better to anatomical models and laboratory workbooks than anatomical dissections (p <0.001). While gender differences were subtle, males responded positively to online multiple-choice question resources ($p < 0.05$) in comparison to females. Following a multimodal delivery of anatomy and physiology, students from all cohorts reported feeling significantly more confident ($p < 0.005$) when discussing all material in the course. The results obtained demonstrate differences amongst cohorts, which indicate that student perceptions to learning anatomy and physiology are dependent on individual course expectations. Moreover, these results support "hands on" practical teaching, and the use of a variety of teaching tools to foster learning and enjoyment of anatomy and physiology in health sciences.

Keywords: Anatomy, Physiology, Teaching practice, Student perception, Active learning, Multimodal

1. Introduction

The teaching of anatomy at a university level is currently in a state of flux. Traditional approaches that are instructive, and encourage a more student-passive method of learning, are in contention with more progressive means that foster active learning. Cadaveric dissections and prosections, which constitute traditional methods of teaching anatomy, have become increasingly difficult due to a lack of donated bodies, increasing concerns over safety, and significant expense (McLachlan, Bligh, Bradley, & Searle, 2004; McLachlan & Patten, 2006). Additionally, anatomy courses at a tertiary level have gradually shifted away from rote memorization, and towards understanding of content, driven by concept-based, problem-solving approaches (Miller, Perrotti, Silverthorn, Dalley, & Rarey, 2002). Dynamic innovations in technology have accompanied these changes, producing greater accessibility and quality of simulations, models, and medical imaging techniques (Collins, 2008; McLachlan & Patten, 2006; P. G. McMenamin, 2008; Pereira et al., 2007; Wright, 2012). This has prompted implementation of mixed, or multimodal, learning strategies, allowing students to acquire knowledge from a variety of traditional and novel sources. Commercial models, computer simulations, clay modeling, body painting, and other living anatomy teaching methods are often supplementing (and at times, replacing) traditional dissections and didactic lectures (Bergman et al., 2013; Brenner & Bio, 2003; Chinnah, de Bere, & Collett, 2011; Collins, 2008; Davis, Bates, Ellis, & Roberts, 2014; Finn & McLachlan, 2010; Johnson, Charchanti, & Troupis, 2012; McLachlan et al., 2004; B. S. Mitchell, McCrorie, & Sedgwick, 2004; Waters, Van Meter, Perrotti, Drogo, & Cyr, 2005).

1.1 Traditional Approaches

Debate over changes in anatomical pedagogy has primarily focused on the continuing role of dissection in medical courses. It has been suggested that recent developments have made it possible to teach anatomy without the use of cadavers (McLachlan et al., 2004). However, cadaveric dissection is viewed as a traditional and defining experience in medical education (Chapman, Hakeem, Marangoni, & Prasad, 2013; Kerby, Shukur, & Shalhoub, 2011; McLachlan et al., 2004; McLachlan & Patten, 2006), and attitudes towards the reduction or removal of human cadaveric dissection from the medical curriculum are often negative (McLachlan & Patten, 2006). Furthermore, studies suggest that both medical students and expert anatomists believe human cadaveric dissections are most suitable for achieving learning outcomes in anatomy (Ang, Yip, Lim, & Sugand, 2014; Kerby et al., 2011).

With regards to didactic lectures, it is still viewed by both students and instructors as a fundamental inclusion in the curricula. The favorability of lectures is often overwhelming, with students often agreeing that they were more beneficial than self-directed learning (Davis et al., 2014). Despite the push for more active modes of learning, these responses have shown that more traditional modes of delivery cannot be entirely ignored when developing curricula in anatomy and physiology (Choi-Lundberg, Low, Patman, Turner, & Sinha, 2016; Minhas, Ghosh, & Swanzy, 2012). Furthermore, it should be acknowledged that no singular approach (lectures, dissection/prosection, models, technology or living anatomy) fulfills all teaching objectives, thus a multimodal approach is best (Kerby et al., 2011).

1.2 Progressive Approaches

Progressive tools for teaching anatomy emphasize a hands-on approach that constitutes active learning, in addition to student-directed, problems-based learning. Although not favored by first years (Davis et al., 2014), students do appreciate its incorporation into a mixed mode of delivery in teaching (Minhas et al., 2012). The rise of more progressive modes of teaching has largely been influenced by the prevalence of technology in daily life. The added variety of tools that can be implemented in the classroom means that some are subjectively better than others. Studies into computer-assisted learning has produced contradictory results, showing student performance improvements in assessments (Kish, Cook, & Kis, 2013), and having no benefit when it came to short-term recall (Khot, Quinlan, Norman, & Wainman, 2013) when compared to anatomical models.

3D modeling on computers is another teaching tool that has been used, but they have been largely inferior to physical models (Palomera, Méndez, & Galino, 2014; Preece, Williams, Lam, & Weller, 2013). However, with the emergence of 3D printing capabilities, computer modeling has been utilized to produce anatomically accurate specimens (McMenamin, Quayle, McHenry, & Adams, 2014). More economical options include the use of plasticine and body painting. Commercially manufactured anatomical models are also available. The use of these alternatives have the added benefit of circumventing cultural and ethical issues surrounding the use of cadavers (McMenamin et al., 2014).

1.3 Student Perceptions to Undergraduate Teaching

The transition from secondary to higher education for most students can be a daunting process, yet potentially be a predictor for their academic success. Engagement with students is a highly valuable tool which can play a role in course completion (Hopper, 2016; Thalluri, 2016). Retention rates in science degrees tend to be poor (Lombardi, Hicks, Thompson, & Marbach-Ad, 2014), and student confidence and perceptions of science are often negative (Craker, 2006). In a university setting, a diversity in students' backgrounds results in variability amongst students in terms of their educational background and thus, learning styles. It has also been suggested that younger students require a more entertaining and immersive approach in order to remain interested in course material (Miller et al., 2002). Since it has the potential to engage multiple learning styles, and create an environment where students are more likely to achieve meaningful learning, many have employed a multimodal learning environment in the hopes that enjoyment of the coursework will lead to a greater investment of time in studying the material, and consequently, academic success (Drake & Pawlina, 2014; Farkas, Mazurek, & Marone, 2016; Lombardi et al., 2014; Michael, 2006).

A recent rise in publications discussing mixed strategies of teaching suggests that this is now commonplace. For example, Chinnah et al. (2011) stated that students now learn from a multimodal delivery, which emphasizes acquiring applicable skills and knowledge over factual recall (Chinnah et al., 2011). To further this, the general perception appears to be that new teaching techniques are best employed to complement the traditional dissections and prosections, rather than replace (Sugand, Abrahams, & Khurana, 2010). While there is strong support for this scenario, it is not always feasible, particularly in the increasingly common situation where time, finances and resources for anatomy programs are limited (Craig, Tait, Boers, & McAndrew, 2010; Johnson et al., 2012; Wright, 2012).

1.4 The Present Study Aims

The literature in this area is mostly restricted to the teaching of anatomy and physiology in medical courses. This limited scope does not take into account differing requirements and learning styles of the large number of students who study anatomy outside of medical degrees. Students in courses allied to medicine often study anatomical and physiological sciences to supplement their knowledge in both theory and practice (Lewis, 2003). This concept is supported by Miller et al. (2002), who stated that students pursuing a variety of health-based careers can benefit from anatomy courses, and that understanding must be emphasized over memorization (Miller et al., 2002). Educators must choose the most suitable active learning approaches to meet the objectives of their own courses (Lombardi et al., 2014). An exemplary case is the development by Miller et al. of an undergraduate human anatomy course in which modalities aimed at increasing understanding and problem-solving (e.g. models, preserved animal organs, textbooks and an in-house laboratory manual) replaced conventional animal dissections (Miller et al., 2002).

The current study evaluated the perceptions of a multi-professional cohort of health science students regarding teaching methods employed in a first-year introductory anatomy and physiology unit at an Australian university. The unit must meet the needs of students undertaking a wide variety of courses, including exercise and sport science, health and physical education, and biomedical science. Students were asked about the educational value of the unit and their enjoyment of each of the teaching approaches utilized. Furthermore, student recommendations regarding a number of potential modalities were recorded to determine cohort variance and effectiveness. The aim was to determine whether the multimodal teaching pedagogy currently employed is perceived favorably, and which, if any, particular modalities were found to be beneficial by students from different health science courses.

2. Methods

2.1 Course Description and Participants

This pilot study took place following the completion of a 2014 first semester anatomy and physiology unit (BMS100; Human Structure and Function). This study recruited students enrolled in BMS100, and was reviewed and approved by the University's Human Research and Ethics Committee. Students enroll in BMS100 during their first semester of a health science-related degree. Three different cohorts, namely first year exercise and sports science students (BESS), health and physical education students (HPE), and biomedical science students (BMS) were assessed in this study. Students attend weekly lectures (2 hours) and laboratory classes (2 hours) in learning anatomy and physiology. Specifically, this unit covers the structure and function of the skeletal, muscular, cardiovascular, respiratory, and nervous systems. Further, the unit assessment structure encompasses a range of continuous and final assessments (Table 1). Following a single year, a convenience sample of 138 students participated (46% male and 54% female), which comprised of 32 biomedical science students, 52 exercise and sports science students, and 54 health and physical education students.

Table 1. Assessment structure used in BMS100

Assessment	Duration (Minutes)	Weighting (%)
Mid-semester examination	60	15
Practical examination	60	20
Online MCQ quiz (5x)	30	10 (2% each)
Laboratory workbook	Continuous	10
Final examination	130	50

2.2 Student Surveys

Students were contacted retrospectively after the completion of the semester's unit content, and asked to complete a Likert-scale survey (ratings of 1-5), give written feedback, and select relevant answers from a list. The questionnaire (Supplementary Figure 3) focused on student perceptions to the teaching tools that were employed, the confidence and attitude of the student pre- and post- completing the unit, and preferences regarding future activities used in teaching anatomy and physiology.

2.3 Final Average Grades

Academic performance was measured to better inform the responses of the survey and determine how effective student learning had been during the semester. Following the completion of this unit, the final grades were collected and averaged according to gender and cohort. Students that commenced the unit and did not complete all assessment tasks were excluded as failures due to non-completion.

2.4 Data Analysis

The Likert-scale survey data was tabulated, and differences in mean student responses were assessed using paired *t-tests* with a p value of < 0.05 considered statistically significant. For measuring changes in perceived student confidence pre- and post- unit completion, paired *t-tests* using five-point Likert-scale data (1 = strongly disagree and 5 = strongly agree) were used to determine and compare cohort and gender averages. To aid in data representation and statistical analysis, student responses for “strongly agree” and “agree” were grouped together to reflect positive reception (and thus considered by students to be beneficial to their learning), while responses for “neutral”, “disagree” and “strongly disagree” were conversely categorized as neutral/negative. This grouping also allowed for Chi-squared analysis between groups. When performing short response analysis from written feedback, student responses were grouped according to the type of teaching tool recorded, and presented as a frequency.

3. Results

3.1 Health Science Students’ Response to Using a Combination of Teaching Tools

Students responded positively to a range of traditional and innovative teaching tools used throughout the semester. Traditional teaching instruments and techniques included the use of anatomical dissections, anatomical models and a related textbook. More progressive tools included anatomical body painting, use of plasticine for modeling a range of structures, regular online multiple-choice assessments, and the completion of a laboratory workbook.

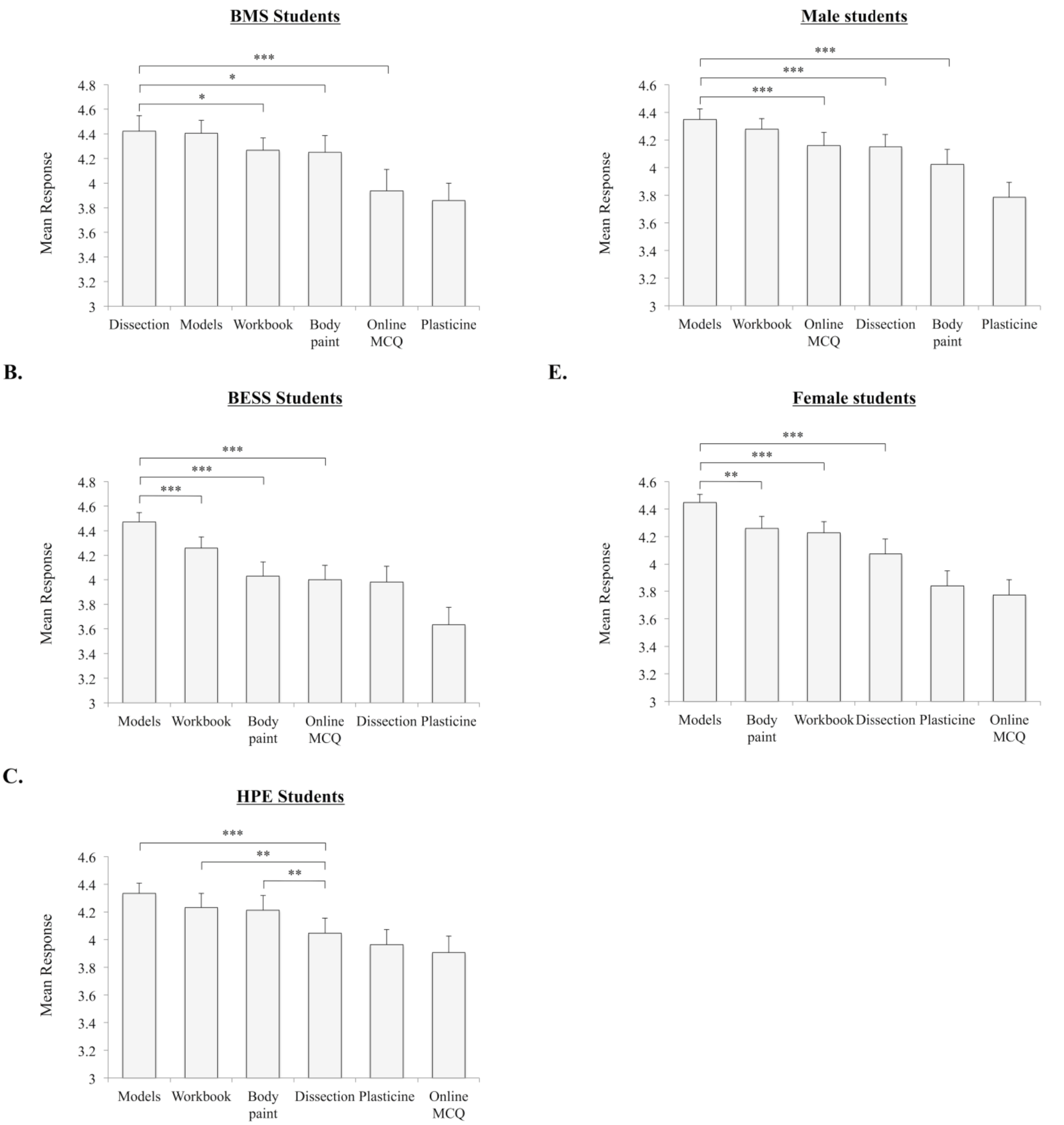


Figure 1. Student perceptions, by cohort (A-C) and gender (D-E), to what teaching tool was most effective in aiding their learning of anatomy and physiology. ***A*** Biomedical science, ***B*** exercise and sports science, and ***C*** health and physical education student perceptions to the effectiveness of each teaching modality. Student responses were also categorized by gender, with ***D*** male and ***E*** female perceptions to teaching modalities also shown (*$p < 0.05$; **$p < 0.005$; ***$p < 0.0005$).

BMS students perceived the traditional anatomical dissections and models as the best teaching tool (Figure 1A), significantly more beneficial than laboratory workbooks or body painting ($p < 0.05$). Similarly, the BESS and HPE students also perceived the use of anatomical models favorably (Figure 1B and 1C). There was a significant difference between the perceived value of anatomical models and dissection ($p < 0.0005$), online MCQ assessments ($p < 0.0005$), and plasticine modeling ($p < 0.0005$) in both BESS and HPE cohorts. Of particular note, the use of plasticine for anatomical modeling was not well perceived by students from all degrees. When assessed by gender, similar responses were observed, with both male and female health science students preferring the use of anatomical models (Supplementary figure 2D and 2E). However, despite inter-gender differences being minimal, male students preferred frequent online MCQ assessments compared to females (Supplementary figure 2A; $p < 0.05$). Interestingly, female students favored body painting over the traditional anatomical dissections ($p < 0.05$), a result not observed amongst male students. When categorized by positive or neutral/negative responses, there was strong support for all teaching tools, with only subtle differences when using Chi-squared analysis for comparison between cohort (Supplementary figure 1) and gender (Supplementary figure 2) teaching modality preferences.

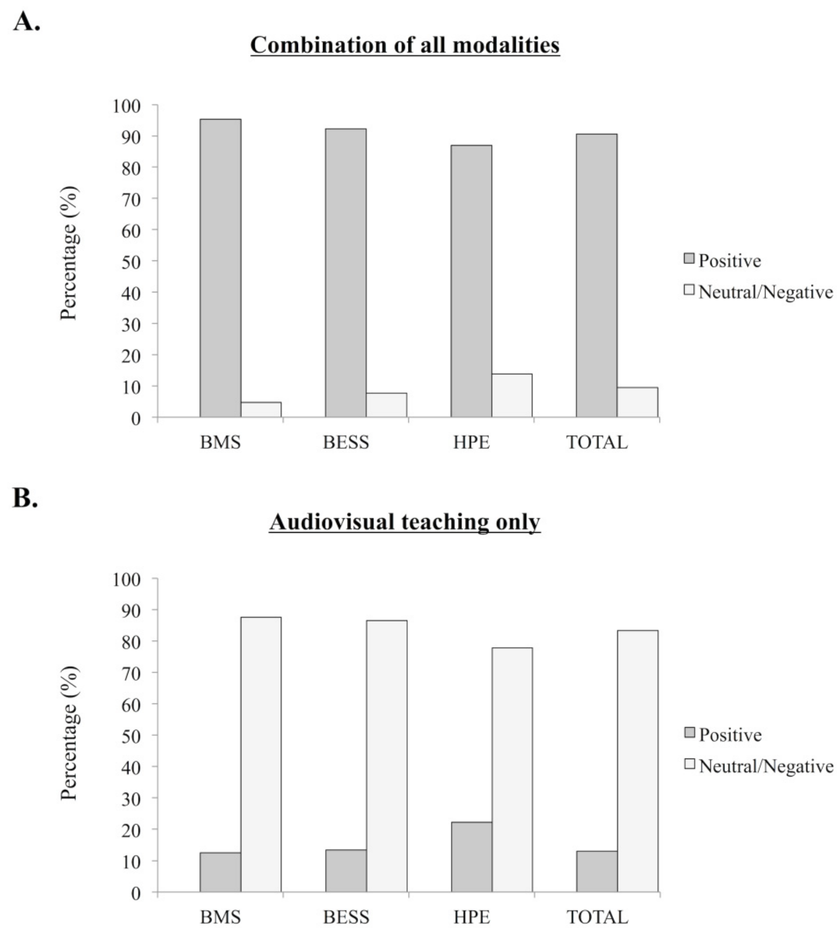
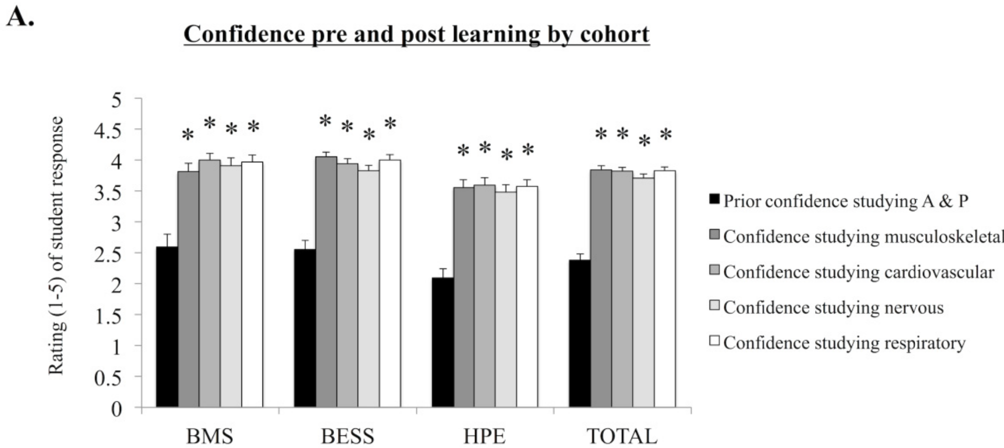


Figure 2. Overall assessment of student perception to teaching modalities. ***A*** Students were asked whether the combined approach of multiple traditional and progressive teaching tools or ***B*** an audiovisual delivery alone, promoted academic success and enjoyment.

The student response to a variety of teaching tools was overwhelmingly positive. However, it was still unclear whether this positive response was unique to individual tools, an integrated approach, or any form of teaching mechanism. Therefore, we next set out to determine if a combination of innovative and traditional teaching tools was well perceived by health science students. Interestingly, when asked whether a combination of material helped in the delivery and learning of material, 91% of students responded positively (Strongly Agree, Agree; Figure 2A). In contrast, 83% of students from all cohorts responded negatively to "I would have learnt as much if this unit only used audiovisual material", showing students would not prefer a unit that would solely rely on audiovisual (lectures and visual material) teaching tools (Figure 2B).



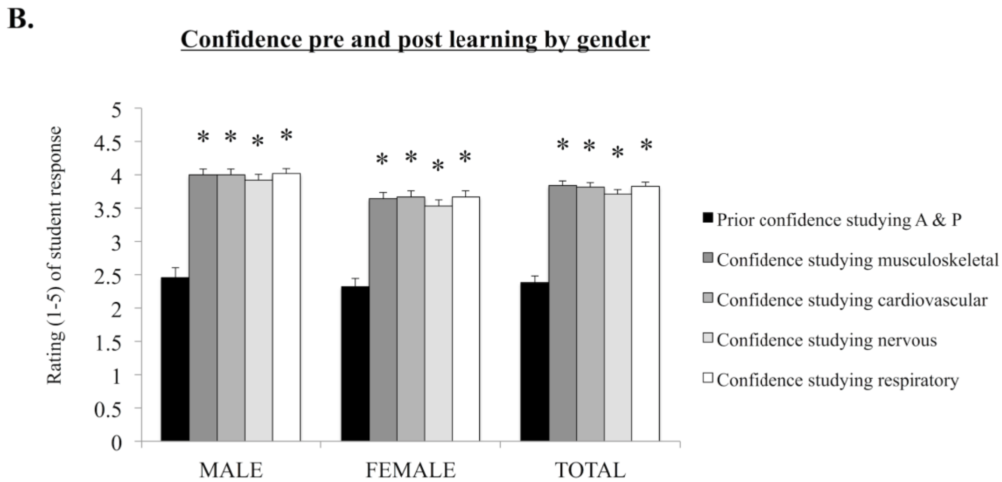


Figure 3. Assessment of perceived student confidence pre- and post- the completion of this unit. Student confidence in learning specific body systems was scored on a 1-5 scale with perceived confidence prior to commencing this unit used as a baseline. ***A*** Perceived student confidence in each cohort ***B*** and gender prior to, and following the completion of this anatomy and physiology unit (* $p < 0.0005$).

3.2 Student Confidence in Learning Anatomy and Physiology with Combining Multiple Teaching Tools

To investigate the overall effect our teaching techniques had on student learning and confidence, we assessed student confidence prior to the unit and after the completion of the unit. Mean scores (1-5), as derived from the survey were used to assess fold changes in perceived confidence in discussing the anatomy and physiology of specific body systems. Overall, student confidence prior to the unit (mean = 2.38) was significantly increased upon completion, with students more confident discussing musculoskeletal (mean = 3.80), cardiovascular (mean = 3.82), nervous (mean = 3.71), respiratory (mean = 3.83) anatomy and physiology (p = <0.001). While all cohorts appear to have similar increases in confidence following this unit, the HPE cohort had a lower level of confidence pre- and post-completion. Moreover, our data revealed the male students showed a larger increase in confidence (average = 1.52) compared to females (average = 1.30) when discussing the anatomy and physiology of all body systems (Figure 3).

3.3 An Integrated Practical Approach towards Teaching Anatomy and Physiology Motivated Students and Enhanced Perceived Success

Adopting a multimodal teaching approach can be receptive to a greater number of students and potentially accommodate a range of student abilities. To determine which specific teaching tools motivated student learning and enhanced academic success, student responses were tabulated. Qualitative analysis of student responses revealed general practical activities and comparative anatomy dissections enhanced student motivation (Table 2). Further, the use of a laboratory workbook throughout the unit enhanced perceived academic success (Table 3), supporting the benefits of a continuous learning tool.

Table 2. The specific tool used which increases motivation, enthusiasm and willingness to study anatomy and physiology

Response *(n=112)*	***N***	***% of respondents***
Practical activities (general)	35	31.1
Dissections	26	23.2
Laboratory workbook	17	15.1
Body painting	11	9.8
Online quizzes	10	8.9
Teaching staff	6	5.3
Anatomical models	2	1.7
Lecture material	1	0.8
Plasticine	1	0.8
Other*	8	7.1

****Includes self-directed study, textbook resources and class/peer discussions***

Table 3. The most helpful teaching tool that contributed towards academic success when studying anatomy and physiology

Response *(n=131)*	***n***	***% of respondents***
Laboratory workbook	61	46.5
Lecture material	38	29.0
Practical activities (general)	30	22.9
Online quizzes	21	16.0
Dissections	13	9.9
Body painting	11	8.3
Teaching staff	11	8.4
Anatomical models	9	6.8
Online (Blackboard) resources	5	3.8
Plasticine	4	3.1
Other*	8	6.1

****Includes class/peer discussions and using clinical examples***

3.4 Average Student Final Grades Following the Completion of This Unit

In order to determine whether reported confidence values were reflective of student final grades in the unit, mean unit grades were determined for each cohort and gender (Table 4). Biomedical science students performed significantly better (69.4%) than BESS (64.6%) and HPE (56.2%) cohorts. The strongest performing cohort, biomedical science, was the most receptive to using the combination of all the teaching tools (Figure 2B), but still preferred traditional anatomical teaching methods. Further, in all three cohorts, female students performed better (66.8%) than males (59.9%).

Table 4. Average final grades in each cohort of students studying health science anatomy and physiology

Student Cohort	Male Average (%)	Female Average (%)	Total Average (%)
BESS	60.7	69.4	64.6
BMS	66.3	72.3	69.4
HPE	52.8	58.5	56.2
Combined	59.9	66.8	62.9

3.5 Student Recommendations to Improve the Teaching and Learning of Anatomy and Physiology in Health Sciences

To further investigate what teaching tools appeal to students learning anatomy and physiology, students were asked to provide future recommendations to help in learning unit content. The most popular responses for improving the delivery of unit content were the incorporation of cadaveric specimens, increased dissections, and increased online resources. Despite cohorts offering similar responses, BMS students overwhelmingly showed more interest for cadaveric specimens and additional dissections (Figure 4).

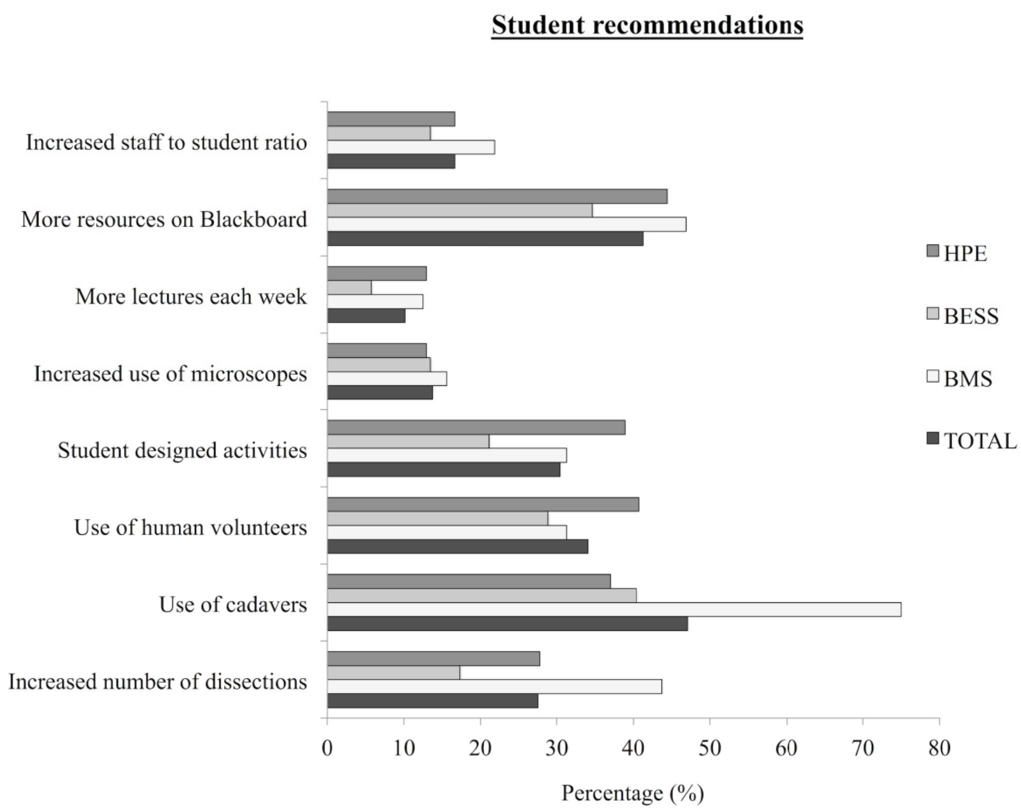


Figure 4. Student recommendations following the completion of a first year anatomy and physiology unit. The most common student responses were tabulated by student degree and represented as percentages.

4. Discussion

4.1 General Perceptions of Active Learning and Multimodal Courses

As undergraduate courses in the fields of science, technology, engineering, and mathematics evolve, there has been an ever-increasing support for the integration of active learning into the pedagogy, and the shift away from student-passive, didactic teaching methods (Freeman et al., 2014; Seymour, 2002). More specifically, in the disciplines of anatomy and physiology, active student participation in the learning process is beneficial to their understanding of the concepts that are taught, potentially contributing to academic success (Gauci, Dantas, Williams, & Kemm, 2009; Michael, 2006). Even if the student is a non-major, methods of teaching that engage and directly involve students, are perceived favorably (Wilke, 2003). One method of incorporating active learning into the pedagogy, is the use of multiple modalities to cater for the varied learning styles of students. Multimodal teaching is preferred by a majority of students interested in pursuing a career in the health professions (Breckler, Joun, & Ngo, 2009), a notion that is upheld by the results obtained from the current study.

Practical activities in general were considered the most engaging aspect of the course, and the concept of a solely audiovisual version of the unit elicited very negative responses in the current study. This correlates with a study by Johnston and McAllister (2008), who found that nursing students were extremely supportive of laboratory classes in an anatomy curriculum. Even in studies where students favored the use of more traditional teaching modalities (e.g. dissection), access to a range of other educational resources (e.g. models, e-learning) was viewed as helpful (Davis et al., 2014; Kerby et al., 2011). Offering learning environments with highly perceived value, and engagement with anatomical material may have the benefit of promoting retention (Lombardi et al., 2014). It is therefore believed that the current use of multimodal teaching approaches at this institution is advantageous and should be encouraged, echoing the sentiments of other researchers (Davis et al., 2014;Johnson et al., 2012; R. Mitchell & Batty, 2009; Sugand et al., 2010).

4.2 Specific Teaching Modalities

4.2.1 Comparative Anatomical Dissections

With regard to specific teaching modalities, comparative anatomical dissection of animal tissue was the most positively viewed activity amongst BMS students. While studies comparing performance of students undertaking animal dissection with those undertaking alternatives (such as computer-assisted learning) have produced varying results (Lombardi et al., 2014; Waters et al., 2005), students tend to place greater value on dissections (Ang et al., 2014), and those performing dissections were more likely to find science entertaining (Lombardi et al., 2014). For example, Waters et al. (2005) found that students carrying out cat dissections were more likely to perceive dissection as valuable afterwards, whereas students carrying out clay sculpting viewed dissections as less valuable, indicating that prior exposure to different teaching resources may play a factor in terms of preference (Waters et al., 2005). The students in the current study were all offered the same range of activities, indicating that this is not a factor in terms of the strong inclination towards dissections amongst the BMS students. Dissection-based activities are often associated with studying medicine. The positive attitude towards, and requests for more of these activities may be due to the considerable number in the BMS cohort with intentions of gaining entry into postgraduate medicine. Dissections offer familiarization with anatomical systems, and the opportunity to integrate theory and practice. Additionally, respect for the body, and an appreciation of dissection within the context of the history of medicine may also be gained by students (Lempp, 2005).

4.2.2 Body Painting

Body painting was viewed favorably by all three cohorts, particularly in terms of engagement with musculoskeletal content in the unit. Again, this correlates with findings from prior studies, which suggest that body painting provides an opportunity for active learning, and that students generally view the activity as enjoyable and useful for learning (Finn & McLachlan, 2010; McMenamin, 2008). This activity was particularly well received by HPE students, possibly due to a greater emphasis on the musculoskeletal systems and the highly kinesthetic nature of the activity (McMenamin, 2008). As a teaching tool, body painting also has the added advantage of helping students to develop skills in professional physical contact (Op Den Akker, Bohnen, Oudegeest, & Hillen, 2002), which is applicable to students in all three cohorts of the current study.

4.2.3 Using Anatomical Models

The use of plastic models was viewed as useful in terms of learning, and was particularly well received by BESS students. However, the activity was not viewed as particularly engaging or enjoyable. Students in general do believe that plastic models are a useful supplement to learning (Davis et al., 2014; Johnson et al., 2012; Johnston & McAllister, 2008; Wright, 2012), although this was dependent on model choice (Davis et al., 2014). BESS students' support for the use of models may reflect their belief that studying the human form as a whole unit is more relevant to their degree, particularly as models provide a three-dimensional perspective of the body (Wright, 2012).

4.2.4 Use of Plasticine as a Teaching Tool

Modeling structures in clay has previously been demonstrated to promote active learning and student engagement (DeHoff, Clark, & Meganathan, 2011; Naug, Colson, & Donner, 2011), with similar effectiveness as animal dissections (Waters et al., 2005). Conflictingly, responses from this study found that fewer students perceived this activity as particularly useful or engaging, despite generally favorable views. However, the most positive response to plasticine modeling in the current study was obtained from the HPE students, which is somewhat consistent with the findings of Grim et al., who noted that athletic training students enjoyed clay modeling of body structures and believed that it helped them to retain information (Grim, 2006). This belief was echoed by few in the current study. Some of the students' uncertainty about clay modeling may simply be a reflection of apprehension around their own artistic abilities (Haspel, Motoike, & Lenchner, 2014), or the perception of the activity as 'childish'. It is possible that use of plasticine modeling would be better received if structures were modeled in sculpting clay and formed on plastic models, as in other studies (Haspel et al., 2014; Waters et al., 2005).

4.2.5 Laboratory Workbook and Online Multiple-choice Quizzes

The laboratory workbook was viewed as the most useful tool in terms of contributing to academic success in the unit. The workbook was specifically designed for the general practical component of this course (which was also rated very highly) and as such contained content specifically related to the learning objectives, possibly contributing to its positive reception. Other researchers have also mentioned the need to develop a specific laboratory manual to guide student learning in their courses (Bergman et al., 2013; Miller et al., 2002; Wright, 2012). Students in this course also believed that the laboratory manual increased motivation to study anatomy, possibly due to completion of the manual having an assessment grade (5%) attached.

Timed online multiple-choice quizzes also had an assessment value attached (2% per test, for a total of 5 tests), which may have promoted engagement, and contributed to the perception of its usefulness as a modality for academic success. Although multiple-choice questions are the most common form of assessment in medical gross anatomy courses (Craig et al., 2010), the relatively new online availability, and 'take-home' format may have contributed to the positive reviews (Dermo, 2009). Additionally, assigning small cumulative values per test and having tests throughout the semester is likely to have prompted continual revision. As assessment is a key factor in student learning, the multimodal assessment approach was designed to reflect course content.

4.2.6 Lecture Material

Although lecture material was not rated highly in terms of engaging students, it was found to be very useful in terms of achieving success in this unit. This contrasts with the perception of practical activities, which were viewed as both engaging and contributing to success. It appears that, in spite of efforts to modernize the course and place greater emphasis on active learning, students still perceive didactic teaching as essential to achieve learning objectives. There is evidence that this may be part of a wider trend, as Australian medical students have requested a greater emphasis on textbook-based learning, and show a strong preference for guided rather than self-directed learning (Mitchell & Batty, 2009). Moreover, the positive attitude towards lecture materials supports the inclusion of auditory, and reading-writing sensory modalities as part of a multimodal approach to teaching (Minhas et al., 2012; Breckler et al., 2009).

4.3 Proposed Activities and Suggestions

The use of cadavers was the most requested activity, and was overwhelmingly requested by BMS students. This was not surprising, given that BMS is generally viewed as a pre-medical course, and students and staff alike perceive cadaveric dissection/prosection as the 'gold standard' of medical anatomy teaching. Despite this, not all Australian and New Zealand medical schools offer dissection, and of those that do, dissection of cadavers is offered as an option (Craig et al., 2010). Mitchell et al. (2004) found that students undertaking a multi-professional anatomy course equally valued dissections; however, biomedical science students showed the greatest preference for dissection, echoing the results of this study.

Interestingly, the use of human volunteers and student-designed activities were requested by all three cohorts, and were especially popular with HPE and BESS students. Peer physical examination develops an understanding of locations of structures in and on the body, and also assists with learning professional skills such as appropriate language and attitude towards clients (Chinnah et al., 2011). Collins (2008) points out that use of live models not only allows students to interact with a living person, but also provides the opportunity to observe the musculoskeletal system in action, which may explain the positive responses of BESS and HPE. Peer examination also allows students to be active and learn from each other (Bergman et al., 2013). This suggests that a combination of the two approaches (e.g. having students design demonstrations of muscle actions for the class) would be well received, and tie together clinical and theoretical concepts.

4.4 Student Confidence and Actual Performance

Overall, student confidence was increased upon completion of the unit. Students in all cohorts reported a significant increase for all body systems, although lower levels of confidence were reported for students in the HPE cohort pre- and post-completion. These findings persisted in final unit grades, with the HPE cohort having an average of 56.2%

compared to higher grades for the BESS and BMS cohorts (64.6 and 69.4%, respectively), a trend previously observed in first year anatomy and physiology (Anderton, Evans, & Chivers, 2016). While these results may reflect investment of the students in the unit (i.e. students perceiving a unit as more relevant to their degree and being more engaged in the unit), it is possible that the lower grades coupled with the HPE students' interest in alternative activities indicate that the current approach does not sufficiently cater to students from the HPE discipline. In any case, the apparent relationship between students' confidence and actual performance in the unit provides support for multimodal approaches to teaching.

4.5 Conclusions

Certain trends have surfaced in the constantly evolving pedagogy of anatomy and physiology. Over recent years, there has been increasing support for fostering active learning, and implementing multimodal teaching strategies in a bid to engage students and garner interest in these health science disciplines. The current study gathered student opinions and attitudes towards such progressions, and the results obtained echo this trend. Although novel and innovative activities gained positive feedback, traditional methods such as lectures and dissections were still deemed beneficial to academic achievement in anatomy and physiology.

Although informative, the results of student perception surveys should be interpreted with caution (DiLullo, McGee, & Kriebel, 2011). Students' perceptions regarding the value of different teaching modalities may not reflect actual worth in terms of their learning of anatomy. Furthermore, it is important that multimodal teaching be explained to students, emphasizing the value of learning through a variety of teaching tools. Mitchell and Batty (2009) noted that staff should explain the rationale behind use of different teaching methods, as adult learners tend to engage more readily when objectives and relevance are clear. The authors also point out that anxiety over new teaching methods is to be expected, particularly when staff or professionals in practice criticize methods. A future endeavor for investigation could examine the relationship between instructor confidence and predispositions with multimodal teaching strategies, and students' attitudes towards learning in this manner. Another consideration is that student-instructor ratios may be an implicating factor in the effectiveness of student-active learning, and multimodal teaching strategies since previous studies on this factor have been inconclusive (Hattie, 2005). While the results of this study have been very positive, it is likely that future development of the course will encompass greater communication between staff and students to further enhance student learning in anatomy and physiology.

References

Anderton, R. S., Evans, T., & Chivers, P. T. (2016). Predicting Academic Success of Health Science Students for First Year Anatomy and Physiology. *International Journal of Higher Education, 5*(1), p250 %@ 1927-6052. http://dx.doi.org/10.5430/ijhe.v5n1p250

Ang, E. T., Yip, G., Lim, E. C. H., & Sugand, K. (2014). Learning undergraduate human anatomy – reflections on undergraduate preferences in Singapore: a pilot study. *The Journal of the NUS Teaching Academy, 4*(1), 36-52.

Bergman, E. M., Sieben, J. M., Smailbegovic, I., de Bruin, A. B., Scherpbier, A. J., & van der Vleuten, C. P. (2013). Constructive, collaborative, contextual, and self-directed learning in surface anatomy education. *Anat Sci Educ, 6*(2), 114-124. http://dx.doi.org/10.1002/ase.1306

Breckler, J., Joun, D., & Ngo, H. (2009). Learning styles of physiology students interested in the health professions. *Adv Physiol Educ, 33*(1), 30-36. http://dx.doi.org/10.1152/advan.90118.2008

Brenner, K., & Bio, C. (2003). Fueling educational reform: Bio2010--biology for the future. *Cell Biol Educ, 2*(2), 85-86. http://dx.doi.org/10.1187/cbe.02-11-0053

Chapman, S. J., Hakeem, A. R., Marangoni, G., & Prasad, K. R. (2013). Anatomy in medical education: Perceptions of undergraduate medical students. *Annals of Anatomy - Anatomischer Anzeiger, 195*(5), 409-414. http://dx.doi.org/10.1016/j.aanat.2013.03.005

Chinnah, T. I., de Bere, S. R., & Collett, T. (2011). Students' views on the impact of peer physical examination and palpation as a pedagogic tool for teaching and learning living human anatomy. *Med Teach, 33*(1), e27-36. http://dx.doi.org/10.3109/0142159X.2011.530313

Choi-Lundberg, D. L., Low, T. F., Patman, P., Turner, P., & Sinha, S. N. (2016). Medical student preferences for self-directed study resources in gross anatomy. *Anat Sci Educ, 9*(2), 150-160. http://dx.doi.org/10.1002/ase.1549

Collins, J. P. (2008). Modern approaches to teaching and learning anatomy. *BMJ, 337*, a1310. http://dx.doi.org/10.1136/bmj.a1310

Craig, S., Tait, N., Boers, D., & McAndrew, D. (2010). Review of anatomy education in Australian and New Zealand medical schools. *ANZ J Surg, 80*(4), 212-216. http://dx.doi.org/10.1111/j.1445-2197.2010.05241.x

Craker, D. E. (2006). Attitudes Toward Science of Students Enrolled in Introductory Level Science Courses at UW-La Crosse. *UW-L Journal of Undergraduate Research IX*, 1-6.

Davis, C. R., Bates, A. S., Ellis, H., & Roberts, A. M. (2014). Human anatomy: Let the students tell us how to teach. *Anat Sci Educ, 7*(4), 262-272. http://dx.doi.org/10.1002/ase.1424

DeHoff, M. E., Clark, K. L., & Meganathan, K. (2011). Learning outcomes and student-perceived value of clay modeling and cat dissection in undergraduate human anatomy and physiology. *Adv Physiol Educ, 35*(1), 68-75. http://dx.doi.org/10.1152/advan.00094.2010

Dermo, J. (2009). e-Assessment and the student learning experience: A survey of student perceptions of e-assessment. *British Journal of Educational Technology, 40*(2), 203-214. http://dx.doi.org/10.1111/j.1467-8535.2008.00915.x

DiLullo, C., McGee, P., & Kriebel, R. M. (2011). Demystifying the Millennial student: a reassessment in measures of character and engagement in professional education. *Anat Sci Educ, 4*(4), 214-226. doi: 10.1002/ase.240

Drake, R. L., & Pawlina, W. (2014). Multimodal education in anatomy: The perfect opportunity. *Anat Sci Educ, 7*(1), 1-2. http://dx.doi.org/10.1002/ase.1426

Farkas, G. J., Mazurek, E., & Marone, J. R. (2016). Learning style versus time spent studying and career choice: Which is associated with success in a combined undergraduate anatomy and physiology course? *Anat Sci Educ, 9*(2), 121-131. http://dx.doi.org/10.1002/ase.1563

Finn, G. M., & McLachlan, J. C. (2010). A qualitative study of student responses to body painting. *Anat Sci Educ, 3*(1), 33-38. http://dx.doi.org/10.1002/ase.119

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proc Natl Acad Sci U S A, 111*(23), 8410-8415. http://dx.doi.org/10.1073/pnas.1319030111

Gauci, S. A., Dantas, A. M., Williams, D. A., & Kemm, R. E. (2009). Promoting student-centered active learning in lectures with a personal response system. *Adv Physiol Educ, 33*(1), 60-71. http://dx.doi.org/10.1152/advan.00109.2007

Grim, M. L. M., A.; Grim, M. L.; Mickle, C. (2006). Teaching Anatomy Kinesthetically Through Modeling. *International Jornal of Athletic Therapy and Training, 11*(4).

Haspel, C., Motoike, H. K., & Lenchner, E. (2014). The implementation of clay modeling and rat dissection into the human anatomy and physiology curriculum of a large urban community college. *Anat Sci Educ, 7*(1), 38-46. http://dx.doi.org/10.1002/ase.1369

Hattie, J. (2005). The paradox of reducing class size and improving learning outcomes. *International Journal of Educational Research, 43*(6), 387-425. http://dx.doi.org/10.1016/j.ijer.2006.07.002

Hopper, M. K. (2016). Assessment and comparison of student engagement in a variety of physiology courses. *Adv Physiol Educ, 40*(1), 70-78. http://dx.doi.org/10.1152/advan.00129.2015

Johnson, E. O., Charchanti, A. V., & Troupis, T. G. (2012). Modernization of an anatomy class: From conceptualization to implementation. A case for integrated multimodal-multidisciplinary teaching. *Anat Sci Educ, 5*(6), 354-366. http://dx.doi.org/10.1002/ase.1296

Johnston, A. N., & McAllister, M. (2008). Back to the future with hands-on science: students' perceptions of learning anatomy and physiology. *J Nurs Educ, 47*(9), 417-421. http://dx.doi.org/10.3928/01484834-20080901-04

Kerby, J., Shukur, Z. N., & Shalhoub, J. (2011). The relationships between learning outcomes and methods of teaching anatomy as perceived by medical students. *Clin Anat, 24*(4), 489-497. http://dx.doi.org/10.1002/ca.21059

Khot, Z., Quinlan, K., Norman, G. R., & Wainman, B. (2013). The relative effectiveness of computer-based and traditional resources for education in anatomy. *Anat Sci Educ, 6*(4), 211-215. http://dx.doi.org/10.1002/ase.1355

Kish, G., Cook, S. A., & Kis, G. (2013). Computer-assisted learning in anatomy at the International Medical School in Debrecen, Hungary: A preliminary report. *Anat Sci Educ, 6*(1), 42-47. http://dx.doi.org/10.1002/ase.1303

Lempp, H. K. (2005). Perceptions of dissection by students in one medical school: beyond learning about anatomy. A qualitative study. *Med Educ, 39*(3), 318-325. http://dx.doi.org/10.1111/j.1365-2929.2005.02095.x

Lewis, M. J. (2003). Computer-assisted learning for teaching anatomy and physiology in subjects allied to medicine. *Med Teach, 25*(2), 204-206. http://dx.doi.org/10.1080/713931397

Lombardi, S. A., Hicks, R. E., Thompson, K. V., & Marbach-Ad, G. (2014). Are all hands-on activities equally effective? Effect of using plastic models, organ dissections, and virtual dissections on student learning and perceptions. *Adv Physiol Educ, 38*(1), 80-86. http://dx.doi.org/10.1152/advan.00154.2012

McLachlan, J. C., Bligh, J., Bradley, P., & Searle, J. (2004). Teaching anatomy without cadavers. *Med Educ, 38*(4), 418-424. http://dx.doi.org/10.1046/j.1365-2923.2004.01795.x

McLachlan, J. C., & Patten, D. (2006). Anatomy teaching: ghosts of the past, present and future. *Med Educ, 40*(3), 243-253. http://dx.doi.org/10.1111/j.1365-2929.2006.02401.x

McMenamin, P. G. (2008). Body painting as a tool in clinical anatomy teaching. *Anat Sci Educ, 1*(4), 139-144. http://dx.doi.org/10.1002/ase.32

McMenamin, P. G., Quayle, M. R., McHenry, C. R., & Adams, J. W. (2014). The production of anatomical teaching resources using three-dimensional (3D) printing technology. *Anat Sci Educ, 7*(6), 479-486. http://dx.doi.org/10.1002/ase.1475

Michael, J. (2006). Where's the evidence that active learning works? *Adv Physiol Educ, 30*(4), 159-167. http://dx.doi.org/10.1152/advan.00053.2006

Miller, S. A., Perrotti, W., Silverthorn, D. U., Dalley, A. F., & Rarey, K. E. (2002). From college to clinic: reasoning over memorization is key for understanding anatomy. *Anat Rec, 269*(2), 69-80. http://dx.doi.org/10.1002/ar.10071

Minhas, P. S., Ghosh, A., & Swanzy, L. (2012). The effects of passive and active learning on student preference and performance in an undergraduate basic science course. *Anat Sci Educ, 5*(4), 200-207. http://dx.doi.org/10.1002/ase.1274

Mitchell, B. S., McCrorie, P., & Sedgwick, P. (2004). Student attitudes towards anatomy teaching and learning in a multiprofessional context. *Med Educ, 38*(7), 737-748. http://dx.doi.org/10.1111/j.1365-2929.2004.01847.x

Mitchell, R., & Batty, L. (2009). Undergraduate perspectives on the teaching and learning of anatomy. *ANZ J Surg, 79*(3), 118-121. http://dx.doi.org/10.1111/j.1445-2197.2008.04826.x

Naug, H. L., Colson, N. J., & Donner, D. G. (2011). Promoting metacognition in first year anatomy laboratories using plasticine modeling and drawing activities: a pilot study of the "blank page" technique. *Anat Sci Educ, 4*(4), 231-234. http://dx.doi.org/10.1002/ase.228

Op Den Akker, J. W., Bohnen, A., Oudegeest, W. J., & Hillen, B. (2002). Giving color to a new curriculum: bodypaint as a tool in medical education. *Clin Anat, 15*(5), 356-362. http://dx.doi.org/10.1002/ca.10049

Palomera, P. R., Méndez, J. A. J., & Galino, A. P. (2014). Enhancing neuroanatomy education using computer-based instructional material. *Comput. Hum. Behav., 31*, 446-452. http://dx.doi.org/10.1016/j.chb.2013.03.005

Pereira, J. A., Pleguezuelos, E., Meri, A., Molina-Ros, A., Molina-Tomas, M. C., & Masdeu, C. (2007). Effectiveness of using blended learning strategies for teaching and learning human anatomy. *Med Educ, 41*(2), 189-195. http://dx.doi.org/10.1111/j.1365-2929.2006.02672.x

Preece, D., Williams, S. B., Lam, R., & Weller, R. (2013). “Let's Get Physical”: Advantages of a physical model over 3D computer models and textbooks in learning imaging anatomy. *Anat Sci Educ, 6*(4), 216-224. http://dx.doi.org/10.1002/ase.1345

Seymour, E. (2002). Tracking the processes of change in US undergraduate education in science, mathematics, engineering, and technology. *Science Education, 86*(1), 79-105. http://dx.doi.org/10.1002/sce.1044

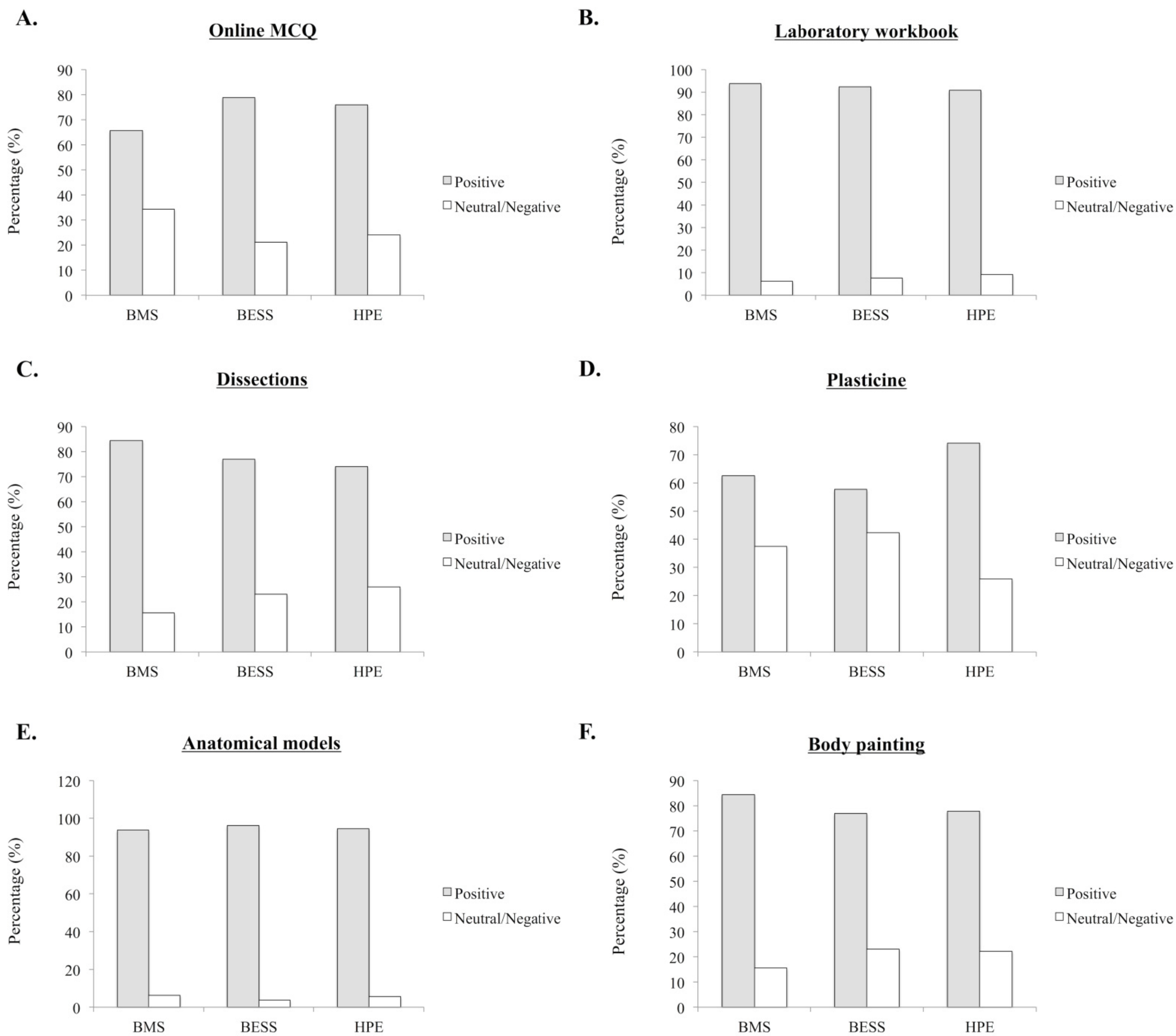
Sugand, K., Abrahams, P., & Khurana, A. (2010). The anatomy of anatomy: a review for its modernization. *Anat Sci Educ, 3*(2), 83-93. http://dx.doi.org/10.1002/ase.139

Thalluri, J. (2016). Bridging the gap to first year health science: Early engagement enhances student satisfaction and success. *Student Success*, *7*(1), 37–48. http://dx.doi.org/10.5204/ssj.v7i1.305

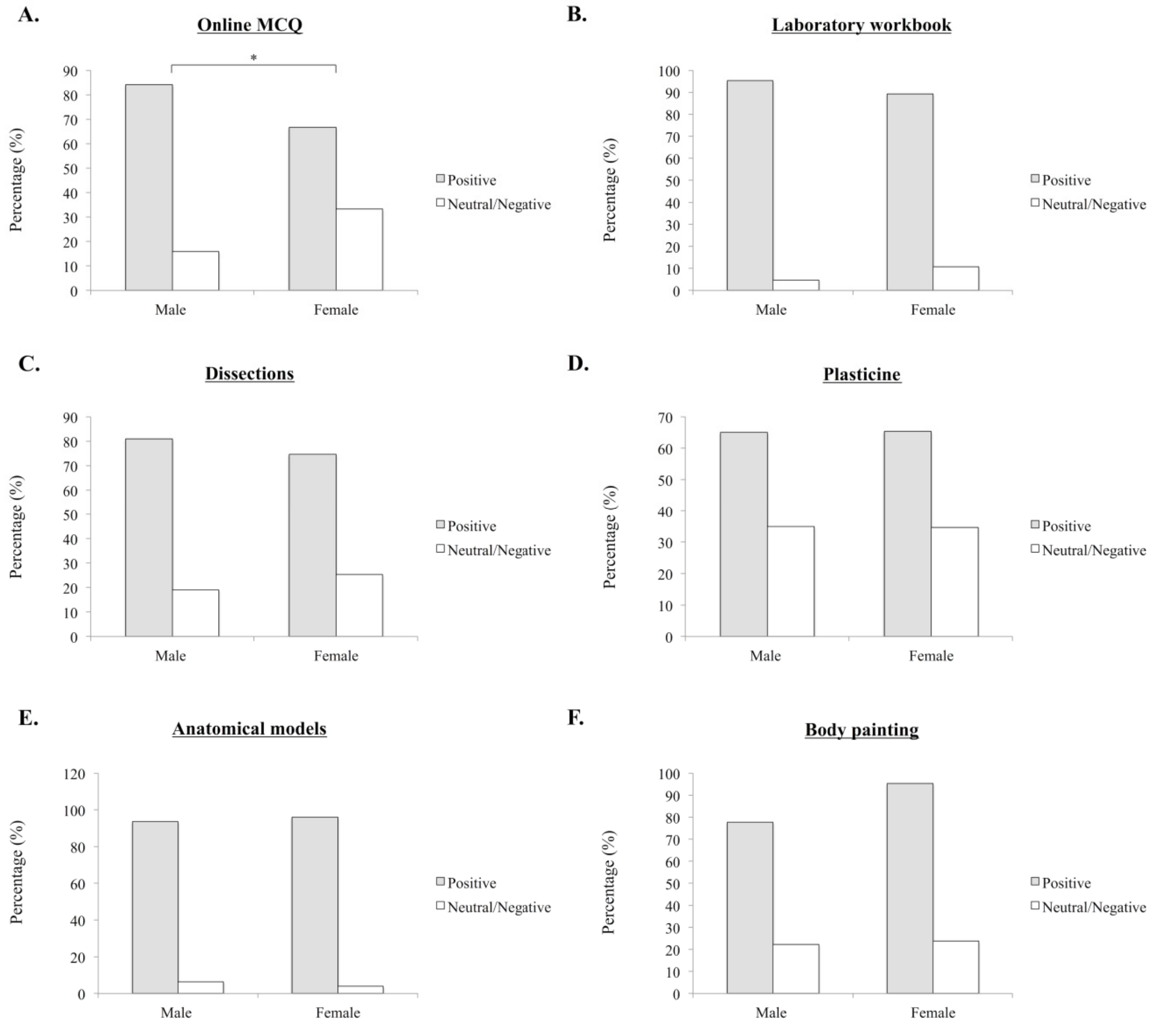
Waters, J. R., Van Meter, P., Perrotti, W., Drogo, S., & Cyr, R. J. (2005). Cat dissection vs. sculpting human structures in clay: an analysis of two approaches to undergraduate human anatomy laboratory education. *Adv Physiol Educ, 29*(1), 27-34. http://dx.doi.org/10.1152/advan.00033.2004

Wilke, R. R. (2003). The effect of active learning on student characteristics in a human physiology course for nonmajors. *Adv Physiol Educ, 27*(1-4), 207-223. http://dx.doi.org/10.1152/advan.00003.2002

Wright, S. J. (2012). Student perceptions of an upper-level, undergraduate human anatomy laboratory course without cadavers. *Anat Sci Educ, 5*(3), 146-157. http://dx.doi.org/10.1002/ase.1265



Supplementary figure 1. Student perceptions to teaching modalities, grouped by positive or neutral/negative responses. Responses are categorized by course and presented as percentages. Student responses to the effectiveness of ***A*** online multiple-choice quizzes, ***B*** laboratory workbook, ***C*** anatomical dissections, ***D*** using plasticine, ***E*** anatomical models, and ***F*** body painting (*$p < 0.05$).



Supplementary figure 2. Student perceptions to teaching modalities, grouped by positive or neutral/negative responses. Responses are categorized by gender and presented as percentages. Student responses to the effectiveness of A online multiple-choice quizzes, B laboratory workbook, C anatomical dissections, D using plasticine, E anatomical models, and F body painting (*$p < 0.05$).