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INNOVATION

Engaging Multidisciplinary First Year Students to Learn Anatomy Via Stimulating Teaching and Active, Experiential Learning Approaches

Claudia M. Diaz[1] · **Torres Woolley**[2]

Abstract Student engagement requires both a stimulating teaching style and provision of meaningfully learning activities involving student peer interactions. This study compares student engagement levels between two different styles and strategies for teaching first year anatomy: a stimulating (passionate) teaching style with active, self-directed experiential learning strategies versus a more traditional didactic teaching style and strategies. In 2008–2011, first-year JCU medicine and health science students undertaking anatomy were assessed using two cross-sectional comparative studies of all courses over consecutive years to investigate differences between the teaching approaches—a traditional didactic teaching style and strategies—and a stimulated, innovative teaching style with guided, self-directed strategies (n=510; response rate=79 %). A content analysis of an open-ended question, asking which aspect of the anatomy course had most benefit to learning, further illuminated findings. Students whom experienced a stimulating teaching style with active, self-directed experiential learning strategies rated engagement variables significantly higher ($p<0.05$) than their counterparts experiencing a more traditional didactic teaching style and strategies, including overall enjoyment of anatomy; overall quality of anatomy learning experiences; general level of interest in anatomy teaching activities; importance of anatomy learning activities to later years of their course and future professional career; and overall level of interaction with both peers and teachers. Those experiencing the stimulating teaching style with active, experiential learning strategies also tended to prefer less structured learning and more self-directed learning. Stimulating teaching and active, experiential learning approaches in anatomy appears to produce students who are achieving desired learning outcomes, and who are also confident, pro-active, motivated, and self-directed learners.

Keywords Anatomy · Engagement · Experiential · Self-directed · Didactic · Learning

Introduction

Student engagement leads to higher level thinking and enduring understanding [4, 28]. However, for effective student engagement to occur, it is recommended for teachers to use two major engagement strategies: (a) have an interested, passionate (stimulated) teaching style [19] and (b) engage students in meaningful learning activities via interaction with others and worthwhile tasks [16, 32, 33].

Meaningful learning activities are those which make learning a creative, purposeful activity; these should be self-directed and experiential (project-based), and aligned with students' occupational or future career interests [16, 32, 33]. Having a purposeful activity aligned with students' future career interest increases their motivation and satisfaction to be able to conduct their own projects is more interesting to students rather than answering sterile textbook problems.

Peer interactions also help to develop the planning, management, and social skills needed for collaborative learning. In the process of collaboration, students are forced to communicate with each other and so clarify and verbalize their problems, thereby facilitating solutions. Collaboration also increases the motivation of students to learn; a significant consideration in

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courses with high drop-out rates, particularly first year university students [10]. Hence, first year is the ideal time to maximize student engagement, and in no subject more so than anatomy. Anatomy is a subject that is difficult for first year students to learn; it involves many new concepts and complex terminologies which students traditionally find dull and labor intensive [3].

To learn anatomy, students often concentrate their efforts on "memorizing" lists of names—the time-consuming "surface" approach [35]. However, the changing face of higher education in Australia has resulted in most Universities now having less contact hours to teach anatomy [6]. Because of these traditional and current pressures, anatomy must be taught more effectively in less time and with often fewer resources.

The Discipline of Anatomy & Pathology at the School of Medicine and Dentistry (SMD), James Cook University (JCU), teaches anatomy to first year students across all health disciplines. First year anatomy teaching consists of lectures plus practical classes in the laboratory. However, because of large student numbers in first year, two classes are run: one for medical students and one for health science students from Occupational Therapy, Physiotherapy, and Sports & Exercise Science programs. Traditionally, the Tertiary Entrance Scores required for entry into the medical (Queensland OP Rank 1–5) and physiotherapy (Queensland OP Rank 1–5) programs are high, while those for the occupational therapy (Queensland OP Rank 14) and sports and exercise science (Queensland OP Rank 18) programs are significantly lower (note: Tertiary Entrance Scores are an Australian rank ordered, school leaving score, which in the state Queensland is called an Overall Position or 'OP' score ranging from 1 to 25, with 1 being higher academically than 2). During 2008–2012, the two classes had two different teachers, each with distinct teaching styles and learning strategies.

This study reports the findings of two separate comparisons, undertaken over successive teaching years, of first year student engagement in anatomy. In 2010, student engagement levels were compared between the two very different styles and strategies: a stimulated teaching style with guided, self-directed, pro-active, innovative experiential learning strategies (for the health science students) versus a more traditional didactic teaching style and strategies (for the medical students). In 2011, the medical students were taught anatomy using the same guided, self-directed, pro-active, innovative experiential learning strategies delivered to the health science students; engagement of the 2011 medical student cohort to the new teaching regime was compared to that of the 2010 cohort taught using the traditional didactic teaching style.

Methods

Study Design

The 2010–2011 study of first-year JCU students undertaking anatomy utilized two cross-sectional comparative studies over consecutive years and a content analysis of an open-ended question asking "which aspect of the Anatomy course was of particular benefit to your learning". The first cross-sectional study in 2010 compared the engagement of first-year JCU medical students with health science students, each experiencing two distinct teaching styles and learning strategies. The second cross-sectional study compared the engagement of medical students under guided, self-directed, pro-active, innovative experiential learning strategies delivered in 2011 to the engagement of medical students under the traditional didactic teaching style and strategies delivered in 2010. Ethical approval for the study was covered under the JCU Human Ethics Committee, number H3031, to obtain student feedback for course quality assurance purposes.

JCU Discipline of Anatomy and Physiology Course

The majority of first-year JCU medical and health sciences students are undergraduates with no previous knowledge of anatomy. The anatomy content for all first year students is very similar, covering musculoskeletal and visceral anatomy. All programs consist of 3 × 1 h of lectures in an auditorium and 2 h of practical classes in the anatomy laboratory each week. Both medical and health science students attend practical classes in the anatomy laboratory using the same resources of prosections, bones, and models. In addition, 2 h of open laboratory sessions were held each week for self-directed study.

Description of the Didactic Teaching Style

The traditional anatomy teaching delivered to medical students in 2010 consisted of didactic lectures and practical classes carried out in the anatomy laboratory using prosections, bones, and models and involving a workbook. Didactic teaching is the traditional pedagogy of a teacher-centered teaching strategy with improving knowledge being the overall goal. In medicine, the workbook is an extensive laboratory manual that leads the students step by step through the activities in the teaching laboratory. Using this approach, students do not need self-directed study skills, and the classes are not run as hands-on sessions. Rather students are "taught" by academics and tutors in a purely didactic approach, with their questions answered directly by staff.

Description of the Guided, Self-Directed Experiential Teaching Style

The guided, self-directed experiential anatomy teaching is designed to engage students as much as possible in the learning activities and to teach them cognitive learning skills meant to serve them throughout their student and future professional lives (rather than just teach anatomical facts). This teaching approach was constructed around Biggs' [3] recommendation

to use appropriate activities to achieve learning outcomes centered on "deep" rather than "surface" learning. Biggs' approach is similar to what theorists have labeled "Engagement Theory" [17, 20, 25] which proposes students need to be engaged in meaningful learning activities involving peer interaction.

In this reconstructed approach to teaching anatomy, the laboratory becomes the key focus for action, where team activities encourage "hands-on", multi-sensory learning by all students. Key innovative teaching approaches and strategies promoted by the health sciences anatomy lecturer between 2008 and 2012 were based on a simple, hands-on approach and include:

1. Being a "passionate", enthusiastic, and supportive teacher—striving to provide a stimulating and nurturing environment for students that make learning engaging, enjoyable, supportive, and inclusive for all students.
2. The introduction of innovative teaching and learning techniques based on simple, "hands-on" approaches to compliment the use of prosected human tissues in the laboratory. Four innovative strategies were delivered:

(a) White-boarding and drawing (Fig. 1a, b)—appealing to visual learners. Students learn to use a whiteboard as a learning tool to summarise and synthesize concepts and facts, leading to powerful mind-mapping. Similarly, visual learners and artists benefit from drawing anatomical structures on paper (or similar), and this is encouraged.
(b) Use of Play-Dough (Fig. 1c)—appealing to tactile learners. Students build anatomical structures using play-dough. This approach is enjoyable and reinforces learning, while assisting students to develop a real 3-D image of structures and their relationships. Visual and tactile learners also benefit from handling bones, skeletons, and plastic models.
(c) Movement/singing/dancing (Fig. 1d)—appealing to some students who learn by "doing". In these practical sessions, performing body movements with weights, a hula hoop, etc., are encouraged, as well as singing and dancing (where appropriate). For example, some students performed a song and dance that explained the anatomy of the abdominal walls, including an anatomical rap and dance to show the direction of muscle fibers (i.e., external oblique—hands in pockets). Instruction that stimulates more than auditory learning—by including kinesthetic learning using body movement—has been shown to enhance learning in a heterogeneous student population [2].
(d) Surface anatomy/body painting (Fig. 1e, f)—students consolidate what they learn with prosections by looking at the relevant surface anatomy painted on living bodies. Body painting has become a popular surface anatomy technique, as it is a very engaging way for students to learn anatomy by looking, palpating, drawing, and then painting. This application to live bodies will assist with development of professional competencies as reference to the key surface landmarks and a thorough understanding of their relationships to underlying structures is a core skill they will need in their professional lives when working with patients or clients. A full body-painted model is brought into the first health sciences musculoskeletal anatomy practical class to surprise, inspire, and motivate students as they witness how engaging and stunning anatomical body painting can be. Student participation in body painting increases in subsequent classes, as they become more confident and motivated to carry out this learning approach as either models or painters. Emphasis is placed on the process of body painting: the identification, palpation, drawing in of landmarks, drawing in of origins and insertions, and finally the painting. In this way, all students can participate and gain the same benefit without having to be great artists (Facebook page: "Innovative Anatomy").

Fig. 1 Innovative teaching approaches in anatomy. **a** "White-boarding"; **b** student drawing; **c** sectioned brain made from play dough; **d** singing and dancing anatomy; **e** body painting by students; **f** the "Anatomical Man" visits the class

3. Making the use of human cadaveric tissues central to students' learning experience of anatomy. Prosections are, and will always be, the primary focus of JCU anatomy practical classes. All laboratory class outlines are principally based on the use of the prosections; however, this is integrated with the innovative approaches. For example, a whiteboard is placed next to the dissection table so that students may whiteboard while they are studying the prosections. Play-Dough, models, bones, and the surface anatomy/body painting area are also nearby so that students may carry out these activities close to the prosections. This allows an integrated approach to all activities presented to students at each class. Medical students in 2010 had access to the prosections, but did not use any of the other approaches listed above. The health science students used all approaches listed.
4. Building up and training an anatomy laboratory tutor workforce to assist the lecturer fostered small-group teamwork in the laboratory environment and encouraged students to develop self-directed learning skills. Ten tutors were trained to encourage maximum student engagement using the prosections and the innovative teaching approaches. The tutors used for the health science practical classes were trained extensively at the start of the year. Training the health science tutors involved discussions regarding non-didactic, self-directed, stimulating teaching philosophy, a detailed workshop regarding the teaching techniques used and role-playing of scenarios that may occur in the laboratory. Medicine tutors did not receive any training.

Participants

Participants were all first year James Cook University health science students from either medicine (n=334), occupational therapy (OT) (n=56), physiotherapy (n=65), or sports & exercise science (n=55). The courses studied were BM1031/1041/1061 and MD1010 in semester 1 and BM1032/1042/106 and MD1020 in semester 2. A total of 510 students participated in the study; 334 out of a possible 384 (87 %) from medicine students, 56/74 (76 %) from OT, 65/76 (86 %) from physiotherapy, and 55/79 (70 %) from sports and exercise science (overall response rate=83 %). The mean age of medical students was 19.0 years (SD±2.6) in 2010 and 18.8 (SD±2.1) in 2011, while the mean age for health science students was 20.0 years (SD±2.6) in 2011. Seventy-two percent of the health science students and 57 % of the medical students were female in 2010; in 2011, 60 % of the medical students were female. Quantitative data were obtained from students towards the end of both 2010 and 2011 through a self-administered questionnaire given during lectures when participation was known to be high. The researchers explained the study to all students as the surveys were handed out. A number of health science students also participated in a focus group.

Quantitative Surveys

The questionnaire collected data on demographics (age, gender, and course) and on variables known to predict student engagement; such as: overall enjoyment of the subject, quality of the learning experiences from teaching activities; general level of interest in teaching activities; relevance of the learning activities to later years of course and future professional career; persistence when undertaking learning activities despite difficulties encountered; general level of accomplishment when completing learning activities; overall level of interaction with peers; and overall level of interaction with teachers/tutors [17, 20, 25]. Students rated each variable across a Likert scale of 1 to 10, with 1 being the lowest and 10 being the highest (Table 1).

Students were also asked to rate how strongly they preferred four particular teaching styles:

1. hands-on (experiential) learning [22] versus traditional didactic learning;
2. individual learning versus small group learning;
3. self-directed learning versus teacher-directed learning; and
4. structured learning versus unstructured learning.

For each of the four teaching styles, students gave a rating from 1 to 7 to show strength of one style preferred over another (Table 2). For example, to show strength of preference for either hands-on (experiential) learning or traditional didactic learning, students could score 1 (100 % preference for hands-on experiential learning); 2 or 3 (more of a preference for experiential learning over didactic learning); 4 (equal preference for either experiential learning or didactic learning); 5 or 6 (more of a preference for didactic learning over experiential learning); or 7 (100 % preference for didactic learning).

Content Analysis

Content analysis was used to categorize each medicine or health science student open-ended response into the major themes around which aspect of the anatomy course was of particular benefit to their learning. Analysis followed a Grounded Theory approach [11, 30] by inductively extracting themes from participant responses. Analysis involved reading through each student comment in the open-ended question repeatedly, using

Table 1 Comparison of self-reported engagement scores between students enrolled in the Health Science Anatomy subject (2010) and students enrolled in the Medicine Anatomy subject (2010 and 2011), as scored on 1 to 10 scale

Engagement variable	2010 Health Science students (n=176)	p value[b]	p value adjusted[c]	2010 Medicine students (n=155)	2011 Medicine students (n=179)	p value[b]
Female gender	57 %	0.008	0.008	72 %	60 %	0.677
Your overall enjoyment of the anatomy subject (mean±SD[a])	7·9 (1.4)	<0.001	<0.001	7·0 (1.4)	7.6 (1.8)	0.001
The overall quality of learning experiences from the activities in the anatomy subject (mean±SD[a])	8·0 (1.3)	<0.001	<0.001	7·1 (1.4)	7.1 (2.0)	0.944
Your general level of interest in anatomy teaching activities (mean±SD[a])	7·8 (1.4)	0.003	0.004	7·3 (1.5)	7.3 (2.0)	0.993
The overall level of challenge when undertaking anatomy teaching activities (mean±SD[a])	7·7 (1.6)	0.596	0.538	7·8 (1.4)	7.7 (1.8)	0.649
The relevance of anatomy learning activities to the later years of your course and to your professional career (mean±SD[a])	8·6 (1.6)	<0.001	<0.001	7·7 (1.4)	8.6 (2.1)	<0.001
Your general level of accomplishment when completing learning activities (mean±SD[a])	7·5 (1.6)	0.391	0.311	7·6 (1.2)	7.3 (1.7)	0.062
Your general attention level during class (mean±SD[a])	7·3 (1.8)	0.672	0.940	7·2 (1.6)	8.0 (1.7)	<0.001
Your overall level of interaction with peers, e.g., discussion of ideas, etc. (mean±SD[a])	7.8 (1.9)	0.018	0.031	7·3 (1.7)	7.7 (1.8)	0.025
Your overall level of interaction with teachers, e.g., feedback, etc. (mean±SD[a])	7·9 (1.4)	<0.001	<0.001	5·8 (1.8)	5.8 (2.5)	0.804

[a] *SD* standard deviation

[b] Independent-samples *t* test or chi-squared test (two-tailed), as appropriate

[c] Independent-samples *t* test or chi-squared test (two-tailed), as appropriate, with *p* values adjusted for gender

immersion to develop a high level of familiarity with the comments, and then manually coding each comment into separate categories (Table 3). Quotes were included directly into the results if they illuminated categories.

Quantitative Data Analysis

Quantitative data were coded numerically and entered into SPSS release 19 for Windows. Tables 1 and 2 list all variables

Table 2 Comparison of self-reported preference scores for teaching strategies between students enrolled in the Health Science Anatomy subject (2010) and students enrolled in the Medicine Anatomy subject (2010 and 2011), as scored on 1–7 scale

Student preferences for specific teaching strategies	2010 Medicine students n=155 mean (SD[a])	2010 Health Science students n=176 mean (SD[a])	p value[b]	p value adjusted[c]	2011 Medicine students n=179 mean (SD[a])	p value[b]
Preference for hands on, experiential learning (less than score of 4) versus traditional didactic learning (more than score of 4)	3·2 (1.4)	3·0 (1.6)	0.161	0.121	4.3 (1.6)	<0.001
Preference for individual-based learning (less than score of 4) versus small group-based learning (more than score of 4)	3·8 (1.4)	4·7 (1.6)	<0.001	<0.001	3.9 (1.4)	0.930
Preference for self-directed learning (less than score of 4) versus teacher-directed learning (more than score of 4)	4·7 (1.4)	4·3 (1.5)	0.008	0.004	4.3 (1.5)	0.014
Preference for structured learning (less than score of 4) versus unstructured learning (more than score of 4)	2·5 (1.2)	3·1 (1.5)	<0.001	<0.001	2.3 (1.2)	0.048

[a] *SD* standard deviation

[b] Independent-samples *t* test or chi-squared test (two-tailed), as appropriate

[c] Independent-samples *t* test or chi-squared test (two-tailed), as appropriate, with *p* values adjusted for gender

Table 3 Aspect of the anatomy course that was of particular benefit to student learning, for 162 Health Science students in 2010, and 155 Medicine students in 2011

	2010 Health Science students n (%)	2011 Medicine students n (%)
Practical activities; including white-boarding, cadavers, body-painting, and "self-teach" sessions	110 (68 %)	97 (63 %)
Lecturer's dynamic style and recording the lecture using "Podcast"	14 (9 %)	23 (15 %)
Tutor explanations in practical classes	13 (8 %)	9 (6 %)
Activities which are specifically designed to aid recall/long-term memory	12 (7 %)	8 (5 %)
Online quizzes and in-class questions	6 (4 %)	8 (5 %)
Prosections	1 (<1 %)	3 (2 %)

that underwent statistical analysis. Bivariate associations between the engagement variables and students' discipline (medicine or health sciences) were assessed by independent-samples *t* tests or X (chi)-square tests, as appropriate. Numerical variables in the tables are described as mean values and standard deviations. Throughout the study, a statistical test was considered significant with a p value<0.05.

Content Analysis of Medicine and Health Science Student Responses for the Best Aspect of the "Stimulating Teaching and Active, Experiential Learning Approach" To Teaching Anatomy

Both medicine and health science students whom experienced the stimulating teaching and active, experiential learning approach to the teaching of anatomy reported that the practical aspects of the subject—use of cadavers, white-boarding, body-painting, and the provision of extra-curricular "self-teach" labs—were easily the most appreciated aspects (63 and 68 %, respectively) (Table 3). Medical students, however, appeared to significantly prefer the use of Podcasts compared with Health science students. The use of many active learning strategies—cadavers and body-painting in particular—was appreciated; as a 2010 health science student (first comment) and three 2011 medicine students (second to fourth comments) noted:

> The new and innovative ways the lecturer developed to help students learn Anatomy in a more practical way was fantastic and I feel I benefited from these activities, in particular body-painting.
>
> The best aspect of this subject is without doubt the hands-on practical classes with the cadavers. It takes the theory learned and puts it into reality.
>
> The lecturer's enthusiasm, the tutor's knowledge and help, and the variety of activities including the body-painting—learning surface anatomy is crucial, so this was a great opportunity.
>
> Body-painting, white-boarding and with the cadavers was a good way to consolidate information and help with remembering.

The lecturer's dynamic style was also highly appreciated by both medicine and health science students in 2011 (15 and 9 %, respectively).

> The lecturer was lively and showed passion for the subject which affected us in a positive manner.
>
> Our lecturer was very engaging and funny. I liked her sense of humour. She tries to make the subject easy to memorise with her own notes and even applies it to surface anatomy.
>
> The teacher introduced new learning methods and that could be applied to her subject and taught a "how to" method of learning extensive material without rote memorization.

Bivariate Analysis Comparing 2010 Health Sciences to 2010 Medical Students

Health science students rated a number of variables significantly higher than their medical counterparts: their overall enjoyment of anatomy ($p<0.001$); overall quality of learning experiences in anatomy ($p<0.001$); relevance of anatomy learning activities to the later years of their course and to their professional career ($p<0.001$); general level of interest in anatomy teaching activities ($p=0.002$); their overall level of interaction with peers ($p=0.016$); and their overall level of interaction with teachers ($p<0.001$). Medical students, however, had a higher level of persistence when undertaking learning activities despite difficulties, than their health science peers ($p=0.022$).

In 2010, the health science students showed significantly higher preferences, compared to their medical peers, for small group learning over individual learning strategies ($p<0.001$);

for less structured learning ($p<0.001$); and for more self-directed learning ($p=0.008$). The majority (83 %) of the health science student respondents also reported that the practical, innovative approaches assisted their deeper understanding of anatomy, 81 % that these approaches assisted their long-term memory of anatomy, and 82 % that the learning and memory skills they acquired in anatomy had been useful in other subjects.

Analysis of first-year health science student grades (both theory and practical examinations held in June and November) from 2007 to 2010 indicate a >30 % drop in the fail rate (Fig. 2) and an increase in the pass rate with complementary increases in the rates of credits, distinctions and high distinctions. Examinations used for these students were the same format as those that had been used before 2008; tests were not altered with the introduction of new innovative teaching approaches. In contrast, the grades for medical students over the same years, where they were not exposed to the innovative approaches, remained relatively unchanged.

Bivariate Analysis Comparing 2010 Medical Students to 2011 Medical Students

The 2011 medical student cohort (now with the passionate teaching style and innovative learning strategies) rated a number of variables significantly higher than the 2010 cohort (traditional teaching and learning strategies): their overall enjoyment of anatomy ($p=0.001$); their general level of attention during class ($p<0.001$); relevance of anatomy learning activities to the later years of their course and to their professional career ($p<0.001$); and their overall level of interaction with peers ($p=0.016$).

Although both the 2010 ($p<0.001$) and 2011 medical student cohorts showed a preference for teacher-directed learning activities and structured learning overall, a shift was observed as the 2011 cohort tended to want more self-directed learning ($p=0.014$) and unstructured learning ($p=0.048$) than their 2010 counterparts by the end of the year.

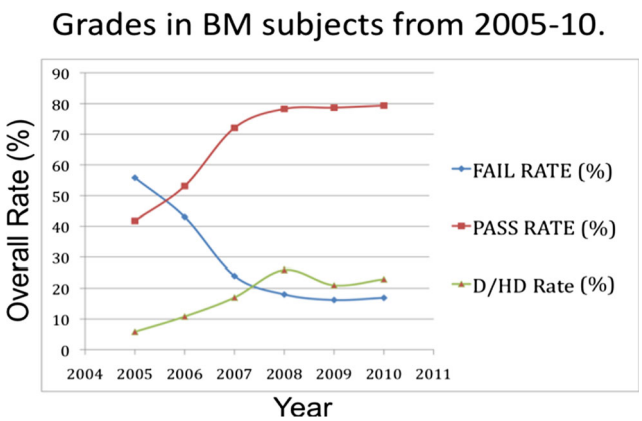

Fig. 2 Comparison of pass, fail, distinction, and high distinction grades from 2005 to 2010. BM refers to the subject codes for the anatomy subjects. Results were obtained from both theory and practical examinations in June and November of the first year of anatomy for health science students

The cohorts who received the passionate teaching and experiential learning strategies—the health science students and the 2011 medical students—derived a significantly higher level of enjoyment from their anatomy course and considered the learning activities to be significantly more relevant to their future work. This study suggests that these teaching approaches in anatomy, at least in the health sciences, are also producing students more likely to pass and to achieve good final grades.

Both 2010 health science and 2010 medical student cohorts were offered the same classes, studied the same content, and had access to the same wet anatomy laboratory with cadaveric tissues. These findings appear to be at least partly the result of the enthusiasm of teaching staff and the lecturer having a passionate (stimulating) teaching style that engages first-year students in learning, in combination with small-group, experiential learning activities. Some student feedback regarding the teaching include: “her enthusiasm has been contagious”, “anatomy was a great and fun subject”, “she made anatomy fun!”, “the lecturer is interesting and makes a very hard subject enjoyable and therefore easier”, “Claudia somehow makes anatomy interesting!”, “Claudia is enthusiastic and this rubs off on us”, “entertaining lectures”, “makes it enjoyable, I like coming to lectures because of her”. Not only did the health science students better engage in lectures and practicals but also appeared to achieve better results as the pass rate increased and the fail rate decreased dramatically during 2007–2010 (Fig. 2). These results were not observed for the medical students. These results are most likely due to undertaking meaningful and worthwhile (personally relevant) learning activities with their peers. Some health science students have been so engaged by their learning experience that they later worked as casual staff in anatomy as tutors and dissectors.

These results are consistent with the previous reports regarding engagement theory that interested and passionate teachers [19] and providing students with meaningful and enjoyable learning activities [16, 25] are critical for student engagement. Furthermore, this study supports the model of experiential learning [22], a process whereby meaning is derived from direct experience [14]. The health science students have “direct encounters with the phenomena being studied”, and they “acquire and apply knowledge, skills and feelings in an immediate and relevant setting” [22].

With experiential learning activities [22], students participate in the four stages of experiential learning: they carry out particular actions in the anatomy laboratory as part of these teaching approaches; they learn and reflect about these effects in particular instances (that is, they learn by “doing”); they come to understand the general principles (they start to

experience deeper learning); and they learn to apply through action in new circumstances (they are able to apply these techniques to new areas encountered).

Health science students also demonstrated a stronger preference for small group activities, less structured learning, and more self-directed learning than the 2010 medical students.

Interestingly, in 2011 when the medical students participated in more experiential learning activities, their preference for both didactic learning and well-structured learning activities significantly increased, though they still had a greater preference for teacher-directed over self-directed learning activities. In 2010, it was noticed by the lecturer that medical students tended to spend most of their practical class working through the workbook and writing down answers for the questions, even though they were able to use prosections and other practical media during their practical classes. This is a clear indication that experiential learning approaches work to promote self-directed learning in both health science and medical cohorts by providing students with the necessary skills to effectively use the extra teaching materials opportunities provided by the medical school to learn anatomy out-of-hours. However, it also appears to show that medical students, more so than health science students, like to have learning activities that are well-structured and involve "text-book" style information. Entry processes for medical students were similar in 2010 and 2011, thus eliminating any possible differences due to intake.

In addition, as examinations used did not change with the introduction of these new teaching approaches, the improvement in health science student results from 2008 to 2010 would, therefore, appear to be a direct effect of the teaching approaches used. Students did not have access to previous examinations, and questions were changed slightly between years. The improved exam results in the health science students also imply that the passionate teaching style, together with the experiential learning activities—techniques such as white-boarding, play-dough, movement, and surface anatomy (principally body painting)—have led to an improvement in anatomy knowledge and retention—as evidenced by improved examination marks. The passionate teaching style engages student more, and the experiential learning activities may provide visual and tactile cues which could help with long term retention of information and deep learning. Similarly, other studies have found that supported self-directed learning improved students' engagement, leading to deeper learning and better understanding and knowledge of anatomy [7, 8, 21, 26 29, 31, 37].

Although techniques such as functional anatomy and body painting have been used in other anatomy courses previously [1, 5, 27, 34], they do not form a standard part of anatomy curricula in Australia. Many medical and health science programs have focussed on developing modern anatomy curricula based on technological advances such as DVDs and computer (iPad and iPhone) programs; however, few have focussed on more traditional hands-on approaches such as using cadaveric materials as used by the JCU medical school. When used in conjunction with wet anatomy classes, human cadaveric tissues, and a team of well-trained tutors providing instruction, these innovative approaches of white-boarding, play-dough, movement, and body-painting appear to lead to deeper learning. Minhas and colleagues [27] also found a mix of active and passive anatomy learning approaches was preferred by students—and had greater benefit to their performance—than either method alone [27].

The active learning approaches used by the JCU health sciences anatomy course also covers each major sensory modality for learning [9]: kinesthetic (lecturer does body movements to represent an anatomical feature, play-dough, and students touching the painted muscles on the body model); visual (students observing the painted muscles on model, and play-dough); aural (lecturer and tutor information); and reading/writing (white-boarding).

The inclusion of all students and their assisted interaction with peers is also important for pastoral support. At JCU, health students are mostly young and away from home for the first time, and in the case of medicine, many students come from diverse cultural backgrounds. Other studies have shown that an engaging and supportive teacher, together with small-group learning activities, assists first-year students to "fit in" to academic life through positive peer interactions and interest in their subjects [20].

Limitations

A limitation of the study is that other factors might play a role in why the learning styles and preferences in the two student groups are different and not just due to the anatomy teaching approach. It is well known that listeners are more motivated by charismatic presenters; thus, there is question of whether the difference in teaching style and activities actually created differences in learning, or rather it was due to differences in student motivation. Gender differences between health science and medicine cohorts may also influence preference for small group learning and may have effects on other variables; though this was controlled by post hoc statistical adjustment. However, this study does involves two cross-sectional comparisons—between successive cohorts of medicine students and between medicine and health science students in the same year—therefore, this increases the likelihood that differences are due to the anatomy teaching approach used.

Concluding Remarks

The findings of the present study support the belief that the role of an anatomy teacher is not to teach students anatomical

facts, but rather to teach them the learning skills that will serve them throughout their student and professional lives. The 2011 JCU anatomy course aimed to take students from the traditional view of anatomy as a subject that requires surface learning (rote learning and memorisation) to one that can lead to deep learning through understanding the information and fixing it into long-term memory, and the ability to place this information into a big, broad picture relevant to their future professions. While these teaching approaches are aimed at supporting and assisting first year health science anatomy students to develop their knowledge and learning skills in anatomy, they also appear to produce more motivated and self-directed learners. Our findings are consistent with previously reported self-directed learning approaches [7, 8, 12, 13, 15, 18, 21, 23, 24, 26, 27, 29, 31, 36–38]; however, the present study offers a greater variety of innovative, active teaching approaches that cover all four of the major sensory modalities for learning than those previously reported.

Stimulating teaching and active, experiential learning approaches in anatomy appears to be producing students who are not only achieving the desired learning outcomes, but who are also confident, pro-active, motivated, and self-directed learners. The strategies of making anatomy engaging, stimulating, and fun, and helping students to be pro-active learners, could lay the foundations for a new approach to learning anatomy, where students become responsible and committed to their own learning goals, and where students develop life-long learning skills. Future studies will examine more closely the perceptions of students to these teaching approaches. Such outcomes encourage us to consider that productive pathways can be developed to revolutionize the teaching of anatomy in ways that meet students' needs and the challenges of the contemporary context.

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