Anatomy learning and retention among students in a graduate-entry medical course

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Abstract

Anatomy forms the basis of clinical examination and is integral to today's medical curriculum. Yet, increasingly evident in the literature is feedback from clinicians and surgeons about the perceived lack of anatomical knowledge among recent medical graduates. To understand the issues surrounding student learning and retention of anatomy, a mixed-methods design was utilized to explore medical students' anatomical knowledge throughout their Bachelor of Medicine and Bachelor of Surgery (MBBS) degree. Students enrolled in the four-year graduate-entry MBBS course at Monash University participated in the study. Participants from the preclinical (Year A) and clinical years (Years B, C and D) sat an online assessment consisting of 60 clinically relevant anatomy multiple-choice and extended-matched questions whose objectives had been previously covered in the preclinical teaching. Altogether, 136 students participated in the study. The results revealed that knowledge of anatomy declined over time and this was significant in the final two clinical years. The drop in anatomical knowledge was not uniform. The regions of anatomy better retained were associated with frequent exposure and reinforcement in the clinical years. Participants cited an intense and time-constrained curriculum, poor integration in the clinical years and rare opportunities for revising and testing anatomy as reasons for the decline of knowledge. The results of this study highlight the need for conceptual coherence at the time of teaching; the importance of vertical integration in providing students with frequent learning opportunities in the clinical years; and, the value of formatively testing students' knowledge of anatomy throughout the clinical years.

Declaration of Originality

I, Michelle Machado, declare that the PhD thesis entitled “Anatomy learning and retention in medical students in a graduate-entry MBBS course” is no more than 100,000 words in length including quotes and exclusive of tables, figures, appendices, bibliography, references and footnotes. The thesis contains no material that has been submitted previously, in whole or in part, for the aware of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signed: [redacted] Date: 7 July 2017

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List of Abbreviations

3D	Three-dimensional
AAMC	Association of American Medical Colleges
ABMS	American Board of Medical Specialties
ACF	Australian Curriculum Framework
ACGME	Accreditation Council for Graduate Medical Education
AMC	Australian Medical Council
AMSA	Australian Medical Students Association
ANOVA	Analysis of variance
AQF	Australian Qualifications Framework
AQFC	Australian Qualification Framework Council
ARS	Audience response system
ASIS	Anterior superior iliac spine
AUQF	Australian Quality Forum
BL	Borderline
CBME	Competency-based medical education
CE	Common Era
CT	Computed tomography
EMQ	Extended-match questions
GI	Gastrointestinal
GMC	General Medical Council
HA	Hand, the alternative
HP	High performers
ICU	Intensive Care Unit
LP	Low performers

MANOVA	Multivariate-analysis of variance
MBBS	Bachelor of Medicine and Bachelor of Surgery
MCQ	Multiple-choice questions
MRH	Monash Rural Health
MRI	Magnetic resonance imaging
NBME	National Board of Medical Examiners
NHMRC	National Health and Medical Research Council
OBE	Outcome-based education
OSCE	Objective Structured Clinical Examination
PBL	Problem-based learning
RCAS	Royal Australasian College of Surgeons
SAQ	Short-answer questions
SD	Standard deviation
SDL	Self-directed learning
SE	Standard errors
SEM	Standard error of measurement
TBL	Team-based learning
UK	United Kingdom
US	United States
USMLE	United States Medical Licensing Examination
VIA	Vertically integrated assessment

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Chapter 1: Introduction

1.1 Foundation of Research

One of the major aims of an undergraduate medical curriculum is to produce excellent doctors who are sufficiently equipped with the basic knowledge and skills required to become competent and safe practitioners (Pabst, 2009). To achieve this solid foundation of medical knowledge and the necessary procedural skills, the discipline of anatomy, which offers a unique perspective on the human body, is regarded by many as one of the most important basic sciences in the curriculum because it “provides the structure on which other disciplines sit” (Boon, Meiring, & Richards, 2002; Herle & Saxena, 2011; Marks, Jr, 1996; McKeown et al., 2003, p. 957).

Anatomy is defined as the structure of the body. Gross anatomy, or topographical anatomy, is the study of the normal macroscopic structure of the human form and its relationship with other body parts, all of which can be seen with the unaided eye (Louw, Eizenberg, & Carmichael, 2009). Anatomy is supplemented by disciplines such as histology (microscopic anatomy), embryology (developmental anatomy) and evolution (comparative anatomy), and it is complemented by physiology (functional anatomy), pathology (abnormal anatomy) and radiography (radiological or sectional anatomy). Further, anatomy plays a key role in clinical practice (Boon et al., 2002) through its use in physical examination, history-taking and clinical reasoning. It also underpins clinical disciplines such as surgery and radiology (Dangerfield, Bradley, & Gibbs, 2000; Louw et al., 2009).

For centuries, anatomy and other related disciplines have been regarded as the mainstay of medical education (Milgate, 2006). They have played a central role in the training of medical students, doctors and other healthcare specialists such as nurses, physiotherapists and radiographers (Abu-Hijleh, 2010; Raftery, 2007; Sugand, Abrahams, & Khurana, 2010). In essence, anatomy forms the language of medicine (Gogalniceanu et al., 2010). For each generation of doctors trained, knowledge of anatomy forms the core foundation for clinical examination. When doctors examine patients, they inspect, palpate (examine by touch) and observe for deviations from the norm. These behaviours serve as the fundamental framework for identifying an underlying condition. Core knowledge of what constitutes normal form and function enables doctors to identify altered states (Banda, 2010; Singh et al., 2015). For doctors to be proficient, they must have a sound knowledge of anatomy.

The rapid expansion of biotechnology in the twentieth century resulted in a massive influx of biological science courses such as microbiology, cell biology and immunology into medical education. Combined with the introduction of social science, law and ethics courses, anatomy became marginalised and began losing its prominence within medical education (Kerby, Shukur, & Shalhoub, 2011). A condensed and packed medical curriculum led to a decline in the amount of time that could be allocated to teaching anatomy (Ramsey-Stewart, Burgess, & Hill, 2010). This reduction led to an outcry in the medical community. Milgate (2006) states that “there is a rising chorus of concern across the medical profession that not so young doctors are being expected to treat patients to the same standards as their predecessors, without exposure to the necessary amount of training in anatomy” (p. 6).

To understand the rationale behind such circumstances, it is imperative to investigate how anatomy was and is delivered to medical students. The literature suggests that the teaching of anatomy in undergraduate and graduate-entry medical degrees has undergone considerable changes over the past century. A comparison of historical data reveals vast reductions globally in anatomy teaching hours over the past century. In the United States (US), medical schools allocated an average of 147 hours to gross anatomy teaching in 2014 (Drake, McBride, & Pawlina, 2014) compared with 167 hours in 2002 (Drake, Lowrie, & Prewitt, 2002) and 549 hours in 1902. Similar observations were made for the United Kingdom (UK) and Ireland (Leung, Lu, Huang, & Hsieh, 2006). Critics in Australian and New Zealand medical schools have opposed the gradual devaluation of gross anatomy. Studies of 19 Australian and two New Zealand medical schools revealed significant differences in teaching hours between the institutions, ranging from approximately 56 to 500 hours, with an average of 171 hours (Craig, Tait, Boers, & McAndrew, 2010). Given the large reductions in teaching hours, it is not surprising that medical students today are viewed by medical professionals as being far less equipped in terms of anatomical knowledge when compared with their predecessors.

In today's medical curriculum, all of the basic sciences are covered primarily in the pre-clinical curriculum, where formal anatomy teaching is confined to the first one or two years of a four- or five-year medical degree. It is assumed that anatomy learned during this stage will be retained and retrieved from memory during clinical training in the later years (Collins, 2009; Sugand et al., 2010). In Australasian medical schools, anatomy is taught in a series of lectures and practical workshops that largely incorporate tutorials, prosections (neat dissections of cadavers undertaken by an experienced professional, with the anatomical specimens used for student learning), dissections (student-led but supervised explorations of the human body), surface anatomy and medical imaging workshops. However, not all methods are used by universities in their teaching practices. Further, different medical schools operate under different curricula. Some follow an old-school traditional curriculum, which incorporates didactic lectures and dissections, while others use modern approaches such as problem-based learning (PBL), which involves small-group teaching sessions that are student-led and facilitator-guided, and some schools use prosections as a replacement for dissections. Assessments of anatomical knowledge also vary across institutions and can involve a range of text- and image-based problems in the form of multiple-choice questions (MCQs) or extended-match questions (EMQs) with or without practical assessments using cadaveric specimens.

Given that anatomy is central to the practice of medicine (Herle & Saxena, 2011), medical institutions and the wider community expect that medical students will have attained sufficient knowledge of the discipline during their medical degree to allow them to practice medicine safely. However, this assumption is questioned when medical students are placed in the clinical setting. There is increasing feedback and criticism from clinical practitioners, surgeons and tutors about the perceived lack of anatomical knowledge among recent medical graduates, as well as a debate about whether a junior doctor's knowledge of anatomy is safe enough for clinical practice (Cottam,1999; Craig et al., 2010; Fitzgerald, White, Tang, James, & Maxwell-Armstrong, 2008; Leung et al., 2006; Patel & Moxham, 2006; Standring, 2009; Waterston & Stewart, 2005). It can be argued that claims of students' inadequate knowledge of anatomy are unsubstantiated because they are largely based on anecdotal evidence within the field. According to some authors, the effects of students' lack of anatomical knowledge on clinical performance are unclear (Collins, 2008; Mitchell & Batty, 2009). Further, students are upset about the current state of anatomy education in medical schools, lamenting its perceived diminished capacity to prepare them for learning in the clinical workplace and for practice and the lifelong learning that underpins this (Dawson, Bruce, Heys, & Stewart, 2009; Farey, Sandeford, & Evans-McKendry, 2014; Gogalniceanu et al., 2010; Linacre, 2005).

One could maintain that the unfortunate experiences of some clinicians with students whose anatomy knowledge does not reflect that of the whole medical population is being generalised to medical cohorts and subsequently medical courses everywhere (Linacre, 2005). There is also some evidence to suggest that a clinician or surgeon's negative attitude towards a student's lack of knowledge can dissuade that student from the particular speciality and alter the student's own perceptions of their anatomy knowledge, thereby negatively affecting their confidence in the clinical setting (Herle & Saxena, 2011; Mitchell & Batty, 2009), resulting in a vicious cycle. Therefore, although medical students and junior doctors have expressed concerns about their lack of knowledge in the clinical environment (Ahmed et al., 2010; Mitchell & Batty, 2009; Smith & Mathias, 2011), these perceptions could be affected by their interactions with clinicians who think students lack sufficient knowledge.

The few long-term retention studies conducted from the late 1960s to the early 1980s show that there was a modest loss of knowledge in gross anatomy (Blunt & Blizard, 1975; DuBois, Nemir, Schumacher, & Hubbard, 1969; Kennedy, Kelley, & Saffran, 1981), although the findings of these studies cannot be applied or generalised to current times given that curriculum models today differ from those of three to four decades ago. However, retention studies to date have also shown that knowledge that is initially learned decays if it is not revisited at a later stage, highlighting the need for vertical integration (Brunk, Schauber, & Georg, 2017; Jurjus et al., 2014; Custers & Ten Cate, 2011; Feigin, Magid, Smirniotopoulos, & Carbognin, 2007; Feigin, Smirniotopoulos, & Neher, 2002; Magid, Hudson, & Feigin, 2009; Rizzolo et al., 2010). Therefore, the reports of students' lack of knowledge in the clinical setting could be linked to learning theories that emphasise the potential positive effects of a spiral curriculum (Bergman, Verheijen, Scherpbier, Van der Vleuten, & De Bruin, 2014;

Bruner 1977; Harden & Stamper, 1999) because knowledge must be revisited, revised and examined at different stages to ensure competency, retention and progression towards proficiency (Sugand et al., 2010). However, this assumption is not clear-cut because the teaching modalities through which knowledge is disseminated and conveyed to students, the quality of the resources used and the ways in which students approach learning may play a role in knowledge transfer and whether students retain information in later years (Fitzgerald et al., 2008; Smith, Martinez-Alvarez, & McHanwell, 2014). As Rizzolo et al., (2010) demonstrate, by using a curriculum design that involves a course structure that is relevant to the profession under study, students can retain anatomy well into and after clerkship training.

Although there are differences in the content and delivery of the curriculum in universities throughout the world, anatomy, which forms the basis for clinical examination, is still a core element in the medical curriculum. Therefore, if anatomy is being taught to medical students, are students really forgetting some or all of their knowledge as they move towards the clinical setting? Or are the voices presented in the literature reflecting those of clinicians and surgeons who have had a few unfortunate interactions with students? Or, do clinicians forget that perhaps their anatomical knowledge grew and was maintained through years of workplace practice and that perhaps they, too, had only an adequate knowledge of anatomy when they commenced their careers? This research will explore some of these questions by first establishing the extent of anatomy knowledge learned and retained during a medical student's degree. It will then explore the situational environments and circumstances that support the retention of knowledge or the lack thereof. This research will use a cross-sectional approach to focus on a group of medical students across all year levels in a Bachelor of Medicine / Bachelor of Surgery (MBBS) course at Monash University.

1.2 Background and Contextual Base for Research

1.2.1 Bachelor of Medicine / Bachelor of Surgery Program in Australia

All medical schools and specialty training college programs must undergo an accreditation and monitoring process governed by the Australian Medical Council (AMC) (Lawson & Bearman, 2007). There are 21 medical schools in Australia and New Zealand (Bouwer, Valter, & Webb, 2016), and most of them are hosted by public institutions. Until about 20 years ago, these medical schools had a traditional six-year curriculum, with a 50% split between learning in the pre-clinical and clinical environments. The pre-clinical curriculum followed a traditional format, with each discipline (e.g., anatomy) taught independently of other disciplines (e.g., physiology, pharmacology). In the clinical years, students rotated through various departments in public hospitals (Lawson & Bearman, 2007).

With the development of the PBL curriculum in the 1980s, a large number of medical institutions in Australia began the transition towards adopting integrated PBL curricula and developing four-year graduate-entry medicine programs, ultimately reducing the separation between the pre-clinical and clinical years (Lawson & Bearman, 2007). Australia's Newcastle University was a pioneer in PBL medical training. The selection criteria for the direct-entry medical programs include academic performance, the Undergraduate Medical and Health Sciences Admission Test and an interview process for all prospective candidates (Lawson & Bearman, 2007). The entry requirements for most graduate-entry medicine programs in Australia are based on three components: academic performance in an undergraduate degree, performance on the Graduate Australian Medical Schools Admissions Test and an objective and structured set of mini interviews designed to assess potential candidates' personal attributes and communication skills (Jones & Harris, 1998).

1.2.2 Monash Graduate-entry Bachelor of Medicine / Bachelor of Surgery Program

Medical Curriculum at the Monash Rural Health, Churchill

In 2008, Monash University opened its doors to a new graduate-entry program in a newly established medical school in Churchill, Victoria (Solarsh, Lindley, Whyte, Fahey, & Walker, 2012). The four-year MBBS course that commenced at Monash Rural Health, Churchill (MRH–Churchill), formerly known as Gippsland Medical School, was similar to other four-year graduate medical programs in Australia (Bouwer et al., 2016) in that it placed no restrictions on the type of undergraduate degree that prospective students had to complete to be considered for admission (Moscova, Bryce, Sindhusake, & Young, 2015). However, it is the only school to cover all of the pre-clinical sciences in one year (Bouwer et al., 2016). Candidates from a wide range of educational backgrounds (such as law, engineering, music, physiotherapy and biomedical science) were given the opportunity to apply and, if accepted, enrol in a Monash University graduate medical course.

The features that characterised the four-year graduate-entry course at MRH–Churchill, and that therefore set it apart from the other eight graduate-entry medical schools in Australia and New Zealand, was its small cohort of 80–90 students, its rural setting and the structure of its program, which comprised of one pre-clinical year followed by three clinical years (other graduate schools offer a two-year pre-clinical and two-year clinical program structure). The MBBS program at Monash University is organised according to four longitudinal themes:

Theme I—Personal and Professional Development

Theme II—Population, Society, Health and Illness

Theme III—Scientific Basics of Clinical Practice

Theme IV—Clinical Skills

In the clinical years, the relative importance of Themes I, II and III becomes less evident.

Year A MBBS Program

The pre-clinical year (Year A), which is based at MRH–Churchill, is PBL-driven in that each PBL case formed the basis of all discipline-specific content delivered for that week. For example, a case on myocardial infarction (heart attack) paved the way for students to learn about the anatomy of the heart that week. Year A consisted of formal teaching delivered to students within the different themes of the course. Year B also uses PBL as a learning tool for students. No formal instruction is provided post Year A. In Year A, the four themes were integrated and taught in two 18-week semesters. In Theme I, students are exposed to law, ethics and professional development. Theme II covers the topics of evidence-based medicine, population health, health and society, and community-based practice. Theme III encompasses all of the basic sciences, including anatomy, histology, physiology, pathology, pharmacology, immunology, microbiology, biochemistry, nutrition, cell biology, and human and health behaviour. In Theme IV, students acquire skills for history-taking, explanation (i.e., giving information), conducting examinations and procedures. To enhance and further develop their clinical skills, students are taught to apply all knowledge learned in the other three themes—especially anatomy. Further, in Year A, all students gain entry into rural general practice over the course of two semesters under the primary supervision of general practitioners on site. This provides a platform for learning across all four themes (Solarsh et al., 2012).

Anatomy Classification in the Year A Program

Anatomy in Year A is taught from different perspectives, including systemic and regional anatomy, surface anatomy, general anatomy and clinical anatomy. As stated by Louw et al. (2009, p. 13), "the unit or building block of anatomy is an anatomical structure or organ". Given that organs form the structural and functional units of a system and they occupy a specific region in the body, gross anatomy can be classified into systemic and regional anatomy.

Systemic anatomy is used to study the organisation and intrinsic properties of organs that have a common function (Louw et al., 2009). It can be categorised into the integumentary system (skin, hair and nails), skeletal system (bones), articular system (joints), muscular system (muscles), nervous system (nerves), endocrine system (hormone-producing glands and tissues), cardiovascular system (heart), respiratory system (lungs), digestive system (mouth, oesophagus, stomach, intestines), urinary system (kidneys, bladder and ureters), circulatory system (arteries and veins), lymphatic system (lymph vessels and lymphoid organs) and reproductive system (male and female sex organs).

Regional anatomy relates to the study of the extrinsic properties of organs that share a common location (Louw et al., 2009). This involves not only the position of the organ within a particular region, but also its relationships to other organs and surrounding structures (e.g., bones, muscles, nerves, blood vessels and lymphatic organs). Regional anatomy can be classified into seven components: cephalic or head region (cranial cavity, i.e., skull and brain), cervical region (neck), thoracic region (heart and lungs), abdominal region (stomach, liver, pancreas, spleen, kidneys and intestine), pelvic region (rectum, bladder and reproductive organs), upper limb region (arm, forearm and hand) and lower limb region (thigh, leg and foot).

In addition to systemic and regional anatomy, *surface anatomy*, which is defined as the study of the external surface of the body and its anatomical features, plays an important role in medicine (Azer, 2013). It involves an understanding and appreciation of not only the internal organisation of the body, but also of the projections that these underlying organs have on the body's surface (Louw et al., 2009). As Standring (2012) states, "surface anatomy was born out of the clinical need to visualise the internal landscape of the body from the outside" (p. 813). Surface anatomy is therefore explored through inspection (looking), palpation (touching or feeling), percussion (tapping with fingers or an instrument) and auscultation (listening through a stethoscope).

While knowledge of systemic and regional anatomy provides specific details about the structure and organisation of the body, a fundamental understanding of the conceptual rules surrounding the structural and functional components of organs (general anatomy) and the clinical relevance of anatomical structures (clinical anatomy) is crucial for medical students to obtain a good grasp of anatomy and develop confidence in their ability to apply that knowledge. As a result, new entities of general and clinical anatomy have emerged in the medical curriculum in recent years.

General anatomy is regarded as an area that provides the foundation for specific anatomy (i.e., systemic and regional anatomy). It incorporates a set of basic rules and principles that have been developed over time through observation and exploration of the human body. Recurring patterns of events linked to various anatomical structures can then be applied to specific anatomy (Louw et al., 2009). An example of a general principle relates to pain referral from injury or inflammation to underlying organs. According to this principle, an unpaired organ (e.g., abdominal organ such as stomach or intestines) will refer pain to the midline region (in this case, the abdomen) because it receives bilateral or dual nerve supply from both the right and left sides of the body.

The brain, which receives this dual nerve supply, cannot interpret the exact location of this incoming signal and therefore maps the point of pain referral to the midline. Conversely, a paired organ (e.g., right kidney) receives unilateral nerve supply from the right side and hence refers pain to the right side (of the abdomen and back in this case) (Eizenberg, Briggs, Adams, & Ahern, 2008). Using their knowledge of general principles, medical students can therefore engage in a process of deductive reasoning when learning anatomy. It should be noted that general anatomy is not a feature of all anatomy teaching; rather, this component is unique to the Monash MBBS program because of the anatomy coordinator on site.

Clinical anatomy can be regarded as the application of general principles and specific anatomy to a clinical problem. When assessing a patient who has presented with abdominal pain in the midline, a doctor will engage in a process of inductive reasoning, which involves acquiring information about the location, site, severity and type of pain to arrive at a potential diagnosis.

Anatomy in Year A is approached from all perspectives because knowledge of anatomy and its principles from the macroscopic to the microscopic level is essential to comprehend the organisation of the body and the implications and manifestations of disease on both structure and function (Louw et al., 2009; McCuskey, Carmichael, & Kirch, 2005). Without an understanding of the normal form and function of the human body and its anatomical variations, a doctor in training will be unable to make the necessary connections required for a diagnosis resulting from abnormal form and function (Bergman et al., 2014). Further, clinical anatomy has become an important part of today’s medical curriculum because it provides a foundation for students to develop and become competent in the scientific principles of clinical reasoning and problem-solving, which will allow them to diagnose and manage patients in the future (Boon et al., 2002; Brooks, Woodley, Jackson, & Hoesley, 2015; Collins, 2008; Ramsey, 2005).

Anatomy Curriculum in Year A

The anatomy curriculum in Year A comprised approximately 150 hours of formal teaching across the year (excluding histology). This is below the average total hours of gross anatomy teaching (179.7 hours) reported for four-year courses in Australia and New Zealand (Craig et al., 2010).

The Year A anatomy program primarily used a regional approach. Weekly content was structured according to regions, and general anatomy principles overarch each of the topics explored in those regions. In semester one, students covered upper and lower limb anatomy, as well as back and head anatomy. In semester two, they learned thorax, abdomen and pelvis. While it appears that a regional approach dominated the program, students were also exposed to systemic anatomy within each of the topics explored. For example, within the upper and lower limb regions, the skeletal, musculoskeletal, integumentary, circulatory, nervous and lymphatic systems are addressed. As part of the anatomy curriculum, a set of learning objectives was outlined for each session to notify students of the expectations of the course. This increased the likelihood that students would develop an understanding of what they must learn, why they need to learn it and what it means to learn it successfully (Louw et al., 2009; Patel & Moxham, 2008).

Given that knowledge of anatomy can be enhanced by extending it to include surface anatomy, clinical skills and imaging (Bergman et al., 2014), different teaching modalities are employed in the Year A program. Few of these modalities are didactic in nature, and most of the teaching engages students in active learning. Each semester comprised a combination of one-hour lectures, tutorials, workshops, two-hour quiz sessions and six-hour specimen days. The lectures took place on Tuesday and Wednesday mornings, and the tutorials, workshops and quiz sessions took place on Tuesday afternoons. Student exposure to cadaveric specimens were held on two Fridays per semester.

Anatomy Lectures and Tutorials

The lectures covered anatomical principles and specific anatomy. Tutorial sessions were designed to engage students through a set of specific objectives around clinical anatomy, which are provided in the form of application-style questions. This ensures that students do not explore tangential issues (Louw et al., 2009). During tutorial sessions, groups of 10–11 students gathered in a tutorial room with a research-based scientist, anatomist or medically qualified tutor to discuss each question and assess how anatomy principles and specific anatomy can be applied to the content. Three one-hour tutorial sessions were scheduled for upper limb, lower limb and back anatomy. Four tutorial sessions were devoted to head anatomy, one tutorial to neck anatomy, three to thoracic anatomy, four to abdominal anatomy and three to pelvic anatomy.

Anatomy Workshops

The one-hour workshop comprised a 30-minute session of osteology, where students followed a set of objectives that were constructed to enable them to examine and study bones that are relevant to the region. Osteology is often combined with radiology (imaging), where students are predominantly introduced to the basic features of X-rays, with some computed tomography (CT) and magnetic resonance imaging (MRI) scans, and are shown how to relate anatomical structures to these images. The remaining half hour of the one-hour workshop was spent in a simulated ward, where students explored surface anatomy in groups of five or six. During these sessions, students gather around one of six beds in the ward and were asked to follow a list of objectives outlined for the session, requiring them to palpate, locate and draw surface markings of anatomical features on the body using non-permanent markers (e.g., count and mark the location of the second rib, palpate the meniscus of the knee joint, find the radial pulse, draw surface markings of the heart). Within each group, one student volunteers to be drawn upon or examined, while the others gather around the bedside to discuss each objective using their knowledge acquired from the lectures and tutorials, as well as the expertise of the tutor overseeing the session. The surface anatomy sessions preceded the teaching of clinical skills by the clinical skills group (Theme IV), who rely on the anatomy team to ensure that students have adequate foundational knowledge against which their material can be delivered.

Anatomy Quiz Sessions

The two-hour formative quiz sessions were overseen by the anatomy coordinator and were held approximately four times per semester. The quizzes enable students to test their knowledge of the material covered in lectures and tutorials. During each session, students were asked to undertake a quiz that consisted of ten MCQs. The quiz was held under examination conditions, and students were not allowed to discuss the questions with other students during the first 15 minutes of the session. After this time, a group discussion session was held for each question, and misconceptions were clarified and important concepts were highlighted.

Anatomy Specimen Days

At MRH–Churchill, students received minimal exposure to wet specimens and no exposure to cadavers (human remains) because of a lack of storage facilities and finances. Resources provided to students at the MRH–Churchill campus included skeleton models, plastic models, bones, radiological images and potted specimens, which involve a dissected specimen of a particular body region (lower limb) or organ (lung, kidney) suspended in a medium and stored in a glass jar. The potted specimens are placed in the Learning Resource Centre, which students can access. However, the specimens cannot be touched or moved from their original location because of the weight and delicate nature of the glass jars. Therefore, they are only visible from the aspect in which they are positioned, and this prevents students from appreciating the spatial elements of each specimen. To ensure that students have an opportunity to explore and engage with the human body, four anatomy specimen days (two in semester one and two in semester two) were scheduled during the year at the main Monash University Campus, which houses an extensive anatomy museum that consists of skeletal remains, potted specimens, prosected specimens and fully preserved and dissected cadavers. The sessions were held upon completion of a regional block (upper and lower limb, back and head, thorax, abdomen/pelvis block).

During these sessions, students spent six hours rotating in groups of ten across different activities using the specimens mentioned above. Each activity was overseen and guided by anatomy tutors and guest tutors such as anaesthesiologists, surgeons and radiologists. The radiologists guided students through the detailed anatomy of an X-ray and CT or MRI scan, and they taught students how to detect normal and abnormal features on the images. These sessions built on the imaging sessions at Churchill and were mainly designed to revisit important imaging concepts while developing a better understanding of the spatial relationships between anatomical structures and building students' confidence in interpreting medical imaging scans. The surgeons and anaesthesiologists guided students in performing procedures on a cadaver, such as intubation (inserting a tube through the oral cavity), tracheostomy (inserting a tube into the trachea), intercostal nerve block (inserting a needle in the chest to anaesthetise a nerve) and pericardiocentesis (inserting a needle in the layers surrounding the heart to drain fluid). At the beginning and end of each anatomy day, a briefing session was held to provide a framework to consolidate the content covered during the day.

Overall Organisation of Anatomy Program in Year A

Operating under the different modalities of teaching described above, 84 hours were allocated to anatomy in semester one, which represents 15% of the total curriculum hours for that semester. The hours were distributed into lectures (34 hours), tutorials and workshops (13 hours each), quiz sessions (12 hours) and specimen days (12 hours).

In semester two, 64 hours were allocated to anatomy, which represents 12% of the total curriculum hours for the semester. The hours were distributed into lectures (22 hours), tutorials and workshops (11 hours each), quiz sessions (eight hours) and specimen days (12 hours).

Anatomy Assessment in Year A

In Year A, students were assessed on anatomy across five written examinations: two mid-semester examinations, two end-of-semester examinations and a vertically integrated assessment (VIA) paper at the end of the year.

The VIA is a written examination that covers all of the content delivered throughout the pre-clinical year of the graduate-entry MBBS degree. This integrated paper, which is worth around 120 marks, incorporates questions across the four themes of the course, with anatomy accounting for approximately 15% of the written paper. There is no practical (wet specimen) component in the assessment. All questions are MCQs or EMQs and are primarily based on clinically relevant anatomy (i.e., mainly taken from the tutorial questions). Some principle-based and image-based questions occasionally form part of this assessment. The results of the VIA (which students receive) are classed into an overall score and are further broken down into discipline-specific scores for each of the disciplines incorporated as part of the assessment. The results also include the overall mean performance for the cohort and for each discipline.

As the semester examinations in Year A only assesses anatomy covered during the semester, whereas the VIA assesses anatomy throughout the entire year, this research will use students' VIA anatomy scores to determine whether students' current anatomy knowledge has increased or decreased from when they were in Year A.

Years B, C and D of the MBBS Course

Following formal anatomy teaching during the pre-clinical year, and upon meeting the progression requirements for the Year A program, students advance to clinical training in Years B, C and D. At this point, graduate-entry students are integrated with their peers from the direct-entry (five-year) MBBS program. Therefore, a Year 3 student (who has finished two years of pre-clinical study) from the direct-entry program will be at the same level as a Year B student (who has just completed the Year A program). Following Year A (where students are expected to remain in rural Victoria to attend pre-clinical teaching), students are dispersed to clinical hospitals and sites throughout Victoria and Malaysia.

The first clinical year (Year B) is a hospital-based year that provides exposure to internal medicine, general surgery and pathology, along with their respective sub-disciplines. The second clinical year (Year C) sees students through four separate block specialties: children's health and paediatrics, women's health (obstetrics–gynaecology), psychiatry and general practice (Solarsh et al., 2012). In the pre-intern year (Year D), students rotate through "six-weeks discipline-specific hospital-based blocks in emergency medicine, aged care (geriatrics), internal medicine and general surgery, plus one selective and one elective block to prepare for internship" (Solarsh et al., 2012, p.

808). During this final year, students also have an opportunity to spend a six-week block at a recognised and approved hospital-based institution overseas as an elective.

Therefore, upon completion of Year A, students spend the remaining three years of their degree (Years B, C and D) in a variety of clinical settings, where their exposure to anatomy is highly varied and dependent on the students’ site of placement.

1.3 Purpose, Aims and Rationale for Research

Students’ exposure to anatomy in the clinical years is wide-ranging and informal. It mainly occurs through bedside tutorials (with consultants), observations in theatre and exposure to radiology and pathology, which all build on anatomical knowledge. Given this variation and the fact that students are formally taught anatomy in Year A (only), does their exposure to and experience of anatomy in the clinical setting account for their retention of anatomy knowledge or a lack thereof? Or are students not learning anatomy thoroughly during the pre-clinical curriculum? If students are forgetting, are there particular areas of anatomy that are more difficult to learn and retain than others? What accounts for the complaints of decreased knowledge in the clinical years, and in what settings do these occur?

To answer these questions, this study sets out to obtain a snapshot of anatomy knowledge among medical students currently enrolled in the pre-clinical (Year A) and clinical years (Year B–D) of the four-year (MBBS) graduate-entry degree at Monash University. Specifically, the research will explore the subject of anatomy retention through a three-part question:

- How does anatomy knowledge differ among students in the pre-clinical and clinical years of the MBBS course?
- To what extent do medical students retain anatomy knowledge?

- What factors may account for the loss or retention of anatomy knowledge across a student's medical degree?

This research aims to examine the extent of students' anatomical knowledge across their degree to investigate how much anatomy knowledge students possess and what regional areas are better learned, and to determine whether any similarities and differences exist between students receiving formal anatomy teaching in Year A and those in the clinical years whose source of learning and revising anatomy is more informal, opportunistic and applied.

Using the theoretical frameworks of post-positivism and constructivism, the research employs a mixed-methods approach incorporating a sequential explanatory design. This design involves a two-phase process with quantitative data collection and analysis in Phase One to examine how students within and across different year levels (Years A–D) perform on an anatomy test comprising clinically relevant knowledge covered during Year A. The data analysed in this phase is compared with the students' anatomy score in the Year A VIA to ascertain whether performance has changed since Year A.

To gain insights into the pattern of results obtained in Phase One, qualitative data collection and analysis in Phase Two is conducted using semi-structured interviews (Creswell & Plano Clark, 2011). This study is unique because it will collect empirical evidence that will indicate the status of students' anatomy knowledge beyond the pre-clinical year. This difference in knowledge will then be explored through student interviews to develop an understanding of the factors that account for students' retention of anatomy or lack thereof.

This is the first study of its kind in Australia and New Zealand to investigate anatomy retention among four cohorts of students in a graduate-entry medical program.

Since its inception in 2008, the educational requirements for students to enter the graduate-entry MBBS program at Monash University have been broad in scope, and students enrolled in the program from 2008 to 2014 came from a variety of science and non-science backgrounds. In 2015, changes were made to the intake of students, and those from non-science or other science backgrounds other than biomedical science and some health sciences (e.g., physiotherapy) were no longer accepted into the program. Further, the anatomy curriculum underwent significant modifications in 2015. While the tutorials and workshops remained the same, all pre-existing lectures were abolished, and the specimen days increased from four six-hour days per year to 14 two-hour sessions still completed remotely per year. Therefore, this study presents the final opportunity to evaluate students across a number of cohorts and explore anatomy knowledge retention among participants. Although the students have varying educational backgrounds and therefore possess a different degree of exposure to anatomy prior to starting the course, they are ultimately instructed using the same curriculum, the same assessments and the same teaching methods, thereby allowing for a comparison across cohorts.

In light of the fear and concern that resonates among the larger medical community, the problem of identifying the true nature of anatomy knowledge among medical students, both in the pre-clinical and clinical years is crucial to the enhancement of the anatomy curriculum. This involves exploring the topic of retention through both quantitative and qualitative means to acquire empirical evidence to support or refute the perceptions underpinning opinions regarding the state of students' anatomy knowledge. Of course acquiring new knowledge or reinforcing old knowledge can occur through clinical experience. However, if such opportunities are not made available to all students, then the pre-clinical curriculum where formal instruction of anatomy occurs accounts for the majority of students' anatomical knowledge and if medical students forget large components of their anatomy knowledge as they transition from the pre-clinical to the clinical years of their medical course, then the current constrained anatomy curriculum is hindering our attempts to prepare newly qualified medical graduates to practice medicine safely and confidently. Although knowledge is formally instructed in the pre-clinical setting, studies (Kulasegaram et al., 2015; 2013) have shown that deeper learning and better retention of knowledge occurs through contextualisation and integration of knowledge, essential components of learning within the clinical environment. This warrants an integrated approach to learning within the pre-clinical and clinical years of the MBBS program. Given that these medical students will become doctors who care for patients on their own, it is imperative to identify gaps not only in their knowledge, but also in the way anatomy is delivered throughout the MBBS curriculum and taught in medical schools. This will result in a curriculum that is well designed, well taught and fit for purpose throughout the four or five years of a medical degree. In doing so, we will be training doctors to confidently establish themselves in a growing profession that requires and demands exemplary knowledge of anatomy.

The results of this research will benefit the entire medical community, including students, universities and teaching hospitals, because they will lead to a deeper understanding of medical students' acquisition and retention of anatomical knowledge across an MBBS degree, and they will provide insights into appropriate assessment practices.

1.4 Organisation of Thesis

This thesis has been organised into nine chapters, as outlined below.

Chapters 2, 3 and 4 explore the existing literature to document and analyse the historical and current state of anatomy in medical education. The chapters present an overview of the importance of anatomy in medical training, and they seek to understand the challenges associated with both the traditional curriculum, which has dominated the teaching of medicine for decades, and the modern curriculum, which has made its appearance in recent years.

Chapter 5 highlights the theoretical framework and assumptions underpinning this research and provides a detailed explanation of the methodology used, including the development and administration of the quantitative and qualitative strands. It also describes the ethical procedures considered prior to the start of the research.

Chapter 6 presents the statistical analysis and the results of the quantitative data. It is organised according to the questions posed in the research. This chapter highlights the differences in anatomy knowledge between and among cohorts, and it provides insights into students' retention of anatomical knowledge. The results of student's learning perspectives and preferences in anatomy via the anatomy-learning survey are also analysed.

Chapter 7 presents the findings of the qualitative data obtained from the interviews. They are organised according to six themes that emerged from the transcripts. The insights revealed in this chapter help to answer the research questions, and they shed light on questions that arose from the quantitative data analysis.

Chapter 8 combines and discusses the results from the quantitative and qualitative phases. It sheds light on new findings highlighted by the research, and it uses the literature review to discuss and debate the current state of anatomy knowledge in this group of graduate-entry medical students. Further, the chapter explores the potential of these findings to optimise the anatomy curriculum and assessment processes.

Chapter 9 concludes the research by highlighting the purpose of the study, its findings and its implications for anatomy education in medicine. It also proposes changes for an optimal curriculum and assessment.

Chapter 2: Anatomy: Origins, History and Current Trends

This chapter begins with a discussion of the importance of anatomy—particularly its significance and use in clinical practice and its subspecialties. It then explores the origins of anatomy as a way of understanding how anatomy evolved as a discipline and the role it has played in the field of medicine.

Sections 2.2 and 2.3 focus on the developments and changes that have taken place in the medical anatomy curriculum over the past century. The traditional way of teaching anatomy and its challenges are explored and compared with the modern curriculum and the various instructional formats through which anatomy is taught. This is contrasted with the graduate-entry MBBS program at Monash University. The educational reform that took place over the past century is also discussed in relation to the traditional curriculum and its effect on the development of outcome-based education and the modern curriculum.

2.1 Anatomy—Importance and Origins

2.1.1 Why is Anatomy Important?

Use of Anatomy in Clinical Practice

The importance of anatomy in clinical practice has been widely acknowledged in the literature because a sound knowledge of anatomy is imperative for safe clinical practice, regardless of medical career specialisation following graduation (Berman, 2014; Cottam, 1999; Davis, Bates, Ellis, & Roberts, 2014). In particular, anatomy is considered extremely important and relevant to the disciplines of diagnostic radiology (89%) and general surgery (74%) and very important to emergency medicine (65%) and family practice (60%) (Cottam, 1999). This is not surprising given that the former two disciplines rely heavily on anatomical knowledge. However, a survey of all residency program and anatomy course directors (79% response rate) in the US revealed that doctors in the fields of radiology and general surgery rated anatomy as the most important subject relative to other basic sciences. This is contrary to the latter two specialties, where anatomical knowledge is primarily used for a physical examination. In these areas, doctors rated physiology, pharmacology and pathology as the most important disciplines relative to other basic sciences (Albertine, 2012; Cottam, 1999). Similar findings were revealed by a study in Spain, where medical professionals (42.9% response rate) highlighted anatomy as the most relevant discipline for daily clinical practice and surgery, whereas physiology and pharmacology were regarded as most relevant to other medical specialties (Arraéz-Aybar, Sanchez-Montesinos, Mirapeix, Mompeo-Corredera, & Sanudo-Tejero, 2010). These results suggest that anatomy has multifaceted uses in different areas of medicine, and while it is crucial to the disciplines of surgery and radiology, the most common application of anatomy that is pertinent to all medical specialties is during a physical examination of a patient (Lazarus, Chinchili, Leong, & Kauffman Jr., 2012).

Physical Examination and Patient Care

In any specialty, clinical examination of a patient rests on a solid foundation of anatomy; thus, knowledge of anatomy plays a very important role in patient care (Bolander, Lonka, & Josephson, 2008; Boon et al., 2002). Regardless of which branch of medicine a doctor chooses to further their career (e.g., family medicine, surgery, obstetrics/gynaecology, orthopaedics, paediatrics), physical examination of patients is essential to their practice. Knowledge and use of surface anatomy is fundamental when performing a thorough physical examination to assess a patient. For example, as Day and Ahn (2010, p. 402) state, “how can we teach the McMurray test for meniscal injuries when students are unable to palpate for the meniscus at the knee joint?” In the McMurray test, meniscal tears are evaluated on a patient. Without a sound knowledge of the anatomy of the knee and the ability to palpate the periphery of the knee joint, signs and symptoms experienced by patients can be dismissed as unimportant, and patients can remain undiagnosed. Consequently, surface anatomy has gained much importance in today's medical curriculum, and its significance in clinical practice is further emphasised by surface anatomy teaching being reinforced in the pre-clinical curriculum, not only in anatomy sessions, but also during the teaching of clinical skills (Sugand et al., 2010). An ability to identify and locate structures under the surface of the skin by referring to anatomical landmarks and clinically defined borders is a core clinical skill that will allow doctors in training to detect signs of abnormality in a patient (Standring, 2012) and potentially diagnose and treat the patient at a much earlier stage.

Surgery and Litigation

Surgery involves exploring anatomical structures to manipulate and repair damaged structures or remove and/or replace diseased organs. Knowledge of anatomy is crucial to be successful in the art of surgery. This has become increasingly evident, especially in the face of surgical malpractice suits and claims (Ellis, 2002; Sugand et al., 2010). A lack of technical competence or knowledge by the surgeon, often referred to as "anatomical ignorance" (Sugand et al., 2010, p. 88), results in increased and inadvertent damage to underlying structures during surgery. For example, a surgeon with experience in general surgery but not with adrenalectomy (removal of the adrenal glands that sit on top of the kidneys) mistakenly ligated (tied up) the blood vessel supplying the kidneys instead of that supplying the adrenal glands. The outcome for the patient was a nephrectomy (removal of the kidney) resulting from a loss of blood supply to the organ (Rogers et al., 2006). Another case of surgical error involved damage to the common bile duct (a tube-like structure responsible for transporting bile from the gall bladder to the intestines to aid in the digestion process) following a laparoscopic cholecystectomy (removal of the gall bladder). The patient developed severe abdominal pain and jaundice because of the leakage of bile into the abdomen (Rogers et al., 2006). Although many factors can be associated with intra-operative errors, such as judgement errors, communication breakdowns, patient-related factors and memory failures (Rogers et al., 2006), one author asks, “What is ‘damage to underlying structures’ if not, in the majority of cases, some anatomical error or even disaster?” (Ellis, 2002, p. i). Given these avoidable errors, it is not surprising that anatomy plays a critical role in surgery, since an intimate knowledge of anatomical regions and their surrounding structures is crucial in maintaining the safety of the patient.

Imaging and Diagnosis

The role of anatomy is most apparent in *radiology*. With recent advancements in technology, it is now possible to examine the living body through the use and application of minimally invasive procedures. New techniques such as endoscopy (a tube-like instrument that examines the patient’s digestive tract), laparoscopy (tiny incisions in the skin through which instruments and a camera are inserted during surgery to guide and perform techniques), CT (X-ray equipment used to produce detailed pictures of the internal body) and MRI (equipment that applies a magnetic field and radio frequency pulses to obtain a clearer picture of internal organs and other body structures) have allowed for three-dimensional (3D) visualisation of the internal body with improved quality of imaging and better depiction of both spatial anatomy (relationship of structures to their surroundings) and sectional anatomy (horizontal or vertical slice cut through clinically important levels) (Louw et al., 2009; Murphy et al., 2015). Further, knowledge of gross anatomy and surface anatomy is important not only in allowing a clinician to position devices appropriately on patients for examination purposes, but also in performing interventional procedures such as an angioplasty (a minimally invasive procedure used to open narrowed coronary arteries) (Azer, 2013).

Given that a strong knowledge of anatomy is required to interpret diagnostic images produced by these sophisticated techniques (Azer, 2013; McCuskey et al., 2005), there is greater emphasis on the importance of gross anatomy as a discipline. Further, diagnostic reasoning, which is obtained through patient interaction (history-taking and physical examination) and technology (medical imaging scans) has been shown to result from a five-stage cognitive process involving the use of anatomy in all its forms. According to Banda (2010), these five stages are: “patient information data gathering; ascribing the information gathered to anatomical descriptors; interpretation; anatomical representation of the clinical circumstances; and, diagnosis” (p. 23).

While most medical students may not become radiologists or surgeons, medical imaging has become an essential tool for modern clinicians and is therefore not unique to specific disciplines such as radiology and surgery. Interns are now expected to recognise common imaging abnormalities such as small bowel obstruction (narrowing or blockage of the small intestines), pneumonia (infection of the lungs), cardiomyopathy (diseased heart) and intracranial haematoma (bleeding inside the skull) (Saha, Roland, Hartman, & Daffner, 2013). These warrant a high level of anatomical knowledge so that diagnosticians can ensure they do not misinterpret medical images, and so that medical practitioners can ensure they understand the consultation reports received from the radiologists and accordingly provide appropriate and timely care (Bohl, Francois, & Gest, 2011; Johnson, Charchanti, & Troupis, 2012; Louw et al., 2009).

Therefore, anatomy has many uses in clinical practice. It underpins physical examination, diagnosis, interpretation of medical imaging, clinical procedures and surgery. Further, it aids communication between medical and allied health personnel, and between doctors and patients (Herle & Saxena, 2011; Lazarus et al., 2012; Murphy et al., 2015; Smith et al., 2014; Standring, 2012).

Given that these findings largely represent the opinions of clinicians and specialists, it is important to obtain students' perceptions of the importance of anatomy in clinical practice because this is most likely to affect their approach to learning anatomy (Ramsden, 2003). Thus, this research will explore students' perceptions of anatomy as it pertains to training in both the pre-clinical and clinical years.

The studies reported in this chapter support anatomy as being important in the medical curriculum; however, they also suggest that its importance in clinical practice diminishes if the specialty under concern does not require its daily use. Therefore, while anatomy is regarded as a foundational and core science in the pre-clinical curriculum, its importance in the clinical years of the MBBS curriculum must be maintained.

2.1.2 Origins of Anatomy

Historical Perspective

Anatomy as a discipline has undergone several changes during its history, with the most significant changes taking place over the past century. There is an ongoing debate in recent literature about the relative merits of the traditional curriculum and how it was taught versus the contemporary syllabus and its teaching process. Although a historical treatise is beyond the scope of this research, a brief overview of the development and teaching of anatomy, as well as its role in medical education, is necessary to understand the radical differences behind traditional and modern anatomy curricula (Louw et al., 2009).

Before Common Era (BCE or BC)

The history of anatomy dates back to ancient civilisations (3000 BCE to 250 BCE), when the ancient Egyptians' knowledge of anatomy enabled them to perfect the art of embalming and mummification—a practice that involved the removal and preservation of organs from body cavities to preserve corpses following death (Loukas, Hanna, Alsaiegh, Shoja, & Tubbs, 2011). Egyptians were the first to elucidate the anatomy of the brain and spinal cord (Fanous & Couldwell, 2012), and the first to practice the advanced technique of the trans-nasal approach to the brain, which involved inserting surgical instruments through the nose to gain access to and remove the brain without disfiguring the face (Loukas et al., 2011, p. 413). In modern-day medicine, this technique has been modified to a trans-sphenoidal approach (passage through the nose and the sphenoid bone in the cranial cavity) and is used to treat tumours of the pituitary gland (a small pea-shaped gland in the brain that controls bodily functions through the secretion and production of several hormones). The possession of such advanced knowledge at the time is a testament to the Egyptians' contributions to the development of anatomy. In fact, the ancient Egyptians are regarded as the pioneers of modern-day medicine and surgery (Fanous & Couldwell, 2012).

Common Era (CE or AD)

Exploration of anatomy continued into the second century CE, when the Greek physician Galen began learning about animals (particularly pigs and primates, whose form resembles that of humans) through the art of dissection—a process defined as the peeling back of layers, one by one, from the skin to the skeleton. Galen's documented findings and knowledge of anatomy formed the basis of anatomical texts for around 1,300 years (Judson, 2012; Sarkis, Treble, Wing, & Ramsey-Stewart, 2014).

Fifteenth to Eighteenth Centuries

Throughout the fifteenth, sixteenth and seventeenth centuries, anatomy had very little to do with medicine and was regarded more as a research activity primarily based on the observation and exploration of the human body. The great artists of this renaissance period, including Raphael and Leonardo da Vinci, were excellent anatomists and made great contributions to its development through detailed paintings and sculptures (Keele, 1964).

However, during the sixteenth century, the ardent anatomist and physician Andreas Vesalius found that Galen's writings on the function of the human body were inaccurate because he had primarily deduced his conclusions from the dissection of animals. After methodical observation and the systematic dissection of human corpses, Vesalius produced his findings in 1543 in a highly venerated publication titled *De Humani Corporis Fabrica* (On the Fabric of the Human Body), which was one of the most influential anatomy books ever written. It consisted of seven volumes and contained anatomical diagrams from skin to skeleton (Judson, 2012; Korf et al., 2008). Vesalius' anatomical works paved the way for contemporary anatomists and "opened the floodgates of future anatomical progress" (Louw et al., 2009, p. 374).

By the eighteenth century, dissection emerged as a respectable teaching form and as a science, taking its rightful place in a society that placed sensualism as its core philosophy (Judson, 2012). According to sensualism, all wisdom is achieved through observation of the senses; therefore, anatomical dissection fitted very well with this model of thinking.

Nineteenth and Twentieth Centuries

As anatomy and surgery evolved together (Judson, 2012), demands to improve medical care called for increasing and detailed dissection of the human body (Hutton, 2006). Consequently, in the nineteenth century, dissection became integral to the teaching of anatomy in the medical curriculum. Knowledge of the structure and function of the body was imparted to students in small-group teaching sessions centred around an unembalmed cadaver (Judson, 2012). During this period, the bodies of executed murderers were donated for cadaveric dissection. However, an increasing number of students resulted in a cadaver shortage. Consequently, in Canada, the US, the UK and other parts of Europe, individuals (called 'resurrectionists') engaged in the illegal activity of bodysnatching, which involved the secret disinterment of bodies from cemeteries (Hutton, 2006). The public outrage that followed bodysnatching raised difficult questions regarding how to legalise cadaver donation. This resulted in the formation of a set of regulations that paved the way for institutions and governments to legalise the process for obtaining cadavers and engaging in cadaveric dissection, and it altered the future of body donation programs globally.

In the UK, the *Anatomy Act 1832* attempted to alleviate the bodysnatching issue by creating strict regulations around the way in which bodies could be obtained (Hutton, 2006; McLachlan & Patten, 2006). The Act allowed for doctors, teachers and medical students to obtain licences to dissect donated cadavers. Hospitals were given permission to use the bodies of their deceased patients if consent was obtained from relatives, who could opt to have the patient buried by the institution in exchange for dissection (Hutton, 2006). In the US, anatomy laws were enacted, but they varied from state to state, with some prohibiting dissection into the early part of the twentieth century (Warner & Rizzolo, 2006).

In Australia, the first medical schools were established at the University of Melbourne and the University of Sydney in 1863 and 1883 respectively (Parker, 2002). Since formalin, the chemical preservative of bodies, was only introduced in the late 1800s, there was a period during which preservation techniques were absent from these medical schools. Consequently, all bodies had to be dissected within a six-week period of their arrival at the medical schools (Parker, 2002). Thus, Australian medical schools were faced with the same shortage of cadavers that was prevalent in Europe, and bodysnatching starting to become prevalent. As a result, an *Anatomy Act* was passed by the Victorian Parliament in 1862 to help legalise the process of cadaver acquisition and dissection (Jones, 2012). However, the Act led to many complaints from the public, who were concerned that there was no mention of where the cadavers would be acquired. Relatives of the deceased also protested about the 24 hours' notice they were given to reclaim the bodies of their loved ones, after which the bodies were volunteered for dissection. Similar to the issues faced in the UK, the inmates in a North Melbourne benevolent asylum were concerned that, following their death, their bodies would be used for dissection purposes without consent. A petition they signed against the Act went unheeded, and unclaimed bodies and those of inmates remained the main source for cadaveric dissection in Australian medical education until the late 1900s, when body donation programs were put into place (Jones, 2012). Today, each state has its own anatomy act. In Victoria, the *Human Tissue Act 1982* outlines the legislation for individuals who are considering body donation for research and teaching purposes, and for institutions involved in the body donation program (Victorian Government Health Information, 2010).

Thus, anatomy in medical education has a history that is well rooted in the art of dissection. What began as research-based activity thousands of years ago expanded into a science—that is, a body of knowledge that has warranted further study not for the sole purpose of exploring the dead, but for its usefulness in treating the living. Consequently, in the early twentieth century, the discipline of anatomy remained the focal point for students entering medicine, and it occupied a large proportion of time and space in the medical curriculum.

2.2 Anatomy in the Twentieth Century—The Early Years

2.2.1 Traditional Anatomy Curriculum

Anatomy and dissection were considered the mainstay and the starting point of medical education well into the first half of the twentieth century (Brooks et al., 2015). In 1902, a survey of existing medical schools with a four-year curriculum revealed that students spent an average of 549 hours in gross anatomy classes (Leung et al., 2006).

However, in 1909, as part of a request by the Council on Medical Education to survey medical education in North America, high school principal Abraham Flexner visited all medical schools in the US and Canada to determine the probability of these schools producing high-calibre physicians (Mitka, 2010). His resulting report on *Medical Education in the United States and Canada* was published in 1910. It brought about radical change and reform in medical education and had two main outcomes: the formation of accredited medical schools that became part of larger academic institutions, and the closure of multiple unregulated medical schools (Mitka, 2010). Flexner stated that medical training should involve a 2 + 2 curriculum that comprised two years of basic science coursework followed by two years of clinical training (Brooks et al., 2015; Kulasegaram, Martimianakis, Mylopoulos, Whitehead, & Woods, 2013). This practice is still followed in many medical schools around the world.

As part of this two-year basic science training, anatomy was to occupy a large part of the curriculum, remaining as a stand-alone course alongside other major disciplines (physiology, histology, pathology), which were considered fundamental to medical education at the time (Australian Doctors Fund, 2006; Drake, McBride, Lachman, & Pawlina, 2009). The remaining two clinical years were thought to stand on the pillars of the foundational basic science knowledge acquired during the pre-clinical years.

Flexner’s philosophy on education revolved around the idea that students must be actively involved in their learning. They must be stimulated to learn not only through observation, but also through practice, which combines action with critical thinking to enable students to understand the significance of what it is they have learned. He believed that most learning should occur in the laboratory, with lectures supplementing the practical lab work—that is, dissection (Ebert, 1992). Therefore, in the traditional curriculum, numerous hours were devoted to lectures, with the teacher conveying large volumes of fact-based information to students. In this didactic form of teaching, lectures contain an overwhelming amount of detail with little clinical relevance; thus, medical students are passive recipients of the information (Heylings, 2002; Older, 2004; Turney, 2007).

In contrast, dissection was thought to significantly contribute to students’ learning of anatomy because it involved active participation on their part (Older, 2004). The value-added benefits arising from dissection (as outlined below) fell into three main categories: knowledge acquisition, integration of knowledge, and development of skills and attitudes (McLachlan & Patten, 2006). Consequently, medical students spent many hours exploring the human body through dissection.

Where dissection is concerned, anatomical variation must be considered because individual differences in anatomical structures exists in all forms, both externally and internally (Older, 2004). Anatomists, who were the prime teachers of dissection at the time, believed that students would learn how to distinguish normal anatomical variants from pathological anatomical variants by exploring the human body and appreciating its 3D orientation. Dissection was therefore viewed as an extremely valuable and enriching experience that formed a critical component of students’ medical training (Collins, 2008; Korf et al., 2008; Lachman & Pawlina, 2006; Leung et al., 2006). Further, anatomists argued that the field of medicine, which involves complex problem-solving skills through the application of scientific knowledge, was best learned and developed by examining the internal components of the body and their spatial relationships with other bodily organs—a skill best achieved through dissection (Older, 2004; Pabst, 2002; Sugand et al., 2010).

Additionally, dissection was seen to have other benefits, such as: fostering the development of teamwork and communication skills through student group interactions; allowing students to develop manual dexterity and analytical skills through practice; and acclimatising students to the notions and reality of death, as well as the accompanying moral and ethical issues (Korf et al., 2008; McLachlan & Patten, 2006; Older, 2004; Pratten, Merrick, & Burr, 2014; Raftery, 2007; Warner & Rizzolo, 2006).

Many anatomists argue that the ideal time for educating students about death is at the start of medical school—that is, during the pre-clinical years (Marks, Bertman, & Penney, 1997). For many students, their first exposure to death will be an encounter with a cadaver in the anatomy laboratory. While this can be a confronting experience, it enables the student to transform into a future physician, and it fosters the development of respect, empathy, compassion and professionalism, which cannot be taught or learned in a classroom setting (Swick, 2006). Additionally, a student's first experience with a cadaver instils a certain level of "compassionate detachment" (Older, 2004, p. 81). This is essential for physicians, who will have to cope with the issues surrounding death and bereavement at some point in their career.

The value-added benefits of dissection meant that it remained a large and compulsory component of pre-clinical anatomy teaching in all nine medical schools in Australia until the 1970s. Students were expected to dissect almost every day, with some schools spending up to 700 hours on dissection (Parker, 2002).

2.2.2 Challenges Associated with the Traditional Curriculum

One of the major issues with institutions adopting Flexner's 2 + 2 curriculum was the failure of the format to integrate basic science and clinical knowledge (Kulasegaram et al., 2013). Under the traditional curriculum, students were exposed to, and expected to learn, a significant amount of detail. Clinical relevance was not necessarily emphasised with anatomical knowledge; therefore, successfully passing an anatomy course "became a rite of passage rather than an educationally valid process" (Abu-Hijleh, 2010, p. 601). Further, non-medically trained anatomists were criticised for imparting too much anatomy knowledge and overwhelming students with details that were irrelevant for general clinical practice (Orsbon, Kaiser, & Ross, 2014). In addition, the didactic passive learning paradigm encompassing the traditional style of teaching anatomy had been negatively associated with student learning outcomes. Many studies had reported poor knowledge of anatomy and increased reliance on memorisation or rote learning styles, which decreased students' ability to apply, synthesise and integrate anatomy to its clinical aspect (Johnson et al., 2012; Kerby et al., 2011; Sugand et al., 2010; Turney, 2007).

Some authors have criticised the extensive hours of dissection associated with the traditional curriculum as an ineffective pedagogical learning tool, with some believing that dissection is essential for future surgeons but not physicians (Collins, 2008). This argument stems from the observation that students must have a good knowledge of anatomy when determining what structures they are examining and when dissecting. Therefore, it is believed that anatomy should not form the primary tool of instruction for a program in which the majority of students will be trained as general practitioners.

Further, by the mid-twentieth century, there was an explosion of knowledge in the field of biotechnology and scientific medicine, with advances made in the genetic and molecular basis of health and disease (McCuskey et al., 2005). To better equip students with the foundational but current knowledge necessary to practice medicine, there was a huge influx of biological science courses such as microbiology, cell biology and immunology, which all gained increasing importance within medical education. Further, the new biological science courses were coupled with the introduction of social science, law and ethics courses, which were seen to give students a holistic view of what it meant to practice as a doctor and the challenges of applying their knowledge in the clinical arena. These new developments, combined with a concomitant increase of clinical diagnostic techniques and interventions, resulted in an overcrowded, condensed and packed medical curriculum (McCuskey et al., 2005; Ramsey-Stewart et al., 2010; Sugand et al., 2010), and medical students had to learn twice as much as their predecessors in the same amount of time (Leung et al., 2006).

2.2.3 Early Medical Education Reform

Given the expanding body of knowledge and the condensed curriculum, medical education was on the verge of being reformed. This reform, which involved culling the major science disciplines, began to take place in North America and Europe in the late 1950s and early 1960s, with Asia–Pacific joining the trend in the 1990s (Leung et al., 2006). The rationale for the reform was that a densely packed medical curriculum placed high demand on students' cognitive load; thus, existing disciplines had to be reduced, cut down or abolished. The anatomy curriculum was one of the major disciplines whose content within the curriculum was reduced to accommodate the expanding body of knowledge (Ramsey-Stewart et al., 2010). Anatomy was an easy target because many of the challenges associated with the traditional curriculum had been based on the pedagogical principle of comprehensive coverage (Rizzolo et al., 2006).

Consequently, the average number of teaching hours in gross anatomy in North American medical schools fell to 330 in 1955 and 290 in 1966 (Blevins & Cahill, 1973; Leung et al., 2006), 50% less than what it was half a century earlier. According to Warner and Rizzolo (2006), teachers of anatomy were left “scrambling to salvage the prestige and salience of their field” (p. 407). Following these cuts, it was suggested that there would be few additional changes in the anatomy curriculum given the reductions that had already taken place (Eldred & Eldred, 1961). However, medical education reform did not end there. In 1968, the Royal Commission of Medical Education was chaired by Lord Alexander Robertus Todd to review medical education in Great Britain. This led to the Todd Report, which further transformed medical education by calling upon universities to increase their intake of medical students and to develop a five-year undergraduate medical curriculum—three years of which would be spent in basic clinical training. This was similar to the Flexner Report, which recommended a two-year period of pre-clinical training for all medical students. The Todd Report also emphasised further widening of the undergraduate curriculum to incorporate other disciplines (Olowo-Ofayoku & Moxham, 2014). The graduate-entry MBBS Monash curriculum follows the Flexner and Todd Reports in that it consists of a period of pre-clinical and clinical training and incorporates numerous disciplines such as population health, health and society, law, and ethics. However, it is also unique because it consists of a 1 + 3 curriculum rather than a 2 + 2 curriculum. Therefore, students in this program have less time to learn the pre-clinical sciences, but they receive more clinical experience than their counterparts elsewhere in Australia, highlighting the importance of understanding students' learning of anatomy and their retention of anatomical knowledge in this study.

In 1973, following the implementation of recommendations from the Todd Report, the average time spent on the anatomy curriculum in medical schools in the US and Canada further declined to 197 hours (Blevins & Cahill, 1973). Concerns were then raised about the level of anatomy knowledge among medical graduates declining below a recognised safety level (Cottam, 1999). Further to the decreasing number of teaching hours, the period between the 1930s and the 1980s saw the sciences being taught in detail, but without clinical relevance to or integration with the clinical sciences, resulting in both "dissonance and dissatisfaction among preclinical teachers and students alike" (Drake et al., 2009, p. 253). These challenges and criticisms began to dominate medical education forums and resulted in a second wave of medical education reform.

2.3 Anatomy in the Twentieth Century—The Past 30 Years and Current Trends

2.3.1 Late Medical Education Reform

The 1980s marked the beginning of the next great reform in medical education, which was initiated by McMaster University in Canada and supported by the General Medical Council (GMC) in England. Some criticisms that drove the reform included the overcrowded medical curriculum, which consisted of didactic teaching and passive learning, a lack of patient communication and the imparting of unrelated facts to students, which resulted in focused memorisation (Older, 2004; Olowo-Ofayoku & Moxham, 2014). As Prideaux (2003) states in his article on curriculum design, "in contemporary medical education…the curriculum should achieve a "symbiosis" with the health services and communities in which the students will serve. The values that underlie the curriculum should enhance health service provision. The curriculum must be responsive to changing values and expectations in education if it is to remain useful" (p.326).

Consequently, anatomy began to be appreciated less as a science and more for its application to clinical practice (Warner & Rizzolo, 2006). Subsequently, in the 1990s, the GMC published *Tomorrow's Doctors* (GMC, 1993) and called for a reduction in the amount of information presented within medical curricula, stating that the large volume of unnecessary detail was not required for a medical course (Johnson et al., 2012; Patel & Moxham, 2006). The report recommended that basic biomedical sciences be taught alongside their clinical applications, and that traditional didactic teaching be replaced by integrated and interdisciplinary curricula in some schools (Brooks et al., 2015; Olowo-Ofayoku & Moxham, 2014). The Monash MBBS curriculum was also established around four longitudinal themes that put emphasis not just on the sciences but also integrated the basic biomedical sciences with those of population health, social sciences and clinical practice (Solarsh et al., 2012) and the PBL curriculum employed by Monash was selected for the purpose of supporting the student's ability to synthesize, understand and integrate difficult concepts – skills which are developed via the process of applying basic science knowledge to clinical scenarios (Chang, 2016).The aim was to reduce the focus on independent disciplines and increase horizontal and vertical integration (Klement, Paulsen, & Wineski, 2011). Horizontal integration occurs when concepts across different disciplines (e.g., anatomy, physiology, pathology) are related, to provide an understanding of how they connect and build upon one another as learning progresses. Vertical integration relates to the process of combining knowledge across different disciplines and year levels—that is, connecting the basic and clinical sciences to foster an understanding and help increase the performance of the professional activities of medicine (Kulasegaram et al., 2013).

These recommendations for change had a significant effect on the anatomy curriculum because “gross anatomy came under siege, eclipsed in curricula by the newer experimental sciences. It was the most antiquated of the basic medical sciences” (Warner & Rizzolo, 2006, p. 408). Around this time, there was a gradual shift in the medical curriculum towards outcome-based education (Harden, Crosby & Davis, 1999) and different curriculum formats. The anatomy curriculum in the Monash MBBS graduate-entry course followed suit, limiting the amount of fact-based information that was disseminated to students, and instead focusing heavily on clinically related anatomy and its implications for patient care.

2.3.2 Three Curriculum Formats and Their Instructional Methods

The educational reform that began in the 1980s has had a profound effect on the current medical curriculum, as medical schools have reduced the number of hours allotted to teaching basic biomedical sciences. Although the change was across all science disciplines (Cottam, 1999), anatomy was affected the most, with an almost 50% reduction in the time and content of anatomy teaching compared with 25 years ago (Older, 2004). Similar reductions in gross anatomy teaching occurred worldwide, as reported in the literature (Azer & Eizenberg, 2007; Collins, Given, Hulsebosch, & Miller, 1994; Cottam, 1999; Dangerfield et al., 2000; Fasel, Bader, & Gailloud, 1999; Leung et al., 2006).

Compared with the traditional model, which views the teacher as the ‘sage on the stage’, the modern medical curriculum is based on constructivist approaches to learning which views the teacher as the ‘guide on the side’. The theoretical bases of pragmatism, meaningful learning, cognitive psychology and social constructivism have realigned the focus of learning from teacher-centred education to learner-centred education (Silen, Wirell, Kvist, Nylander, & Smedby, 2008). Consequently, anatomy education has been incorporated into two other forms in the modern medical curriculum: the PBL curriculum and the organ/systems-based curriculum (Bergman et al., 2013; Brooks et al., 2015; Heylings, 2002).

Problem-based Curriculum

PBL is an instructional method that drives all learning and is based on the notion that learning occurs when we solve everyday problems (Barrows & Tamblyn, 1980; Marra, Jonassen, Palmer, & Luft, 2014). It is similar to inquiry-based learning, which is grounded in the philosophy established by John Dewey and states that students learn through active inquiry, investigation, discoveries and reflection. Although both are student-centred, the major difference is that the tutor takes on a facilitator role in PBL and supports students through their inquiry rather than acting as a primary source of information (Savery, 2006). PBL was first introduced by McMaster University in 1969 as an alternative to the 2 + 2 curriculum, which involved traditional lectures and a practical-based science curriculum followed by clinical sciences. Although it underwent revisions and modifications in subsequent decades, the pedagogical philosophy of the original PBL curriculum was based on the notion of a spiral curriculum (Bruner, 1977), wherein basic sciences and clinical sciences could be integrated and, under the guidance of a facilitator, students could engage in self-directed study and peer teaching while working towards identifying essential learning outcomes (Barrows & Tamblyn, 1980; Neville & Norman, 2007).

The prevailing force behind PBL in the modern medical curriculum is that of integration between disciplines (Abu-Hijleh, 2010). During a PBL session, students are presented with a real-world problem in the context of a clinical case and must work in small groups to learn the basic science and clinical information surrounding the case, while also incorporating concepts surrounding the legal, ethical and social aspects of health and disease that are pertinent to the case (Association of American Medical Colleges [AAMC], 2001). Historically, the theoretical underpinnings of PBL have been based on constructivism and situated learning theory (Hung, 2002; Jonassen, 1991). Constructivism follows the principle that individuals' knowledge and understanding of the world is constructed through their interaction with the environment and their reflection of that interaction. In the PBL setting, this translates to students using problem-solving techniques such as information gathering, discussion and reflection to create more knowledge and develop a better understanding of the clinical case (Marra et al., 2014). Situated-learning theory is based on the principle that students learn best in the environment in which they will apply that learning. According to this theory, students form part of a community. At the beginning of their medical career, they occupy the periphery of that community (pre-clinical year[s]) as passive members. Through the learning process they move towards the centre of the community (clinical years) and become active and recognised members (Bolander et al., 2008; Lave & Wenger, 1991).

The PBL concept did not become popular until Harvard Medical School adopted a hybrid curriculum combining PBL with a few lectures and practical sessions to supplement students' learning. (Moore, Block, Style, & Mitchell, 1994). The authors demonstrated that with a PBL curriculum, there was no reduction in basic science knowledge. Instead, students acquired better pre-clinical learning experiences because the clinical scenarios challenged them to develop active learning strategies, memorise less and apply basic science knowledge to clinical medicine, while also acquiring a distinct set of skills and attitudes that would see them through the rest of their career.

PBL is based on the pedagogical principle that learning takes place in the context in which it will be used. Therefore, creating such learning environments fosters better learning outcomes for students by increasing their understanding and facilitating the storage, retrieval and retention of relevant knowledge (Mann, 2002; Prince et al., 2003; Rizzolo et al., 2006). Moreover, the focal point of the PBL curriculum model is to prepare students for professional practice because medical students will engage in an interdisciplinary environment upon entering clinical training, and thereafter as clinical practitioners.

To date, medical schools that have adopted a PBL curriculum (e.g., Harvard Medical School in the US, Maastricht Medical School in Amsterdam and the Monash graduate-entry MBBS program in Australia) use an interdisciplinary approach to teaching. In this curriculum, problem-based cases are constructed based on real-world clinical situations (Yiou & Goodenough, 2006; Prince et al., 2003), and they form the basis of the content to be covered for the week or block. By integrating the basic and clinical sciences with scientific reasoning, clinical reasoning and decision-making skills (Chakravarty et al., 2005; Herle & Saxena, 2011), students develop an understanding of the relevance of each discipline and its contribution to medicine. With respect to anatomy, students are directed to ask thoughtful questions about the importance and relevance of anatomical structures in the context of the clinical problem, and this process is thought to evoke interest beyond that of the learning objectives (Sugand et al., 2010). The PBL approach minimises didactic teaching, although some medical schools that use a PBL approach have reintroduced didactic anatomy lectures as part of their modified PBL program (Johnson et al., 2012). Strong emphasis is placed on active learning and self-directed learning, and academic staff mainly serve as facilitators to guide students in their learning (Brooks et al., 2015; Drake, 2007; Johnson et al., 2012;

Yiou & Goodenough, 2006). Small-group work is the main mode through which PBL cases are disseminated, and visual aids, clinical images and technology are the main tools employed in this form of teaching. No cadavers are used in the PBL setting (McLachlan, Bligh, Bradley, & Searle, 2004), but schools using PBL might still use dissection. Although students value the contextualised learning experience in this setting, PBL and self-directed learning have been regarded as both the best and worst features of medical education—primarily because some institutions lack a structural framework for the basic sciences (Lawson & Bearman, 2007). This is not to say that traditional learning of anatomy is better and that PBL does not have a positive outcome on the student learning experience. After all, no amount of time spent of teaching anatomy is useful unless the quality of the resources underpinning it is high (Fitzgerald et al., 2008).

Organ/Systems-based Curriculum

In the systems-based curriculum, schools organise their content according to system blocks, with each block extending over a few weeks. All of the basic science courses that were delivered separately in the traditional curriculum are now integrated into the organ-system course. The curriculum is structured over one to two years using traditional style lectures, with an equal distribution in terms of emphasising normal structure and function and abnormal structure and function of organ systems (Brooks et al., 2015; Johnson et al., 2012).

There is still some debate on the usefulness of this type of curriculum. Some authors have reported that the systems-based course has a positive effect on students' knowledge of anatomy (Klement et al., 2011), whereas another study reported a negative effect on students' knowledge of surface anatomy in particular (McKeown et al., 2003). It is unclear whether this can be applied to knowledge of gross anatomy because many factors (e.g., teaching hours, teaching staff and mode of delivery) must be considered when determining whether a particular curriculum aids in students' learning. The graduate-entry MBBS program at Monash uses the systems-based curriculum combined with a PBL curriculum so that for each system block (e.g., musculoskeletal), which runs for approximately four weeks, there are four PBL cases. Each case occurs at the beginning of a week and sets the tone for the topics to be covered during that period. Given the combined PBL system-based curriculum and the lack of literature findings on the usefulness and effectiveness of such a curriculum, this study provides a unique opportunity to explore the learning and retention of anatomy among medical students immersed in such a curriculum and subsequently identify the 'gaps' in their current knowledge base.

Modified Traditional Curriculum

The modified traditional curriculum follows that of its predecessors, and some medical schools have resisted the urge to integrate anatomy with other basic science disciplines; instead, they have opted to teach anatomy as a stand-alone course (Eisentein et al., 2014; Vasan, DeFouw, & Holland, 2008). The pedagogical delivery of this *modified* curriculum follows a regional approach and ranges from faculty-centred didactic lectures (Sugand et al., 2010) to a combination of didactic lectures and student-centred team-based learning (TBL) sessions (Brooks et al., 2015; Johnson et al., 2012).

Didactic teaching has always been regarded as a passive pedagogical approach to teaching. However, the introduction of technology in the classroom has altered this perception. Today, technological tools such as audience response systems (ARSs) are used to engage students in the classroom. ARSs allow students to respond to clinically relevant MCQs posed in the classroom setting and receive immediate feedback. This system is believed to enhance students' learning because they become actively involved in the delivery of content in the classroom. Therefore, lectures no longer have to be perceived as a passive process of conveying information to students. In fact, research conducted on the effectiveness of ARSs in all didactic teaching across anatomy/radiology and histology/genetics sessions over three years found a significant positive correlation between the use of ARSs and students' performance in summative assessments (Alexander, Crescini, Juskewitch, Lachman, & Pawlina, 2009).

Further, there is a positive association between student learning outcomes and the TBL approach, which involves a combination of individual pre-class preparation, in-class work and group-based in-class activity. In-class sessions begin with a quiz (first attempted individually and then as a team) to assess students' knowledge of the pre-class content. This is followed by a set of clinical application exercises to help students apply their content knowledge and develop their analytical and communication skills. The TBL approach to teaching gross anatomy has been shown to have a positive effect on developing students' critical thinking skills, as well as their long-term retention of knowledge (Vasan et al., 2008; Johnson et al., 2012). This approach was also viewed favourably by all medical students in a TBL anatomy course, irrespective of their performance in the examination (Vasan, DeFouw, & Compton, 2009). Group assessments associated with TBL activities have been shown to increase cooperative learning and summative performance in examinations (Pratten et al., 2014).

In relation to learning using cadavers, some schools that use the modified traditional curriculum have continued to use dissection supplemented by demonstrations of prosected material as their primary teaching method (Older, 2004). Studies comparing students' knowledge of anatomy within the traditional and PBL curricula have found that those in the traditional curriculum tend to have a stronger grounding in anatomy (Hinduja, Samuel, & Mitchell, 2005).

Thus, there is substantial variation in the organisation of the anatomy curriculum throughout institutions worldwide. Subsequently, there is a lack of consensus on what constitutes core knowledge of anatomy for junior doctors (Older, 2004; Orbson et al., 2014). Further, there is conflicting evidence in the literature regarding the best curriculum model. One study reports no significant difference in students’ anatomy knowledge between schools that offer a PBL curriculum and those that offer a traditional curriculum (Prince et al., 2003). Another study indicates that students who are actively involved in peer-to-peer learning through problem-based and team-based approaches are more likely to perform well on examinations than those who learn primarily and passively through didactic lectures (Vasan et al., 2008).

According to Bergman, Prince, Drukker, van der Vleuten and Scherpbier (2008), irrespective of the curriculum, there is a correlation between students’ performance in anatomy and three other factors: the amount of time spent on anatomy, the clinical relevance of anatomy being taught, and the revision and integration of that clinical knowledge in later years.

Regardless of the curriculum model used, the current pedagogical goal in medical education is focused on outcome-based education and developing or adopting a multimodal approach to teaching and learning—that is, an approach that involves active and contextualised learning (to increase students’ engagement and critical thinking skills), as well as horizontal and vertical integration (to increase students’ retention and consolidation of knowledge) (Drake, 2014; Drake et al., 2014).

2.3.3 Outcome and Competency-based Education

Outcome-based education (OBE) is rooted in the theoretical assumptions of behaviourism, which states that learners should be guided by an explicit set of outcomes to achieve a change in behaviour (Morcke, Dornan, & Eika, 2013). It primarily aims to establish learner and program outcomes, and the processes used to attain these outcomes are regarded as secondary. OBE specifies what a learner should be able ‘to do’, and it emphasises the type of doctor produced rather than the process of education (Harden, Crosby & Davis, 1999), thereby contributing a “visionary new approach to medical education”—that is, a paradigm shift (Morcke et al., 2013, p. 853). In essence, the end goal of education is to ensure competency so that individuals can adequately perform their role in professional practice (Basu, Roberts, Newble, & Snaith, 2004; Miller, 1990).

In medical education, the term *competency* is defined as “the habitual and judicious use of communication, knowledge, technical skills, clinical reasoning, emotions, values, and reflection in daily practice for the benefit of the individuals and communities being served” (Epstein & Hundert, 2002, p. 226).

Competency-based medical education (CBME) can be considered a component of OBE. CBME involves a transparent and structured organisation of the curriculum in the form of a competency framework such that the educational model that is developed specifies a set of competencies or pre-defined abilities expected of the learner at the end of a program. These competencies are listed as learning outcomes within the curriculum, and students are expected to acquire the necessary knowledge and skills associated with these outcomes by seeking out experiential activities in the workplace and actively engaging in the learning process (Frank et al., 2010). A curriculum or competency framework is viewed as necessary for sustaining professional competence (Frank et al., 2010). Further, it specifies the need to ensure that every medical graduate attains and demonstrates a certain level of competence in all domains (e.g., knowledge, clinical skills, communication, professionalism) required of practicing doctors.

Competency-based education has only recently come to the forefront of medical education (Leung, 2002), despite having been proposed decades earlier (McGaghie, Miller, Sajid, & Tedler, 1978) and having been used in professions such as pharmacy (Marshall, Adams & Janich, 1997) and chiropractic (Wangler, 2009). CBME has four main goals through which it aims to achieve its place in medical education (Frank et al., 2010). First, it focuses on developing curricular outcomes that are intrinsically related to the needs of those served by medical graduates. Second, it uses a constructivist approach to design curricular outcomes that are similar to a spiral curriculum in that each learning element builds upon previous components and continually incorporates prior elements while emphasising observable abilities (Frank et al., 2010; Phillips, 1995). Third, it emphasises developing learners' abilities in a time-flexible curriculum to sufficiently and efficiently engage students in mastering the skills required for their practice, given that all individuals are different and will achieve outcomes at a different pace. Finally, it epitomises learner-centredness, so that learners are encouraged to take responsibility for their learning by mapping the progress of each milestone required to become competent in a particular skill at a pace that reflects their learning style (Frank et al., 2010).

In Australia, national reform of competency-based education began in the early 1990s with the introduction of the Australian Qualifications Framework (AQF)—a national competency-based framework designed to ensure alignment and quality of Australian qualifications across all accredited education and training programs in the country (Australian Qualification Framework Council [AQFC], 2016). The framework consists of a taxonomic structure of ten levels—each with its own set of learning outcomes that describe the complexity and level of achievement and autonomy required of graduates. Within this organising framework, one represents the lowest level of complexity and ten represents the highest (AQFC, 2016). Currently, most medical schools producing MBBS or MBBS (Hons) graduates operate at an AQF level of seven or eight respectively. However, most medical schools are now moving towards a new Doctor of Medicine (MD) program, which has an AQF of nine (Australian Medical Students Association [AMSA], 2015).

Upon completion of a medical degree, students enter the prevocational phase—that is, the period between graduation and vocational training (AMC, 2016). A number of prevocational competency frameworks have been established in Australia and New Zealand, including: the National Intern Training Accreditation Framework (AMC, 2014), which provides a national standard for intern training in Australia; the general registration standards for new medical graduates (Medical Board of Australia [MBA], 2014) in Australia and New Zealand following internship; and the continuing professional development registration standard (MBA, 2016), which requires medical practitioners to continually maintain and enhance their knowledge, skills and performance through participation in professional development programs. In addition, there is the Australian Curriculum Framework (ACF) for Junior Doctors, established by the Confederation of Postgraduate Medical Education Councils (CPMEC, 2012), which consists of five domains—clinical management, professionalism, communication, clinical problems and conditions, and skills and procedures—each with its own set of categories and learning outcomes. The ACF builds on the principle of self-directed learning, workplace-based learning and vertical integration, and it specifies to prevocational doctors the outcomes they are expected to achieve during this phase (CPMEC, 2012).

In the US, similar competency frameworks in medical education were established by the AAMC with the introduction of six major domains of competence—

"patient care, medical knowledge, interpersonal and communication skills, professionalism, practice-based learning and improvement and systems-based practice" (Englander et al., 2013, p. 1089)—each with its own set of competencies regarded as necessary for certification by the Accreditation Council for Graduate Medical Education (ACGME) and the American Board of Medical Specialties (ABMS) (Morcke et al., 2013). The ACGME/ABMS framework provides medical students with the expectations for each competency, and it "currently forms the basis of all accredited residency and fellowship training programs in the US" (Englander et al., 2013, p. 1089).

While there are professional competency frameworks for medical graduates in Australia and New Zealand, there is no core competency-based framework for the discipline of anatomy. In fact, medical education programs in the region are built on the principles of integration. Over the past 15 years, nine new medical schools have been established in Australia—twice as many as there were prior to the year 2000 (Medical Deans Australia and New Zealand, 2011). These medical curricula house the five- or six-year direct-entry MBBS programs, where students can enter medicine directly from high school if all entrance requirements are met, as well as the four-year graduate-entry curriculum, which students enter after having obtained a previous degree. In both curricula, disciplines such as epidemiology, society, law and ethics are integrated with the basic sciences and clinical skills and are underpinned by an overarching curriculum delivery model, which is the PBL systems-based curriculum model at Monash University. Therefore, students must successfully pass integrated examinations as a whole and not worry about meeting competencies in any particular discipline. The assessment of the curricula in this manner has led to many debates in the literature, which will be discussed further in Chapter 4.

2.3.4 Modern Teaching Tools Used in Anatomy

In the modern curriculum, where time for learning has been contracted, the focus on what must be learned has shifted, and there is a need to ensure that an adequate amount of anatomy is taught to prepare medical students for safe clinical practice. With declining resources and reduced teaching hours, a multimodal approach to teaching anatomy has been implemented (Johnson et al., 2012), and a number of methods may be employed by medical schools to facilitate the delivery of anatomy. These include teaching mainly through formal lectures; small-group teaching through PBL, TBL and tutorial-based sessions; dissection of cadavers; prosections with tutor demonstrations; models (both plastic and plastinated); e-learning; and living and radiological approaches (Olowo-Ofayoku & Moxham, 2014; Patel & Moxham, 2006; Sugand et al., 2010). Not all methods are used by all institutions; however, modern teaching of anatomy involves an integrated and multimodal approach, and several methods are used in the delivery of the course (Sugand et al., 2010).

Didactic and Small-group Teaching

Institutions around the world have employed, either in combination or as a sole pedagogy, the use of lectures, tutorials and/or problem-based sessions to teach anatomy to students (Olowo-Ofayoku & Moxham, 2014). In the US, the reported average number of lecture hours for anatomy is 41 (standard deviation [SD]+/- 24), with a range of 0–110 hours (Drake et al., 2014). Given that the average number of course hours for anatomy is around 147 (SD+/-41), with a range of 65–249, this number represents almost 50% of the anatomy teaching time. The difficulty with the ‘sage on the stage’ style of lecturing is that students’ attention starts to diminish after 15 minutes in a one-hour lecture. If the content of the lecture is overly fact-based and dry, and if students are not engaged during the session, it could overwhelm their cognitive load capacity, leading to limited attention. Perhaps using ARS to pose clinically-relevant questions to students can be a way of increasing student engagement during lectures (Alexander et al., 2009).

To engage students in their learning, small-group teaching has emerged as a teaching modality, with students at one end immersed in discussion of the allocated topics and a tutor at the other end serving as the facilitator for the session. Small-group teaching that fosters active participation and learning can result in increased student engagement, attention and motivation (Moscova et al., 2015). However, research has shown that many students still prefer didactic teaching, dissection and prosection when they are first exposed to anatomy in a medical course (Azer & Eizenberg, 2007; Snelling et al., 2003; Lempp, 2005). This is not surprising, as one would expect that when exposed to the large volumes of information that encompass the discipline of anatomy, novice medical students would likely find comfort in being directed by an experienced teacher or faculty member than by peers and their own learning (Fitzgerald et al., 2008). Further, educational theory postulates that self-directed learning is enhanced by giving students a firm foundation of basic principles (Davis et al., 2014). In the modern curriculum, new methods of delivering lectures have been introduced as part of the blended learning model. Within this model, the flipped classroom technique involves individual self-study and preparation for class, which is achieved by reading the prescribed resources and/or listening to an online recorded lecture so that classroom time is devoted to discussion, problem-solving and other team-based activities that promote a more active and engaging learning environment (Moscova et al., 2015). In this way, students are actively involved in their learning instead of passively receiving information. The Monash curriculum offers a combination of didactic lectures and small-group teaching in anatomy and consequently, this study explores students' perceptions about the usefulness of these two types of teaching modalities to obtain insights into how their learning of anatomy takes place in a time-pressured and condensed medical curriculum.

Dissection

The exploration of the body through dissection has been a focal point of traditional anatomy teaching since the beginning of ancient civilisations, and it is dissection that separates historical and traditional medicine from modern-day medicine. Questions surrounding the importance and use of dissection have been debated for decades. Given that anatomy is a constant science, there is always a question of whether we have learned all that we can from the human body. Further, should medical students with no foundation or knowledge of anatomy be given an opportunity to dissect at the start of medical school?

As the evidence below will illustrate, there were and still are many opponents of dissection who believe that its presence in the medical curriculum should be removed, much like the older forms of the traditional curriculum. At a time when anatomy was being squeezed out, ‘traditionalists’ (anatomy teachers favouring dissection) struggled to retain dissection as a teaching form, claiming that it had practical value as an applied science, and therefore its place in the curriculum was warranted (Turney, 2007; Warner & Rizzolo, 2006). Further, the increasing complexity of biomedical knowledge meant that collaboration among healthcare professionals was essential in providing optimal patient care. Therefore, the dissection laboratory was viewed as the most appropriate venue to instil the values of teamwork, collaboration, professionalism and leadership (Swick, 2006). However, the modernists’ approach was to phase out dissection-based teaching in favour of newer teaching modalities (Turney, 2007).

The formation of new anatomy laws to govern the acquisition of bodies for teaching and research purposes, as well as the introduction of body donation programs and an increase in the number of medical schools worldwide, led to a lack of cadavers available for medical institutions (Leung et al., 2006). Fewer people were donating their bodies to science, and the governing laws meant that unclaimed bodies could no longer be sourced to meet the increased demand. Consequently, dissection was phased out as a teaching aid to learning anatomy in many, but clearly, not all, institutions.

Critics believe there is insufficient evidence in the literature to suggest that dissection is essential in producing good doctors with long-term retention of anatomical knowledge (McLachlan & Patten, 2006; Pawlina & Lachman, 2004; Sugand et al., 2010). Dissection is also seen to have health and safety risks, including exposure to embalming fluids and infectious diseases within cadaveric tissue such as human immunodeficiency virus, tuberculosis and other pathogens (McLachlan & Patten, 2006; Pratten et al., 2014). However, the *Human Tissue Act 1982* in Victoria, Australia prevents the donation of bodies plagued with infectious diseases.

Other critics have opposed the idea of the students' first patient encounter being with a cadaver because it could result in a level of desensitisation and detachment and lead to physicians treating patients—particularly dying patients—with a lack of empathy (Marks et al., 1997; McLachlan & Patten, 2006). However, students in today's integrated medical curriculum often encounter patients within the first few weeks of medical school, both in the anatomy laboratory and on clinical placements, so this view is no longer warranted. Further, some studies suggest that the confrontation with death experienced through exposure to a cadaver causes some students to undergo severe anxiety, stress and depression (Davis et al., 2014; Druce & Johnson, 1994; Nnodim, 1996; Quince, Barclay, Spear, Parker, & Wood, 2011). While there are psychological and emotional effects associated with cadaveric exposure, medical schools are now well equipped to offer support to students who have difficulty coping with these encounters. A student who has recently lost a loved one and struggles with participating in the dissection room is encouraged to seek support or is offered counselling through the university. In addition, a plan is formulated between the student and the teacher to assist them in their learning. For example, the student may be asked to initially attend a one-on-one session with the tutor using prosected or potted specimens rather than a full cadaver. This allows students to slowly transition into the anatomy laboratory, which is equipped with large numbers of fully dissected bodies.

Although these factors may affect an institution's decision to retain or abandon dissection as a teaching tool, the issue of finance has had the greatest influence. Dissection is an expensive resource to maintain; it not only requires an extensive storage facility with proper ventilation and drainage, but the cost of transporting cadavers and disposing of the bodies following their use either via burial or cremation must be considered (Leung et al., 2006; Older, 2004). In addition, the issue of staffing resources, and of having appropriate and qualified teaching staff to prepare and maintain the cadavers, is further associated with increased costs, which puts a strain on an already-constrained university budget. Consequently, institutions are often faced with the task of measuring the pros and cons associated with maintaining such a facility. In the face of economic stringency, dissection rarely weighs up (Older, 2004) and is often sidelined in favour of newer cost-effective visualisation software such as Visible Body—3D Human Anatomy (www.visiblebody.com), virtual dissection software such as Anatomage (www.anatomage.com), 3D printing (http://www.3danatomyseries.com) and multimedia learning software such as Ana@tomedia (www.anatomedia.com). Additionally, to accommodate dissection as a teaching resource, a significant portion of time needs to be invested in a medical curriculum that is already time-constrained and heavily scheduled (Leung et al., 2006). Therefore, as a cost-saving measure, most medical institutions worldwide abandoned dissection as a form of teaching to support learning in anatomy (Guttmann, Drake, & Trelease, 2004; McLachlan, 2004; McLachlan et al., 2004), thereby instituting what is known as “the reformed curriculum” (Pabst, 2009, p. 543). In light of this reformed curriculum, and “in hope of coping with modern practice, the conventional pedagogy of dissection is in the process of being revolutionised and enhanced if not replaced by more innovative modalities” (Sugand et al., 2010, p. 83). The “cadaverless gross anatomy lab” then remains (Korf et al., 2008, p. 18).

Australia has not followed the trend for all schools to abandon dissection. Currently, there are 19 medical schools in Australian and two in New Zealand. Of these, 15 universities give students an opportunity to experience dissection, with six schools offering it as an optional elective (Craig et al., 2010) and three making it a compulsory experience (Parker, 2002). Another recent study indicates that 17 of the 21 medical schools give students an opportunity to dissect during their medical degree. However, the opportunity varies, with some schools making it optional and others having compulsory dissection (Bouwer et al., 2016). Given the financial considerations associated with housing such facilities, institutions that offer dissection as part of their curricula must have well-established body donation programs and in-house facilities for storage to maintain a supply of cadavers for teaching purposes.

It has been speculated that anatomists who believe dissection is important to medicine would be reluctant to accept a move away from dissection as a teaching tool for anatomy. However, a survey measuring the attitudes of anatomists towards curricular change appears to be positive, with 92% of respondents being receptive to such modifications in the curriculum (Patel & Moxham, 2006). However, some studies ascertain that anatomy teaching using cadaveric dissection is recognised by clinicians, anatomists and students to be a superior tool and the gold standard for learning anatomy and achieving course aims (Davis et al., 2014; Patel & Moxham, 2006; Raftery, 2007). An in-depth analysis of the outcomes of cadaveric dissection suggest a slight in-favour vote for dissection over prosection (Winkelmann, 2007). Some critics feel that in the absence of justifiable evidence for modern teaching methods, medical students should be given an opportunity to engage in dissection, which is the time-intensive traditional instructional tool for anatomy (Farey et al., 2014). Other studies investigating students' attitudes towards anatomy teaching have favoured dissection as the most preferred approach for both teaching and learning (Olowo-Ofayoku & Moxham, 2014). Unfortunately, this theory cannot be tested in this study because dissection is not a component of the graduate-entry anatomy curriculum. Given the learning theories discussed in the next section, it can be argued that students' preference for dissection (Azer and Eizenberg, 2007; Lempp, 2005). can be attributed to the constructivist approach that this teaching tool offers, because students are actively engaged in the process of learning and consolidating knowledge from lectures in the dissection room, which subsequently helps them learn and retain anatomy better. However, studies have also shown that students learn through a variety of different ways (Davis et al., 2014; Smith et al., 2014) and knowledge of anatomy (as demonstrated by examination scores) is therefore not dependent on whether students learnt from a prosection-based or a dissection-based curriculum (Cuddy et al., 2013; Nnodim, 1990). Ultimately, whether medical schools choose to offer dissection as part of their curriculum largely depends on institutional costs, facilities and staffing support. For those that do not or cannot offer dissection, prosection is an alternative solution.

Prosection

Soon after dissection was abandoned in institutions, many medical schools worldwide began investing in prosections—that is, a cadaver that has been carefully dissected into regional or systemic components by a professional anatomist (Pabst, 2009; Parker, 2002). These pre-dissected wet specimens are subsequently used to teach gross anatomy, thereby giving students an opportunity to explore, visualise, understand and appreciate the 3D and spatial relationships between the different anatomical parts.

The debate between dissection and prosection has been ongoing, and it appears that the medical anatomy curriculum has undergone repeated transformations, with some institutions reverting to their original mode of teaching. This occurred as a result of complaints from the medical student body about the lack of opportunities to engage with and learn from specimens, with some schools reverting to dissections following complaints from clinicians about students' lack of anatomy knowledge (Pabst, 2009; Rizzolo & Stewart, 2006). In a resource-poor environment—both in terms of teaching staff and sourcing cadavers—prosections offer all the benefits of dissection, but they do not allow medical students to develop technical skills in the art of dissecting. Hence, prosected specimens occupy a large part in the modern curriculum in Australian and New Zealand medical schools (Bouwer et al., 2016).

Comparison Between Dissection and Prosection

In a survey conducted by Azer and Eizenberg (2007), first-year medical students indicated a strong preference for dissection as a preferred tool for learning anatomy, indicating that it is important for developing a deep understanding of anatomy (Smith & Mathias, 2007) while supporting them in better recall of knowledge. In contrast, second-year students preferred textbooks to dissection, indicating that learning anatomy is a dynamic process. That is, as students acquire infrastructure knowledge and experience, the process of teaching and the resources required to support them in their learning also evolve.

Similar views have been observed elsewhere, with most students favouring dissection over alternatives because it builds on their anatomy knowledge and helps develop their confidence (Johnson, 2002; Kerby et al., 2011). At a Singaporean medical school, 90% of students agreed that dissection was more valuable and should not be replaced by prosected specimens (Leong, 1999). However, prosections accompanied by tutor demonstrations of the prosected cadavers was viewed as the second-best option for learning anatomy (Kerby et al., 2011). This suggests that guided exposure to anatomical specimens can provide similar benefits to dissection. This theory was corroborated by a study that showed little difference between the prosection and dissection groups when students' retention of anatomy knowledge was compared five years after anatomy teaching (Nnodim, Ohanaka, & Osuji, 1996). One could speculate that students' approaches to learning styles affect their preference for dissection over prosection and vice versa. Given that there are fewer course hours in a prosection class relative to dissection, this suggests that prosection is equally effective and is probably the most efficient tool for achieving course outcomes in anatomy (McLachlan & Patten, 2006). Further, prosection is considered a close second to dissection (Davis et al., 2014) because it offers a practical learning experience without the need to carry out dissection.

Once again, the evidence for dissection versus prosection is conflicting. Studies that compare the anatomy performance of students who have undertaken dissection with those who have undertaken prosection have found educational outcomes to be similar, with no significant difference in performance (Nnodim et al., 1996; Snelling, Sahai, & Ellis, 2003). Conversely, some studies have found a small but statistically significant difference favouring students who perform dissections (Dinsmore, Daughtery, & Zeitz, 1999; Winkelmann, 2007; Yaeger, 1996). Regardless of whether the teaching modality is dissection or prosection, the Anatomy Museum, which houses a large collection of wet specimens, cadavers, skeletons, electronic teaching platforms, and plastic and plastinated models, remains an important teaching resource in many institutions worldwide (Jones & Harris, 1998).

Teaching Models—Plastination

Plastination is a relatively new and advanced science that enables the preservation of bodies in their entirety, as individual body parts or as cross-sectional slices of individual body parts (Dhingra, Taranikanti, & Kumar, 2006). Since its development in 1977 by the German anatomist Gunther von Hagens, the technique of plastination has revolutionised the way anatomy is taught in medical schools. It involves replacing bodily fluids such as water and fat with polymers such as resin, silicone and polyester, which possess different mechanical properties (von Hagens, Tiedemann, & Kriz, 1987). The result of the plastination process is that the tissues are dry and mimic life-like specimens, while their robustness and lack of odour enable their use in educational settings (Reidenberg, & Laitman, 2002; von Hagens et al., 1987).

As is the case with any instructional tool, proponents and opponents have voted for and against its presence in an educational setting. The proponents of plastination highlight the importance of these specimens in teaching, stating that the extremely high quality of plastinated material (which is produced from bodies obtained through the body donation program) allows students to fully appreciate the human form and to study it repeatedly, with minimal wear and tear occurring. Plastinated specimens are considered more valuable than plastic models because they retain anatomical variations and pathology. As demonstrated by Latoree et al. (2007), plastinated specimens are highly used and appreciated by veterinary students in learning anatomy, and statistically significant differences are recorded in post-test anatomy scores between the control (without use of plastinates) and experimental groups (use of plastinates).

Opponents of plastination acknowledge that plastinates are useable and durable, but also that they are rigid in nature, so the haptic and tactile experience of manipulating actual specimens is lost. Therefore, plastinate models are limited in their ability to offer students a truly valuable learning experience. In essence, these models lack a vital component of the human form, leading to a loss of authenticity in the final product. Water and fat, which largely form the human body, are replaced by synthetic material, thereby restricting mobility and subsequently an understanding of the relationships between the underlying and surrounding structures (Korf et al., 2008). In addition, while a series of plastinated models depicting a list of anatomical variations may be interesting to a medical student who first encounters them, they soon lose their novelty value as the student begins to memorise the list of variations (Korf et al., 2008). When compared with the process of dissection—where every cadaver has unique anatomical variations—dissection provides a greater opportunity to strengthen students' cognitive and analytical skills (Slotnick & Hilton, 2006).

Thus, several authors believe that, while plastination provides many advantages to students, it should be used in conjunction with dissection (Older, 2004; Sugand et al., 2010) or prosection. In Australia and New Zealand, plastinated models are used as part of the anatomy teaching program in nine of the 19 medical schools surveyed (Craig et al., 2010).

Plastic Teaching Models

Plastic models can be found in every medical school. These specimens, which are modelled on prototypical representations of anatomical structures and are devoid of variations or pathology, are often found in tutorial rooms, anatomy museums and laboratory rooms. They are considered an alternative to dissection because they give students a 3D perspective of an anatomical organ or structure. However, in reality, structures within a plastic model are colour-coded to be distinct from surrounding organs and moulded with such perfection that they lack authenticity and fail to give students an understanding of variation. This leads to a false sense of, and a superficial orientation to, the human body, which can result in misdiagnosis, especially if this is the only resource used by the student when learning anatomy (Pawlina & Lachman, 2004; Sugand et al., 2010) and a review of the literature has found no significant benefits of the use of plastic models against traditional teaching using dissection, textbooks and lectures (Azer & Azer, 2016).

E-learning and Technology

Anatomy as a discipline is concerned with studying the different parts that make up the body and the spatial relationships between these parts. Therefore, possessing good spatial ability is the key to improving one's understanding of the 3D relationships between various anatomical structures (Moscova et al., 2015). Spatial ability can be defined as "the ability to rotate images mentally or the ability to mentally interpret the spatial relationships between parts of an object or between different objects in space" (Vorstenbosch et al., 2014, p. 109). Students who have well-developed spatial abilities have been found to be more successful in practical anatomy examinations than those who have poor spatial skills (Rochford, 1985) because 3D visualisation stimulates deep learning within students and increases their motivation to develop further insights into the topic area (Silen et al., 2008).

Developing spatial ability also requires students to be exposed to the presence of visual images. This is seen to influence both the learning processes and learning outcomes and is therefore fundamental to learning anatomy (Vorstenbosch et al., 2014).

In the absence of dissection, many interactive multimedia tools have surfaced in the education market to give so-called ‘digital natives’ a variety of resources with which they can learn anatomy and subsequently better equip themselves to develop their spatial skills. The term *digital natives* is used to describe the new generation of learners who have grown up in the digital age, who are proficient in accessing technological resources and who are “no longer the people our educational system was designed to teach” (Prensky, 2001, p. 1). Award-winning resources mainly used by this generation of learners include Acland’s DVD of Anatomy (Acland, 2003), which contains exquisitely dissected specimens as they appear in the body; Anatomy.tv (2006), an interactive online 3D anatomy database; and An@tomedia online (Eizenberg, Briggs, Barker, & Grkovic, 2000), a comprehensive online learning package that gives students an opportunity to explore and learn anatomy from general, systemic, regional and radiological perspectives.

Further, students can rely on these online tools and access them from any device, such as a desktop, laptop, tablet or phone (Srinivasan, Keenan, & Yager, 2006), thereby increasing their usability outside of the classroom setting. Studies on computer-assisted learning have found that not all students use such tools in their learning, and usage is predominantly associated with gender and learning style. Also, students who accessed online content scored significantly higher on examinations than their counterparts (Kish, Cook, & Kis, 2013; McNulty, Sonntag, & Sinacore, 2009). Another study that examines the applicability of mobile technology and its efficacy in increasing learning in medical students finds that students access learning resources provided through mobile technology on a daily basis and often use such resources while travelling to placements (Fuller & Joynes, 2015). This not only allows them to better prepare for patients they are about to see, but it also makes their workplace learning experience more enjoyable and meaningful.

Given that the anatomy curriculum in many medical schools moves students away from the dissection room, there is often a struggle to retain what has been learned in anatomy without the visual reinforcement obtained through prosected or dissected specimens. Therefore, the importance of web- and mobile-based instruction tools is crucial to the future of anatomy teaching and learning because poor 3D visualisation of anatomical structures can lead to inefficient use and interpretation of 3D imaging technology and subsequent errors during surgery and treatment (Marks, 2000, 2001). Errors and incompetencies in reading and interpreting anatomical images could have disastrous consequences. Therefore, the use of e-learning and technology in medical education is highly warranted.

Imaging

Imaging is used in clinical practice as outlined earlier in this chapter. However, given its significance in patient diagnosis and patient care, medical imaging and its innovations in technology have produced powerful new tools for studying anatomy. As a result, it is being used as a teaching tool for anatomy in many medical schools around the world. CT, MRI and ultrasound are among the modern techniques that have revolutionised medicine and highlighted the importance of cross-sectional anatomy by enabling detailed observations of the internal anatomy of the body—especially that of spatial and sectional anatomy (Murphy et al., 2015; Older, 2004). These instruments are viewed as adjuncts to dissection, which is regarded as a destructive process because the body is taken apart layer by layer to appreciate and understand the organisation and spatial relationships of the different body parts. With imaging tools—for example, an MRI of the brain—a detailed internal visualisation of the intracranial structures is provided without the need to deconstruct the body. Additionally, these technological tools enable the study of brain function and relevant physiology, as well as depictions of muscles, ligaments, tendons, cartilages and nerves, which are usually difficult to achieve through other means (Collins, 2008). The increased use of imaging technology in medicine has placed a greater demand on medical education to incorporate medical imaging in the anatomy curriculum (Davis et al., 2014). Many studies have called for imaging to be introduced in the pre-clinical years because it is one of the most basic and important aspects encountered in everyday clinical practice (Ahmed et al., 2011; McLachlan et al., 2004). However, there are variations within different schools regarding the amount of teaching that students receive in this area, if any at all.

Further, the field of radiology integrates the disciplines of anatomy, physiology and pathology to interpret signs that may be visible on these images (Gunderman & Wilson, 2005). Therefore, many institutions are now implementing radiology and cross-sectional anatomy sessions into pre-clinical teaching to prepare students for the clinical years (Chowdhury, Wilson, & Oeppen, 2008). In doing so, students are more likely to develop key skills in interpreting anatomical structures on medical images, and therefore recognise the importance of medical imaging in clinical practice (Moscova et al., 2015). Radiological images used in teaching can also be stored electronically and made available for students to access at a later stage, thereby increasing their usability outside of the classroom.

Surface Anatomy

As previously outlined, surface anatomy is the interpretation of anatomical and clinically relevant surface landmarks in patient care (Boon et al., 2002; Sugand et al., 2010). Given the demographic variations in age, gender, ethnicity, body weight and height, textbook descriptions of surface anatomy cannot be directly translated into a one-size-fits-all category (Standring, 2012). Its importance in clinical practice is widely recognised because it primarily applies to the act of physical examination, radiological interpretation and diagnosis. Many institutions now implement surface anatomy workshops as part of their teaching curriculum to foster an environment where students can not only apply anatomy knowledge to the body surface, but also develop confidence in examining peers and being examined by peers (Aggarwal, Brough, & Ellis, 2006). Students in a traditional curriculum have better knowledge of surface anatomy than those in an integrated curriculum (McKeown et al., 2003) for reasons that are yet to be determined. It may be because of the amount of curriculum time devoted to learning anatomy, as well as the opportunities students receive to practice what is being learned in class. Nonetheless, surface anatomy is a relatively important skill for medical students because it forms the basis of physical examination in any medical speciality and paves the way for other anatomy-related learning activities, such as body painting.

Body Painting

Body painting involves the application of non-toxic paint to the body surface in an attempt to appreciate surface and clinical anatomy. A good knowledge of surface anatomy is required so that students can paint the organ onto the body surface at the site of its projection (Op Den Akker, Bohnen, Oudegeest, & Hillen, 2002). In essence, body painting combines art and science and allows students to draw anatomical structures such as muscles, tendons, nerves, blood vessels and organs on other students. It enables students to transfer knowledge obtained from a textbook onto a 3D figure, resulting in consolidation of that knowledge. Body painting is seen to enhance students' learning of anatomy while promoting retention and recall of knowledge (Finn & McLachlan, 2009; McMenamin, 2008). However, this may not apply to students who do not participate in such activities, and who are passive members within the group, because contextualisation and recontexutualisation of knowledge is more likely to occur when students are actively engaged in the learning process (Evans, Guile, Harris & Allan., 2010).

Further, while surface anatomy and body painting require participation from all students and a level of camaraderie among peers, research has shown that physically examining a peer creates issues of embarrassment for some students—particularly females and ethnic minority groups—because it requires exposure of certain body parts that are being examined or drawn upon (Aggarwal et al., 2006). Therefore, during surface anatomy, clinical anatomy and body-painting sessions, male students often volunteer themselves to be examined and drawn upon. This type of gender segregation is considered a hindrance because it creates a barrier to clinical examination (Aggarwal et al., 2006). Given that the clinical environment does not discriminate against patients, it is important for medical students to become familiar and comfortable with the activities surrounding physical examination.

Textbooks

Irrespective of other teaching methodologies, medical students deem textbooks to be the primary and most valuable resource for learning anatomy—particularly because they provide a strong foundation in understanding anatomical content and clinical applications (Azer & Eizenberg, 2007). Further, most anatomy textbooks recommended by institutions offer surface anatomy, radiological anatomy and practice questions for testing and consolidating learning (Azer, 2013). This gives students a one-stop resource for acquiring and evaluating their anatomy knowledge. Two of the most common textbooks used in the anatomy curriculum today are *Clinically Oriented Anatomy* (Moore, Agur, & Dalley, 2013) and *Gray's Anatomy for Students* (Drake, Vogl, Mitchell, & Gray, 2010). Students rely on textbooks as a guiding reference tool through which they approach anatomy learning while appreciating the relevance and significance of anatomical structures in medicine (Smith & Mathias, 2007).

To conclude, there is no single best method for teaching anatomy because all pedagogical tools have advantages. Instead, modern anatomy teaching involves both integrated and multimodal approaches, with several of the methods described above being used in the curriculum (Estai & Bunt, 2016; Davis et al., 2014). By providing students with multiple modalities for learning and a variety of experiential learning opportunities, those with different learning styles can engage with and meet their learning goals (Johnson et al., 2012). Visualisation of the 3D relationships of anatomical structures helps to reinforce anatomy knowledge and makes content more meaningful, thereby decreasing cognitive load (Pratten et al., 2014). Students who learn anatomy through a condensed and integrated curriculum that combines lectures (to provide the framework), case-based active learning (to facilitate clinical integration), tactile hands-on practical applications such as dissections, prosections, interpretation of imaging (to facilitate 3D spatial anatomy learning), and frequent assessments (to test and consolidate knowledge) are more likely to have better anatomy knowledge and scores (Halliday, O'Donoghue, Klump, & Thompson, 2015). In fact, similar to a spiral curriculum (Bruner, 1977), increased horizontal and vertical integration of anatomy throughout the MBBS curriculum, combined with increased exposure to clinically relevant concepts results in better student performance, regardless of the teaching approach utilised (Bergman et al., 2008). However, in a modern medical curriculum that is driven by OBE, it is important to explore the theories behind learning, the processes surrounding assessment of anatomy and how the curriculum influences students' approaches and outcomes because these can affect the learning activities developed within the different arenas of medical education.

Chapter 3: Learning and Assessment of Anatomy

In this chapter, Section 3.1 describes some of the different learning theories and examines how learning occurs not just in a formal educational setting, but also in the workplace, where the physical environment plays a role. It discusses three different approaches to learning as they relate to the discipline of anatomy, as well as how these approaches can affect learning and knowledge retention.

Section 3.2 outlines the different modalities through which anatomy used to be assessed in the traditional curriculum, how it is assessed in the modern curriculum and the similarities and differences in how it is assessed in the graduate-entry MBBS program at Monash University.

3.1 Learning Approaches and Theories

Given the nature of this research, the theoretical aspects of learning must be considered and explored to develop a better understanding of how students acquire and retain knowledge when this is presented in a variety of settings.

3.1.1 Theories of Learning

Learning is a process of change that occurs when individuals acquire knowledge about the world. By understanding the process involved in absorbing information and the factors that influence learning, theorists have described learning from two different perspectives: objectivist and constructivist. Historically, the teaching and learning of anatomy draws upon a range of these theories.

Both behaviourists and cognitivists are regarded as objectivists; that is, they view knowledge as objective—as existing outside the mind of an individual.

Behaviourists

Behaviourists such as Skinner, Pavlov, Watson and Thorndike view learning as a process that is determined by the external environment rather than the learner, which results in an observable and quantifiable change in behaviour (Merriam & Caffarella, 1991). They view the world as fundamental to transmitting knowledge to the learner in the absence of any contextualisation or interpretation, and repetition and reinforcement are the key components of the behaviourist approach to learning (Hartley, 1998). The traditional form of teaching anatomy, which centred around numerous hours of lectures, could be regarded as operating under the behaviourist approach, wherein the teacher is the active provider of information, or the “sage on the stage” (Collins, 2009, p. 19), and the learner is the passive recipient. This didactic approach to teaching results in students adopting memorisation techniques and learning by rote (Collins, 2009) to assimilate information presented by the teacher, and there is evidence to suggest that such approaches to learning make it more difficult to retain knowledge (Vasan et al., 2008).

Cognitivists

Cognitivists such as Lewin and Gagne focus on the learner’s internal (mental) processes (e.g., information processing, storage and retrieval) that are involved in the act of learning (Ertmer & Newby, 2013; Merriam & Caffarella, 1991). According to the cognitive approach, conditions for learning must be optimal in that instruction must be clearly structured, well organised, easy to understand and contain feedback so that learners can begin to appreciate the importance of prior knowledge to the learning process (Hartley, 1998).

The cognitive model has the student as the learner at its centre. It emphasises developing or constructing tools that allow the student to learn and apply that knowledge in a variety of settings—a process that involves deep learning (Collins, 2009). For this to occur, new knowledge and concepts must be presented considering what is already known, as this has been shown to facilitate learning (Norman, 2009). Theoretically, it can be argued that dissection follows the cognitive model of learning because students apply knowledge from lectures to the dissection table, where they actively engage in the process of dissecting (Older, 2004; McLachlan & Patten, 2006). However, given that anatomy is a fact-based discipline, students must remember to apply a vast amount of information in the practical setting. For example, for every structure, students need to know its anatomical name, its origin and course through the body, and where it can be damaged during dissection. In the traditional curriculum, anatomists were criticised for their role in providing such detail because it not only overwhelmed students and subsequently affected their learning, but it was also considered irrelevant to clinical practice (Orbson et al., 2014).

Therefore, it is not enough to create activities that one hopes will allow students to make inferences. It is equally important to understand how students acquire and retain knowledge, and how the transfer of knowledge from short-term to long-term memory occurs (Magid et al., 2009) because it is important to manage students' cognitive load to maximise learning.

Cognitive load is defined as "the amount of mental activity that a particular task imposes on a working memory" (Moscova et al., 2015, p. 216). For students to learn, information must be processed first within their working memory (i.e., short-term memory) before it can be transferred into long-term memory (which has an unlimited capacity to store information). Since working memory has limited capacity, the transfer of knowledge becomes difficult if the cognitive load is too high. Total cognitive load is based on a combination of intrinsic load (the inherent level of difficulty of the content to be learned) and extraneous load (the way in which instructional material is conveyed to students). If students are presented with too much extraneous load through large amounts of information at any given time, they are more likely to experience cognitive overload—particularly if their intrinsic load is already high (Kirsh, 2000). This is most likely to occur in a condensed and integrated curriculum where time is constrained but the volume of information to be covered increases. Consequently, students become unable to process the information, let alone store it in their long-term memory, and this is viewed as detrimental to their learning (Moscova et al., 2015; Mousavi, Low, & Sweller, 1995). To combat the overload of content, students adopt surface approaches to learning (Pandey & Zimitat, 2007). Therefore, to maximise students' learning and cognitive capacity, content must be delivered in a simple way. For example, the use of images accompanied by an audio explanation has been found to be more beneficial in learning than the use of both audio and text in addition to an image (Kalyuga, Chandler, & Sweller, 1999). This finding can be further extrapolated to combine other approaches to provide information to students and help them with the transfer of knowledge from short-term to long-term memory.

Constructivists

Constructivists are contemporary cognitive theorists who question the philosophical nature of objectivity and ascertain that although an external reality exists, individuals construct reality differently depending on their beliefs and interpretations of their experiences with the external world (Jonassen, 1991). Piaget, Bruner and Dewey are among the theorists who represent the constructivist perspective in which learners are considered central to the learning process because they use their existing knowledge and personal experiences to construct and adapt to new knowledge (Ertmer & Newby, 2013; Phillips, 1995). Therefore, with the paradigm shift along the behaviourist, cognitivist and constructivist continuum, the focus of instruction moves from passive learning, where the teacher is the 'sage on the stage', to active learning, where the student is a key participant in problem-solving and reasoning to develop and extend knowledge structures.

Thus, learning involves a combination of processes that are both external and internal to the learner. External processes involve memorisation, extensive knowledge of a topic and acquiring facts and skills that can be used when required. Internal processes involve abstract reasoning, making sense of the world from the information acquired and comprehending the world by interpreting and reinterpreting knowledge (Ramsden, 2003). The discipline of anatomy involves a certain level of memorisation and comprehension to apply factual knowledge to a variety of clinical settings. Thus, learning cannot be simplified into an ‘either–or’ approach. Possessing knowledge of a particular task does not necessarily translate into being able to perform that task (Lazarus, Chinchilli, Leong, & Kauffman, 2012).

While it appears that the constructivist approach to learning dominates modern education, Alexander, Schallert and Reynolds (2009) remind us that there is no grand theory of learning. Further, the philosophical assumptions of learning that highlight the developmental processes of cognition and behaviour cannot be fully applied to the processes used in adult learning. Therefore, a new set of principles and theories have been developed to generate a better understanding of how adults learn—particularly in the workforce.

3.1.2 Adult Learning and Learning in the Workplace

Adult learning is defined as “the process of adults gaining knowledge and expertise” (Knowles, Holton, & Swanson, 2015, p. 157). All decisions regarding the curriculum, teaching and assessments are significantly influenced by learning perspectives (Mann, 2002), and curriculum experts in tertiary institutions will often examine how adults learn when creating or developing learning outcomes for a course.

There is no single theory that can be applied to adult learning. Instead, multiple learning models have been discussed in the literature to identify how adults acquire knowledge and how educators can help adult learners achieve the best outcomes from their practice. According to Bennett, Blanchard and Hinchey (2012), "adult learning theory is a complex phenomenon" (p. 129) comprising an interconnected set of learning models to address how adult learners gain knowledge. Although several learning models are discussed in the literature, those of andragogy, self-directed learning and workplace-based learning will be discussed in the corresponding sections.

Andragogy

Leading theorist Malcolm Knowles (1980) is renowned for distinguishing the adult learner from the child learner. His *andragogy* theory, which is defined as the "art and science of helping adults learn" (Knowles et al., 2015, p. 40), outlines six foundational principles through which adults learn. This theory is differentiated from that of *pedagogy*, which is defined as "the art and science of teaching children" (Knowles et al., 2015, p. 19). Although pedagogical assumptions are teacher-directed and based on the learner being dependent on the teacher—that is, learning only what the teacher teaches—assumptions about adult learners include *need to know* (learners must understand why they need to learn something to invest full energy into learning); *self-concept* (learners become increasingly self-directed and take responsibility and control for their life and learning); *life experience* (learners use their life experiences to aid their learning); *willingness to learn* (upon assuming a new life or social role, learners are ready to learn from real-world problems); *orientation to learn* (learners are problem-centred and contextualise their learning using real-world or simulated problems to apply that learning effectively and immediately); and *motivation to learn* (learners are motivated by internal factors such as increased job satisfaction, self-esteem and quality of life) (Knowles et al., 2015). The authors further lament that theories of learning are only useful if they are applied in some way to facilitate learning.

According to the principles of andragogy, for educators to instil effective learning, effective teaching practices should be developed and enforced. Therefore, as the facilitators of learning, instructors and teachers should inform and clarify for adult learners why the content taught is necessary, and how the skills obtained through such learning can benefit learners in the workplace. The pre-clinical anatomy curriculum seeks to do this by planning and implementing clinically relevant teaching sessions such as tutorials, surface anatomy and imaging. Additionally, if learning outcomes and learning tasks are consolidated through practice while incorporating real-world problems (such as in PBL, case-based teaching, clinical settings and even clinically relevant assessments) rather than through memorisation, it would enrich students' learning experiences and increase their participation, willingness and motivation to learn. This might in turn affect the learning approach used by adults, and subsequently their knowledge retention.

Self-directed Learning

As described by Knowles (1975), self-directed learning is a process:

> …in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes. (p. 18)

Self-directed learners engage in *self-teaching*, which is an informal process that takes place outside the classroom setting and involves "taking control of the mechanics and techniques of teaching themselves" (Knowles et al., 2015, p. 171). In addition, a level of *personal autonomy* develops as a result of self-directed learning (SDL). This involves learners taking control of their own learning, including establishing the purpose and goals of learning (Knowles et al., 2015). It is important to note that not all learners possess good SDL skills; in such individuals, learning in an environment that is highly dependent on SDL can make them feel frustrated and intimidated. Similarly, not all self-directed learners can be autonomous, as is the case when teaching and the curriculum are highly structured and controlled. Therefore, self-teaching and autonomy are independent of each other, and possessing one form does not necessarily translate into possession of the other.

SDL has been widely incorporated into medical education—particularly with the introduction of blended learning models such as the flipped classroom and TBL. This is considered beneficial to helping learners recognise the importance of self-study—particularly as they move from the classroom setting to the real world, where formal teaching is absent or not as prevalent, and where lifelong learning is considered an essential skill. Adult learners must learn to develop such skills by incorporating SDL into their daily regime using their own learning preferences. SDL forms a large part of the PBL-style curriculum in the graduate-entry Monash program, and this study will explore whether students are successful in learning independently of formal instruction. The reason for incorporating SDL into the program is to prepare students for the clinical years. SDL is a large component of adult learning in the workplace, as formal modes of instruction are replaced by adults assuming responsibility for their own learning. This is both an intrinsic and extrinsic process because learners develop a professional identity and workplaces impose criteria that require initiative and autonomous effort.

Workplace-based Learning Theories

All individuals are in a phase of constant learning that is neither restricted nor enhanced by intentional or educational means, and their everyday thoughts, actions and interactions with their environment shape what they learn. Therefore, workplace-based learning theories help educators to understand how and where learning takes place.

Although many people associate learning with knowledge that has been gained mainly through formal education and training, and they regard working and learning as two separate and non-intersecting activities, many leading theorists in this area, including Stephen Billet and Michael Eraut, have observed the opposite—that is, on-the-job learning is an essential component of adults' overall learning experience (Eraut, 2004).

Learning occurs through active participation in the workplace, where learning and participation are inseparable (Billet, 2001). This is similar to situated learning theory. Students occupy the periphery of a community in the pre-clinical years and then move towards the centre of the community in the clinical years as they acquire and develop more knowledge and experience and contribute as active and useful members of society (Lave & Wagner, 1991). As students become engaged in communities of practice, the workplace and the learner play an equal role in enhancing learning (Billett, 2001). Learning takes place when learners actively seek and engage with opportunities that are available in the workplace. Further, workplaces (e.g., clinical settings) that have a particular physical and social environment enhance adult learning by offering a supportive atmosphere that not only engages learners, but also encourages participation. According to Billett (2016):

> their occupationally authentic goal-directed activities and interactions grant access to and assist in securing the kinds of knowledge required for effective health care work, in ways that classroom-based experiences alone cannot. (p. 125)

A unique feature of the Monash graduate 1 + 3 curriculum is that students have three years of clinical 'on-the-job' training through which they can acquire, build and perfect their skills. Therefore, in the absence of any formal anatomy teaching during this period, it can be hypothesised that students can learn and revise anatomy if the clinical environment is conducive to allowing them to gain exposure and experience through supportive means.

Learning at work is viewed as a process that involves individual and social aspects (Eraut, 2004). Learning in the workplace occurs through informal means, through the learner's experience and through interactions with other individuals and colleagues in their environment in the absence of any formal structured or organised event. Informal learning can be implicit, deliberate or reactive. Learning that takes place without the learner being consciously aware of what has been learned is known as *implicit* or *tacit learning* (Eraut, 2000; Reber, 1993). Such reflective learning can occur during the clinical years, when students who are immersed in their clinical environment assimilate knowledge through observation and practical experience. This is different to tacit knowledge, which arises from implicit processing of knowledge and is described as personal knowledge used to generate a hypothesis or other source of action, such as in making a medical diagnosis (Eraut, 2004). *Deliberative learning* occurs during a time specifically set aside for it and includes deliberate engagement in activities and definite learning goals. Students often recognise and acknowledge learning something when they have been engaged in deliberative learning that takes place within formal teaching sessions. In contrast, *reactive learning* is "near spontaneous and unplanned" (Eraut, 2000, p. 115) because the learner's level of intentionality is variable (as it occurs during the middle of action), although they are aware of what has been learned (Eraut, 2000, 2004).

Considering the ways in which learning takes place in the workplace, Dreyfus and Dreyfus (1986) developed and described a five-stage progression model of learning through which adults acquire skills in the workplace. The model begins with the learner as a novice member of their workplace setting (Year B student) and can be contrasted to the novice learner in an educational setting (Year A student), where they are part of a larger cohort in a similar state (Eraut, 2008). The Dreyfus model, which is similar to situated learning theory, documents the process of informal learning and tacit knowledge that develops as an individual acquires experience in the workplace setting. They view the learner as progressing from a novice to an advanced beginner, wherein they begin to follow a set of explicit rules and guidelines to develop an understanding of their day-to-day environment. Individuals become competent when they progress to the third level (final-year medical student), and it becomes easier to complete explicit tasks that previously required much effort. Upon mastering the skills in this stage, the learner progresses towards becoming a proficient worker (intern/resident) who can view and tackle situations using a holistic approach. As Eraut (2008) states:

> The difference between being competent and being proficient is neatly captured by the old training distinction between a trained worker and an experienced worker. The experienced worker will normally be more productive, need less supervision, be more aware of contextual variations and be competent in a wider range of situations. (p. 4)

The final stage in this five-step model is the expert (consultant/specialist), who no longer relies on rules or guidelines because they have a deep and tacit understanding of the situation at hand. This understanding usually comes about because of experience, which encapsulates basic science concepts and constructs more progressive and sophisticated schemas around clinical activity. While basic science information becomes implicit as the learner progresses further away from being a novice (i.e., as pre-clinical students progress through the clinical years), it forms a framework around which clinical knowledge is built (Kulasegaram et al., 2013). Therefore, medical curricula must inculcate such knowledge to provide the best learning opportunities and environments for students. Of course, one must also account for the fact that learning does not always progress in such a linear fashion as each individual develops at a different rate and possesses a range of prior experiences which impact on their learning. Therefore, a spiral approach to expertise must also be considered – one in which an individual experiences phases of progression, regression and pauses in their learning process.

When examining factors that affect learning in the workplace, two major issues are confidence and commitment to learn, and the performance and progress of the individual's role. When students are proactive in seeking opportunities to learn in the clinical environment, and when they become engaged in the act of doing—that is, when they successfully and progressively meet new challenges and receive feedback and support from their clinicians and supervisors—they not only develop confidence, but also a motivation to learn (Eraut, 2004, 2007). However, if the learning environment does not foster good professional relationships and encouragement and trust between students and their colleagues, then learners (students) will be uncomfortable in the environment. As a result, they will be less likely to seek opportunities and take the initiative to enhance their learning; hence, they are less likely to be confident. In this context, 'confidence' refers to the concept of self-efficacy, or students' ability to successfully execute or perform a task or role (Bandura, 1982).

Further, for students to progress in their learning, they must be aware of the learning outcomes. If learning goals are not made explicit or are too broad, students may find it difficult to understand what needs to be accomplished and how to go about achieving these goals (Billett, 2016). In addition, tasks set for students who have just entered the clinical years (i.e., novice learners) in the workplace must be gauged at an appropriate level so students can approach the tasks in a positive way. The work should be varied enough that it challenges students but does not daunt them, otherwise students may develop ineffective coping mechanisms and be less confident because "learning at work is either facilitated or constrained by (1) the organization and allocation of work and (2) relationships and the social climate of the workplace" (Eraut, 2004, p. 270).

Although workplace environments such as clinical settings can vary in structure, they are rarely structured with learning in mind (Eraut, 2004). Therefore, environments that lack sufficient access to activities that develop learners' skills and provide guidance for performing such activities in clinical settings could be considered detrimental to effective learning because students are deprived of opportunities to gain appropriate clinical knowledge. These issues will be explored in this study from a constructivist perspective that considers the views and experiences of participants in the clinical setting and how they affect students' learning of anatomy. However, regardless of the stage of learning, the task of acquiring knowledge is ultimately based on learners' actions and intentions. The physical and social environments of the workplace significantly contribute to learners effectively acquiring the skills they need for their occupation.

3.1.3 Approaches to Learning Anatomy

The process of learning has several meanings. In one aspect, it can be regarded as an outcome (a process that demonstrates what learning has occurred) or as a means to an end (Louw et al., 2009); in another aspect, learning is seen as "a process whereby knowledge is created through the transformation of experience" (Kolb, 1984, p. 38). This section explores students' approaches to learning anatomy.

Much of the research in educational psychology over the past four decades has provided an understanding of how students learn. Marton and Saljo (1976) have made significant contributions in this area. They introduced the term *approach to learning* to characterise how students approach a learning task. In a study of students learning anatomy, Eizenberg (1988) identifies five approaches to learning: avoid the task, memorise factual information, memorise chunks or sections of information, understand some aspects of anatomy, and comprehend the anatomical structure/site and its components as a whole—that is, grasp the common functions shared by organs and how they can be grouped into systems. These approaches suggest that the process of memorising and understanding might not be mutually exclusive after all, and that some memorisation is essential to scaffold later understanding. Studies by other authors characterise three distinctive approaches that students take to learning—surface approach, deep approach and strategic approach (Biggs, 2003; Louw et al., 2009; Newble & Entwistle, 1986; Ramsden, 2003)—which are all related to different learning outcomes (Ramsden, 2003). The learning approach adopted by a student depends on a variety of factors (none of which are fixed): their conception of learning (recognising what they are learning and why), their perception of the context in which learning takes place (Ramsden, 2003), the influence of their past learning experiences, their intentions for learning (to pass examinations or to understand) and their preferences for learning (Smith et al., 2014; Smith & Mathias, 2007). That is, depending on the topic, content, delivery style and assessment methods, students can adopt one learning style for one activity and a different learning style for another activity. Learning styles can also be based on students' personal attributes, goals and cultural differences (Mitchell, Xu, Jin, Patten, & Gouldsborough, 2009). The next section will closely examine the different learning approaches and their outcomes.

Surface Approaches

The surface approach is referred to as superficial learning and is characterised by rote memorisation of facts and regurgitation of material in assessment tasks (Smith et al., 2014), often without links to or connections made with other content. Students who adopt this approach often aim to achieve only the basic requirements for a task (Smith & Mathias, 2007), which in most cases involves an intention to memorise information and recite it back for assessment purposes (Louw et al., 2009; Pandey & Zimitat, 2007; Ramsden, 2003). As part of this approach, students often develop mnemonic devices, which are memory tools or devices that assist with remembering large pieces of information through the formation of a set of lists, phrases, words or steps. Mnemonics are used by most medical students in anatomy, and they usually form the foundation upon which students build their knowledge. For example, to remember the cervical nerve root supply of the phrenic nerve, students often remember the phrase ‘C 3, 4, 5 keeps the diaphragm alive’.

It has been assumed that in the early stages of the pre-clinical curriculum, when students are novices in the field of medicine and are exposed to a vast array of science and non-science disciplines, they are more inclined to adopt surface approaches—particularly for content-rich subjects, such as anatomy, as a way of coping with the large volumes of information they must grapple with (Smith et al., 2014). Studies that investigate how undergraduate medical students learn anatomy show that if students are not motivated to learn and do not appreciate the importance and relevance of the basic science disciplines for their course of study (similar to the principles of andragogy), they fail to make the connection between the two. Consequently, these students adopt surface (superficial) approaches to cope with large volumes of information (Smith & Mathias, 2007, 2011), and they fail to associate what they memorise with its application in clinical practice (Louw et al., 2009). Further, students who learn by rote report that learning is a difficult task and that their primary aim for adopting this approach is to pass their examinations (Smith & Mathias, 2007). This may be linked to a lack of sophistication rather than a lack of motivation. Subsequently, these students perform worse in anatomy than those who aim to understand content through a deep-learning approach (Louw et al., 2009; Ward, 2011).

Deep Approaches

The deep approach involves an active search for meaning through learners' willingness and motivation to understand the content being taught and to apply this material to a variety of settings. By engaging in deep learning, students focus on significant concepts related to problem-solving while using prior knowledge and knowledge from different courses upon which to build new and existing information (Louw et al., 2009; Ramsden, 2003). This model of learning is one that educators aim to have students adopt when approaching the learning of a subject. Studies have proven that medical students prefer to use a deep approach to learning (Smith & Mathias, 2007; Ward, 2011) so they can experience high-quality learning and the subsequent application of knowledge (Smith & Mathias, 2007). In the context of anatomy, deep learning occurs when students can relate the importance of anatomical structures to their clinical significance, thereby finding meaning in clinical problems. This integration of the basic science with the clinical science leads to conceptual coherence (Woods, 2007). That is, it allows learners to create a conceptually coherent mental map in which basic science concepts are organised and subsequently form the framework for developing clinical reasoning (Kulasegaram et al., 2015).

As a discipline, anatomy has its own language to describe the organisation of the body and to distinguish between different structures in the body. The language requires students to make a considerable effort to learn or memorise anatomical terms, identify structures and apply knowledge to clinical practice. Therefore, it is "one discipline area where the distinctions between deep- and surface-learning strategies are blurred"

(Pandey & Zimitat, 2007, p. 8) because students often employ a combination of the two approaches to achieve the course outcomes (Pandey & Zimitat, 2007; Smith et al., 2014). That is, both approaches are often considered a necessary part of developing and consolidating knowledge. Therefore, a surface approach should not be considered a bad one because it provides an infrastructure for constructing meaning and understanding (Hattie, 2009).

Strategic Approaches

Another form of learning adopted by students is the strategic approach, which is based on or driven primarily by assessments. Students choose a mixture of surface and deep approaches when preparing for examinations. Those who adopt a strategic approach base their decision on their perception of which learning method will generate the best outcome in the assessment (Smith et al., 2014; Ward, 2011). Strategic learners will at times be able to distinguish between factual knowledge, which warrants a surface approach, and knowledge that is essential for clinical understanding, which warrants a deep approach (Smith & Mathias, 2007). Given that students are under immense pressure to pass examinations to progress further in their course, more students are using the strategic approach. Research shows that the mean grades of students who use the strategic approach are significantly higher than the grades of those who primarily use a deep or surface approach (Ward, 2011). Such research needs to be explored further to determine the long-term consequences of students who employ the strategic approach because one could hypothesise that a superficial understanding of anatomy and learning for assessment purposes only could result in information not being transferred to long-term memory.

3.1.4 Recontextualisation of Knowledge

The modern curriculum has been designed to facilitate two main types of knowledge transfer: ‘forward reaching’ and ‘backward reaching’. Forward-reaching transfer refers to the process of learning basic foundational knowledge so it can be applied to future clinical situations—for example, during the physical examination of a patient. Backward-reaching transfer refers to the process of searching one’s memory to retrieve foundational knowledge to solve a present clinical problem (Bolander et al., 2008). Given that a surface approach precedes a deep approach, with the latter more usually applied in recall, the use of both approaches can assist with the transfer of knowledge from one setting to another. To facilitate this contextualisation of knowledge in medical students, it is best to use a backward-reaching approach by presenting a clinical problem first and then following through with the relevant basic science information to help students integrate their knowledge (Bolander et al., 2008; Evans et al., 2010). This approach underpins the philosophy of the PBL curriculum.

To conclude, modern medical education is based on the principle of active learning, which seeks to engage students in the acquisition and application of knowledge. Consequently, passive approaches to teaching and learning are outdated, and surface approaches to learning that involve rote memorisation have been deemphasised and downgraded in the curriculum. Instead, teaching styles such as small-group work, which involves application activities, SDL, PBL and TBL to encourage student interaction and embrace the principles of active learning, have been adopted and are at the forefront in medical instruction (Magid et al., 2009; Smith et al., 2014). This style of teaching has been largely adopted in the graduate-entry medical curriculum; consequently, this study will explore its effect on students’ learning and retention of anatomy.

This is significant because instructors' approaches to teaching are equally important in fostering good learning practices in students. A teacher-centred approach, or information transfer paradigm, results in students adopting surface approaches, whereas a learner-centred paradigm is considered more likely to foster deep-learning approaches in students (Trigwell, Prosser, & Waterhouse, 1999). Therefore, for effective learning to take place, the design of the curriculum must be underpinned by theories of adult learning and instructional learning (Moseley et al., 2005) so that educators can facilitate the kind of learning they want students to adopt, and to support students' gradual transition from novice to expert learners. According to Ward (2011):

> There is no such thing as a deep student, surface student or strategic student because approaches to study are not ingrained personality traits but context-dependent ways in which students respond to their learning environments. In fact, the same group of students can manifest different approaches to study in separate classes, depending upon the course design. (p. 126)

The importance of understanding how students learn anatomy in the context of a PBL systems-based curriculum is crucial to understand the claims surrounding medical students' inability to retain and apply anatomy knowledge. Better knowledge transfer can be achieved by presenting clinical problems, which provides a structural framework to which basic science disciplines such as anatomy can be anchored (Patel & Kaufman, 2002). However, reinforcement, revisitation and re-exposure to anatomy in later clinical years are equally important. Therefore, in addition to the student variables isolated above, the way in which educators design the curriculum and the mode that teachers use to teach can influence the learning approaches adopted by students.

3.2 Assessment

Assessment is an essential tool for learning. As Boud (2016) suggests, assessment must be sustainable in that it must provide students with opportunities and experiences for developing lifelong learning skills. In medical education, assessment is used as a competence instrument to ensure that good-quality doctors are produced upon completion of a medical degree (Vorstenbosch et al., 2014). Assessment has many benefits, and students that have frequent and repeated testing followed by focused feedback, which consolidates understanding and addresses deficits, develop long-term retention of that knowledge—a phenomenon known as the testing effect (Larsen, Butler, & Roediger, 2009).

Assessment also drives students' behaviour towards learning (Newble & Jaeger, 1983); that is, it exerts a strong influence on how students approach learning (Smith & Mathias, 2007). It has been shown that students are quite strategic in their approach to learning. This strategy is primarily determined by assessment, and probably more so in a time-constrained and condensed curriculum. Depending on the content and format of an assessment, students will mould their study approaches to adopt superficial learning strategies, a deep and meaningful understanding of the content (Larsen et al., 2009; Smith & Mathias, 2007) or a combination of the two. Therefore, it is important to consider the content, format and frequency of assessment during the planning and blueprinting phase of the curriculum and curriculum assessment. The blueprinting process, which involves mapping examination questions to learning outcomes for a course, has been developed to enhance and align assessment processes with curriculum content (Crossley, Humphris, & Jolly, 2002). In the design of an assessment, it is equally important to consider the type of feedback that will be provided to students following their performance evaluation; this will help to improve their learning experience (Halliday et al., 2015).

3.2.1 Types of Assessment in Anatomy

There are different modes of assessment in the anatomy curriculum. They range from written examinations to practical evaluations such as spotter tests and oral-based assessments such as *viva voce* (Vorstenbosch et al., 2014).

The written component of an anatomy examination usually involves MCQs (consisting of one stem and up to five distractors with one best answer), EMQs (consisting of short cases called vignettes [Wood, 2003], a number of distractors and one best answer for each stem) or short-answer questions (SAQs). The advantages of MCQs include objectivity and ease of grading; thus, they are favoured for use in education today (Wood, 2003). Testing students' ability to recall information from long-term memory is often dependent on retrieval cues, and it has been found that recognition tests such as MCQs are better placed to use retrieval cues than recall tests such as EMQs and SAQs (Hall & Durward, 2009).

Practical-based assessments usually include spotter tests that contain a number of wet specimens, such as cadavers or prosections, as well as radiological images, and students are asked to identify the pinned anatomical structures in relation to that particular specimen (Vorstenbosch et al., 2014). A variant of the spotter test is the "steeplechase method" (Smith & McManus, 2015, p. 63), where students are asked to identify not only the pinned structure, but also the function and/or relevance of that structure. Given that spotter assessments use cadaveric specimens, they are considered valuable tools for testing students' understanding of the 3D spatial elements of anatomical structures. They are also useful for assessing students' ability to differentiate between blood vessels, nerves and other structures (which are usually depicted as distinct colours—e.g., red arteries, blue veins and yellow nerves in anatomical textbooks, atlases and plastinated models), and for understanding and appreciating anatomical variation—all of which are important in clinical practice, especially in diagnosis and surgery (Smith & McManus, 2015).

Finally, the oral-based assessment for anatomy can form part of an Objective Structured Clinical Examination (OSCE), which tests the application of anatomical knowledge to patients (Yaquinuddin, Zafar, Ikramm, & Ganguly, 2013), an Objective Structured Practical Examination, where a number of clinical cases in the form of vignettes are presented to students along with a problem that requires the use of anatomy (Yaquinuddin, 2013), or an oral assessment (*viva voce*) in which examiners pose anatomy questions that students must verbally answer on the spot (Smith & McManus, 2015).

3.2.2 Assessment of Anatomy in the Traditional and Modern Curricula

In the traditional curriculum, anatomy had its own place in assessment, and students had to sit through all three forms of assessment (written, practical and oral). In fact, prior to 2005, medical students were assessed more often by practical (94.2% *v*. 33.3%) and oral (84.5% *v*. 13.1%) methods and less often by written methods (25.2% *v*. 68.7%) when compared with graduates post-2005 (Rowland et al., 2011). However, despite being used for a considerable amount of time in medical education, the practical spotter tests have been criticised for testing low levels of knowledge in students (Yaqinuddin et al., 2013). Thus, in the modern curriculum, spotter examinations have been eliminated in most institutions (Smith & McManus, 2015). These types of examinations also require more labour to set up stations and invigilate the session, and they place an increased workload on staff to mark the results. Oral forms of assessment have also been abandoned because of examiner bias and reliability issues (Smith &

McManus, 2015). There are no practical-based assessments or vivas for anatomy in the graduate-entry program at Monash University. The demise of practical forms of assessment, which are considered the better option for testing anatomy knowledge (Rowland et al., 2011), as well as oral forms of assessment, has led to an emphasis on written examinations that test students' ability to recall, apply and critically analyse information (Rowland et al., 2011; Vahalia, Subramaniam, Marks Jr, & De Souza, 1995; Vorstenbosch et al., 2014). As the most common form of assessment, some authors have argued that written examinations primarily rely on "pattern recognition" (Herle & Saxena, 2011, p. 662). However, the quality of the written assessment (i.e., how each MCQ is constructed) determines whether an assessment functions purely as a fact-based testing tool or as a critically analytical and synthesis tool. In Australia and New Zealand, 16 of the 19 medical schools surveyed used MCQs as the most common examination form for assessing anatomy, while 12 schools used SAQs, six used EMQs and nine used practical-based spotter identification tests (Craig et al., 2010).

In the modern curriculum, the inclusion of newer biomedical sciences (e.g., immunology, biochemistry, microbiology and genetics), other disciplines (e.g., population health, social sciences and clinical skills) and older and foundational sciences (e.g., anatomy, histology, physiology and pharmacology) has led to the development of integrated assessments, as is the case with the Monash graduate-entry MBBS curriculum. With these forms of testing, students in the pre-clinical years are assessed through a number of integrated written papers. That is, rather than a separate anatomy or physiology examination, the integrated written paper contains questions from all disciplines taught during the pre-clinical year. Following an assessment, students in the pre-clinical year are given combined and discipline-specific feedback. In the Monash curriculum, anatomy is assessed directly (as a component of integrated written examinations) and indirectly (as part of OSCEs). In the written component, MCQs and/or EMQs are linked to clinical scenarios, and students are expected to use their anatomical knowledge to answer questions posed in the clinical context. For OSCEs, students' knowledge of anatomy is primarily assessed during examination and procedural skills; however, during OSCE feedback, they do not receive a specific anatomy score. This is similar to students in the clinical years, who receive combined feedback. Therefore, students do not discover how they perform on components of an examination that may have emphasised anatomical knowledge (e.g., an EMQ or OSCE station). There is a practice of yellow carding students who make critical errors, but this has not been found to identify high-risk trainees (Schoenmakers & Ryssaert, 2013), and it often relates to higher-order skills incorporating anatomical knowledge such as diagnosis, differential diagnosis and management.

Although anatomy assessment in the modern curriculum is integrated, it can still function as a reliable tool for demonstrating students' anatomy knowledge if the assessment tasks are designed to foster a deep approach to learning (Logan & Marskak, 2011). Hence, if questions are primarily aimed at knowledge regurgitation, students are more likely to employ surface approaches to learning. Conversely, if questions are constructed in a manner that assists learners to bring together chunks of factual knowledge and then clarify and organise them in the first instance (relational thinking), before applying and synthesising that knowledge into context (elaborated thinking), students preparing for assessments are more likely to adopt deep approaches to learning (Smith et al., 2014; Vorstenbosch et al., 2014). Therefore, although MCQs form the main components of written examinations, the process of blueprinting ensures that the assessment items selected are constructed in a way that "rewards a deep approach to learning and is reflective of the purpose of learning, that is, clinical practice" (Smith &

McManus, 2015, p. 64). Additionally, incorporating repeated testing across a particular period and providing feedback after every assessment can assist students in long-term and better retention of anatomical knowledge (Larsen et al., 2009).

Given that students are directly assessed on anatomy in written examinations only, this study seeks to replicate this through the development of a similar type of assessment. It aims to determine whether students who have been taught and assessed in a certain way retain their anatomical knowledge when assessed at a later stage and, if not, it explores the factors affecting the retention of anatomy.

Chapter 4: Anatomy: Current Debates

In this chapter, the numerous issues and existing debates surrounding the modern anatomy curriculum will be explored, including the lack of vertical integration and core competencies for anatomy. The modern trend for teaching and assessing anatomy combined with the condensed medical curriculum is explored in relation to its effect on medical students' learning of anatomy, their retention of anatomical knowledge, their performance in clinical practice and the subsequent development of postgraduate surgical programs. These issues are also discussed in relation to the graduate-entry MBBS curriculum. Finally, a brief overview of the methodology of the research study is described, and the hypotheses of the study are formulated.

4.1 Current Debates Surrounding the Modern Anatomy Curriculum

4.1.1 Curriculum Format

In a constrained and condensed curriculum, anatomy is afforded a small amount of time relative to its significance in medicine; therefore, it is under-valued, under-assessed, under-resourced and under-appreciated (Cottam, 2012). Confined primarily to the pre-clinical years in accordance with the traditional Flexner model, one of the biggest challenges in the modern medical anatomy curriculum is that information about normal form and function that is taught in the pre-clinical years is not easily transferred into pathological form and function in the clinical years (Bolander et al., 2008). At one end of the spectrum, the modern medical curriculum has resulted in fewer dissection opportunities, less teaching time and fewer lectures when compared with the traditional curriculum. At the other end, anatomy instruction involves a greater number of problem-based and tutorial-based sessions involving SDL, as well as increased use of prosected specimens, technology and web-based resources (Pandey & Zimitat, 2007).

Knowledge of anatomy is a crucial requirement when performing a physical examination or interventional procedure, or when viewing and/or interpreting medical imaging (Standring, 2009). However, representatives from the Australian Students Medical Association (AMSA), have called for a core anatomy curriculum (Farey et al., 2014), noting that many factors, such as the PBL curriculum, the reduction in time devoted to anatomy and the lack of dissection opportunities, have made them feel inadequate and insufficiently equipped with their anatomy knowledge (Mitchell & Batty, 2009; Smith, 2005; Linacre, 2005; McHanwell et al., 2007; Older, 2004; Prince et al., 2003; Prince, van der Wiel, Scherpbier, van der Vleuten, & Boshuizen, 2000; Watmough, O'Sullivan, & Taylor, 2010).

There have been many debates in medical education regarding the efficacy of learning through PBL. In one sense, the trend to incorporate PBL and reduce didactic lectures in anatomy is seen as a way of enhancing students' knowledge of anatomy by allowing for horizontal integration across all of the other disciplines. However, one of the main issues surrounding PBL is that students can only employ reflective and critical thinking skills once they are familiar with all the facts behind the problem in question. Therefore, some authors argue that PBL is not the best way for students to acquire new knowledge (Gogalniceanu et al., 2010). The literature suggests that while graduates from PBL programs become confident in problem-solving, communication and examination skills, many feel that their knowledge of anatomy is inadequate, uncertain and deficient (Prince et al., 2003), and they prefer a more structured didactic teaching approach to gain more knowledge (Watmough et al., 2010). Given that graduates in the Monash program were immersed in a PBL-driven curriculum, it would be interesting to note whether they felt that the anatomy knowledge taught in Year A was adequate.

In a study comparing students experiencing two different curricula, second-year students who were enrolled in the traditional curriculum scored significantly higher on a standardised anatomy test consisting of 50 true/false anatomy questions than those enrolled in an integrated PBL curriculum (Hinduja et al., 2005). Similar results were found when comparing knowledge of surface anatomy between students enrolled in the traditional curriculum versus a system-based integrated curriculum (which incorporates the teaching of basic sciences by systems alongside clinical training), with the former group scoring higher than the latter (McKeown et al., 2003). Case and Swanson (2001 argue that in attempting to phrase true/false stems that are unambiguous, the questions that result are more likely to assess students' recall of an isolated fact rather than application or analysis of content. Therefore, the results of these studies could be seen to favour students from a traditional curriculum because they are more likely to have received formal didactic instruction, and thus spend more time learning fact-based information. However, other studies have contradicted these findings. When anatomy performance is compared across three different schools with three different curricula (a full PBL curriculum; a mixed PBL and a traditional curriculum, or a full traditional curriculum), performance in anatomy between the PBL students and other non-PBL students was found to be similar (Prince et al., 2003). Once again, the results of this study are based on an assessment tool that entirely consists of true/false questions, which raises the issue of reliability and validity. Also, this is a superficial recognition test, not a sophisticated test of the application of knowledge. As Case and Swanson (2001) state, true/false questions require additional judgement on the part of the examinees to determine the extent to which a response may be true. To ensure the validity of such questions, certain guidelines for constructing true/false questions are required, including having clear and unambiguous stems and options that are absolutely true or false. Another study reveals that over a period of five years, medical students who were taught anatomy through a problem-based format, in which clinical cases were used to highlight important knowledge and were tested in a similar format using a problem-focused assessment, were more likely to perform well on department anatomy examinations and the national board anatomy examinations (Vasan & Holland, 2003).

Given these conflicting findings, it has been hypothesised that:

> …students' perceived and actual basic science (anatomical) knowledge is less determined by the general educational approach of the curriculum than by educational strategies such as time on task, repetition, and teaching in context. This shows the importance of a vertically integrated and spiral curriculum design. (Bergman et al., 2013, p. 2)

Vertical integration can be considered the integration of basic sciences and clinical sciences in one setting, whereas a spiral curriculum is one where basic ideas and concepts are revisited repeatedly, "building upon them" each time "until the student has grasped the full formal apparatus that goes with them" (Bruner, 1977, p. 13). In most cases, vertical integration tends to be unidirectional and mainly occurs in pre-clinical years during the teaching of basic sciences (Bergman et al., 2014). However, theoretically, it should be emphasised during the clinical years to revisit the basic sciences. The trend to incorporate vertical integration in a curriculum has already occurred in some schools in the UK (Evans & Watt, 2005) and is now in even greater demand in medical institutions globally. This concept will be explored in this study by asking participants their views on anatomy learning in the clinical years and how it can be improved upon.

4.1.2 Declining Knowledge with No Vertical Integration

It is widely accepted that with scientific knowledge constantly growing in the face of technological advances, medical knowledge is doubling every 2–5 years (Johnson et al. 2012). Thus, there are immense pressures and challenges to reform the medical curriculum to accommodate this growing body of knowledge so that students will have the necessary information to practice medicine safely as junior doctors, albeit acknowledging the need to embrace lifelong learning behaviours.

The discipline of anatomy has remained constant for decades because it comprises foundational knowledge that is essential for medical students in training. However, as a result of large reductions in teaching hours, the anatomy curriculum has been drastically altered over the past century, and some critics have labelled this transformation a downward spiral (Brooks et al., 2015; Older, 2004; Pratten et al., 2014; Rainsbury, Barbour, & Mahadevan, 2007). To illustrate the significance of this change, a comparison of historical data indicated that, in the US alone, medical schools allocated an average of 190 hours to gross anatomy teaching in 1990 compared with 549 hours in 1902 and 330 hours in 1955. This further decreased to 167 hours in 2002 with a range of 55–252 hours (Drake et al., 2002), 149 hours in 2009 with a range of 56–231 hours (Drake et al., 2009) and 147 hours in 2014 with a range of 65–249 hours (Drake et al., 2014). Similar data were found in the UK and Ireland, with an average decline in anatomy of around 100 hours (Leung et al., 2006; Older, 2004).

Further, research conducted in 19 Australian and two New Zealand medical schools shows a large difference in teaching hours between these institutions. The time allocated to teaching anatomy ranged from approximately 56–500 hours across a student's medical training, with an average of 171 hours across all 4–6-year courses. The five-year MBBS courses had the lowest teaching time, with students spending an average of 96.2 hours on anatomy throughout their course. This was compared with the six-year courses (221.7 hours) and the four-year courses (179.7 hours) (Craig et al., 2010). This large variation creates an area of immediate concern because there is no magic number for the total number of hours of anatomy teaching that a medical student must undertake prior to graduation. Each institution designs its own curriculum; there is no set standard for anatomy or a national curriculum, and such diversity is regarded as a highly valued feature of Australian universities (Booth, Melano, Sainsbury, & Woodley, 2011). However, given the large variation in teaching hours, is there a large gap in anatomy knowledge between graduates from one university and those from other universities? According to the Australian Medical School Assessment Collaboration, which benchmarks the performance of medical students in the pre-clinical years, standards in pre-clinical teaching are similar across universities in Australia (O'Mara et al., 2015). However, the article does not provide details across disciplines; hence, it would be important for future research to examine the differences in anatomy knowledge across universities.

It has been estimated that since the introduction of graduate medical programs and problem-based curricula, anatomy teaching time has been reduced by as much as 80% (Craig et al., 2010), causing fears and concerns about students' anatomical knowledge or lack thereof upon graduation. For example, the University of Sydney's four-year graduate medical program came under intense scrutiny for its lack of dissection, its emphasis on PBL and the significant decline of anatomy teaching from 253 hours in 1996 to 50.5 hours in 1997 (Ramsey-Stewart et al., 2010). The negative press surrounding this drastic change in the curriculum was further compounded in 2006, when a review by the Royal Australasian College of Surgeons revealed that the University of Sydney's graduates had the lowest pass rate in the Basic Sciences Examinations for surgical trainees among all Australasian universities (Ramsey-Stewart et al., 2010). Following the bad press and a subsequent curriculum review, the University of Sydney tripled its anatomy teaching time from 50.5 hours to 170.5 hours in 2007, which is the mean in Australia and New Zealand medical anatomy programs.

This example demonstrates that a significant decline in anatomy knowledge leads to dissatisfaction among the medical community, in particular the surgical community where knowledge of anatomy is paramount in terms of safe surgical interventions. “The falling standard of anatomy has been inferred as a major factor in the rising failure rate in surgery” (Singh & Tubbs, 2015, p.56) and studies have shown that surgeons believe that anatomy in the modern curriculum is taught to very poor standards (Lawson & Bearman, 2007) and consequently surgeons often faced difficulties when attempting to teach clinical medicine and surgery to a group of students lacking essential anatomy knowledge (Staskiewicz et al., 2007). Ellis (2002), who was an examiner in Part II of the Membership of the Royal College of Surgeon’s examination, which allows students to apply for specialist registrar training posts, expresses amazement regarding students’ lack of anatomy knowledge:

> I have sat in on this examination on a number of occasions and have been amazed at candidates who do not know how to find the ureter, or who have such little idea of surface anatomy that they would put a chest drain into the liver if they carried out in practice their description of this procedure. (p. ii)

Ellis (2002) further elaborates that when students are faced with a ten-minute examination in practical surgical anatomy, it becomes evident that some of the candidates are encountering a real anatomical specimen for the first time. Oliver Beahrs, an internationally acclaimed surgeon and the first President of the American Association of Clinical Anatomists, states that “today’s residents in surgery are learning their anatomy on sick patients for the first time in the middle of the night: operating without a firm knowledge of anatomy leads to increased morbidity and mortality" (Green, 1998, p. 69). As Singh and Tubbs (2015) state, "A skilled and successful surgeon has to be a perfect anatomist first, by not only mastering anatomy at the start of medical education but also by commanding/refreshing it during surgical practice" (p.56).

Critics of the modern curriculum have expressed concern that the new methods of teaching, which involve problem-based sessions, e-learning, computer-based technology, and plastinated and plastic models, and that have replaced the centuries-old practice of dissection and lecture-based teaching, have been adopted without an 'external audit or validation' (Judson, 2012). Some critics have argued that the cessation of dissection in most medical schools has resulted in graduates leaving medical school with far less anatomical knowledge than ever before (Ellis, 2002; Older, 2004; Standring, 2009). Others feel that without a good understanding of the workings of the human body obtained through a sound knowledge of anatomy and dissection, doctors are more likely to order unnecessary tests and imaging studies, which not only increase costs for patients, but also create undue stress on the healthcare system (Kanzaria et al, 2015; Leung et al., 2006). Further, the lack of dissection opportunities provided to students affects their ability to develop key critical thinking skills required during emergency circumstances (Sugand et al., 2010). Having access to a cadaver or a simulated surgical resource enables students to practice procedures in the presence of a trained clinician to improve their technique, skills and confidence on the ward. Examples of such procedures include cricothyroidotomy (incision in the neck between the thyroid and cricoid cartilage to establish an airway in a patient in a life-threatening situation), lumbar puncture (insertion of a needle in the back to assess for meningitis or a haemorrhage in the brain) and intercostal chest drains (insertion of a tube in the chest in the event of air or blood or a combination of the two accumulating within the chest wall and compressing the lungs).

For years, cognitive psychologists have emphasised the importance of integrating knowledge in the learning process because it facilitates the storage and retrieval of information. Therefore, modern curriculum design has been based on this theory of learning, with the aim that integration of the different sciences will enable students to be better prepared for clinical practice. However, this integration has mostly taken place on a horizontal basis, and it has only been covered in the pre-clinical years, with all disciplines incorporated into a number of clinical cases and assessed as part of an integrated examination. There also appears to be a lack of vertical integration of anatomy throughout students' clinical years. As Craig et al. (2010) state:

> A key tenet of problem-based courses has been to strongly integrate clinical subject matter into the earlier stages of courses, often at the expense of basic sciences. However, it appears that as yet, basic science has not been integrated into the later stages of courses to compensate. (p. 215)

This is an indictment of the so-called spiral curriculum because, there is often not enough time or willingness to revisit material taught earlier. In the absence of a vertically integrated and core curriculum, institutions have been free to develop their own curriculum and teaching style. Further, there is a lack of sufficient evidence on the effect of reduced anatomy teaching in various institutions (Judson, 2012). Consequently, upon graduation, many undergraduate students from universities around the world have felt inadequately prepared for clinical practice because of their self-appraised poor anatomy knowledge (Farey et al., 2014; Fitzgerald et al., 2008; Linacre; 2005). Some graduates—particularly those who are interested in a surgical career—who want to develop and expand on their anatomical knowledge enrol in postgraduate surgical training programs to further their professional development and increase their confidence in the workplace (Insull, Kejriwal, & Blyth, 2006; Raftery, 2007).

According to clinicians from a variety of specialities, anatomy is viewed as one of the most important basic sciences in the medical curriculum (Arraéz-Aybar et al., 2010; Cottam, 1999; Orsbon et al., 2014) because it enables anatomical reasoning to occur through integration of the three-dimensional aspects of the body with an understanding of the various structural, functional and pathological processes (Hall & Durward, 2009). Therefore, "inadequate retention of anatomical detail may adversely affect efficiency and effectiveness of clinical practice" (Hall & Durward, 2009. p. e27). Given this view, it is not surprising that the overall effect of undervaluing anatomy in the medical curriculum has led to an outcry in the medical community, with clinicians (especially surgeons) complaining about the low levels of anatomical knowledge among medical students and new medical graduates (Cottam, 1999; Craig et al., 2010; Gogalniceanu et al., 2010; Herle & Saxena, 2011; Lawson & Bearman, 2007; Waterston & Stewart, 2005). It has been suggested (by many clinicians) that the current standards of anatomy education in medical schools are inadequate for preparing students to practice medicine safely (Staskiewicz et al., 2007; Lawson & Bearman, 2007; Craig et al., 2010; Warner & Rizzolo, 2006; Waterston & Stewart, 2005) and the main factors associated with this perceived decline in students' knowledge are reduced curriculum and teaching time, loss of experienced anatomy teachers and integrated curricula (Standring, 2009).

The attitudes of clinicians towards medical students' knowledge of anatomy are not unwarranted. A study that examines the retention of anatomy by third-year medical students commencing their clinical rotations in general surgery and obstetrics and gynaecology shows that students' anatomical knowledge declined by 30% from the first year, as measured by 20- and 25-question anatomy tests assessing students' knowledge of the abdomen and pelvis respectively (Jurjus et al., 2014). Given that students receive formal anatomy teaching and basic science teaching during their pre-clinical years before entering clinical rotations, these results suggest that knowledge retention and transfer into long-term memory cannot take place without reinforcement and relearning. Hence, a spiral curriculum needs to be implemented in medical education.

Further, results from Cottam's (1999) survey provide strong evidence to support clinicians regarding the importance of anatomy in clinical practice. A retrospective study by Pabst and Rothkotter (1997) reveals that physicians who were seven years out of medical school considered anatomy the most relevant discipline to clinical practice. Similar findings are evident in a larger study of 1,000 specialist doctors, who rated anatomy as the most relevant discipline by surgeons, and anatomy and physiology together were rated as very relevant by non-operating doctors, although anatomical knowledge was applied differently depending on their speciality (Pabst, 2009).

As medicine heads towards technological advances and innovations relating to super specialised and minimally invasive interventions, the importance of anatomy and its finer details are critical to a doctor's ability to investigate, diagnose and treat future patients (Sugand et al., 2010). Thus, for the modern curriculum to be most effective in optimising learning and retention of learning, there must be vertical integration of anatomy across the pre-clinical and clinical years in addition to horizontal integration. In this way, students can be trained to further develop their knowledge of anatomy in clinical practice, and therefore become better equipped as future physicians. As far as the Monash graduate-entry curriculum is concerned, no formal teaching of anatomy is implemented in the clinical years; thus, the concept of vertical integration will be explored in this study as a measure of how it affects the learning of anatomy.

4.1.3 Lack of Core Curriculum and Competency-based Education in Anatomy

The accrediting body for all medical education programs and providers in Australia and New Zealand is the AMC (2017). The AMC assesses all institutions based on context, outcomes, curriculum, learning, teaching and assessment of the medical program to ensure that graduates are sufficiently competent to practice safely as interns under supervision (AMC, 2017). Although all institutions must meet the necessary standards to be approved for accreditation, the AMC does not direct the specific structure and processes employed to meet these standards. Therefore, each institution is free to develop and implement different curricula and different modes of instruction and assessment. Schiller, Lucewicz and Yang (2011) have criticised the AMC's guidelines, stating that:

> …the guideline for curriculum content of the basic biomedical sciences, which occupies one line of the document, does not even mention the names of the various biomedical disciplines….Either the AMC is not prepared to put more specific guidelines in the public domain, or little guidance exists to direct curriculum development. The open-ended regulatory framework has seemingly acted for more than a decade to feed a process of medical schools constantly reinventing the wheel with 'revolutionary' medical programs. (p. 10)

This heterogeneity in teaching is evident when Craig et al. (2010) compare anatomy teaching across universities in Australia and New Zealand and find differences in curriculum content, teaching hours, delivery and assessment. As many studies have shown, the absence of a core anatomy curriculum is considered a major contributing factor to students' apparent difficulty in retaining anatomical knowledge (Judson, 2012; Raftery, 2007; Sugand et al., 2010). According to Olowo-Ofayoku & Moxham (2014), "if there is inadequate anatomical knowledge, the reasons are structural within the curriculum and do not relate to student attitudes or motivation" (p. 985).

Both clinicians and students are in favour of instituting a core curriculum (Craig et al., 2010; Drake et al., 2009; Heylings, 2002; Older, 2004) that involves more clinically relevant anatomy teaching (Fitzgerald et al., 2008; Gupta, Morgan, Singh, & Ellis, 2008), more involvement of clinical skills in anatomy teaching (Davis et al., 2014) and more vertical integration of anatomy across the undergraduate medical curriculum (Bhangu, Boutefnouchet, Yong, Abrahams, & Joplin, 2010; Jurjus et al., 2014; Waterston & Stewart, 2005).

Rafferty (2007) argues that, at the bare minimum, there should be a national core curriculum for anatomy when it comes to three main components of clinical practice: physical examination, interpretation of medical images, and knowledge and practice of basic procedures, which would facilitate safe practice in emergency situations. Others emphasise the importance of a core anatomy curriculum in providing the foundational principles, as well as its relevance to the various branches of clinical medicine, and not just to the specialty of surgery (Abu-Hijleh, 2010). Similarly, another study suggests that culling the amount of anatomy within the medical curriculum prevents future doctors from receiving the fundamental anatomy education necessary for safe practice (Fasel, 1996). Therefore, a core anatomy curriculum could be implemented for the general practice of medicine, and that this core anatomy content could be modelled to fit with existing curricula (Fasel, 1996; Fasel et al., 1999). While all physicians deem anatomy to be important to the study of medicine (Fasel, Bader, & Gailloud, 1998; Orbson et al., 2014), there are differing views regarding which regions/topics are most important. Except for medical imaging, which is rated as essential for medical practice, there is a lack of consensus among physicians regarding what constitutes core anatomy knowledge for medical students (Orbson et al., 2014). This can be a confounding issue when attempting to consider or specify a set of core anatomical competencies.

Current standardisation policies for the anatomy curriculum have been recognised by the American Association of Clinical Anatomists (Leonard et al., 1996), the Netherlands Association of Anatomists (Van Engelshoven & Wilmink, 2001) and the Anatomical Society of Great Britain and Ireland (McHanwell et al., 2007), who have set out to publish documents that aim to "define the indispensable anatomical knowledge for a competent physician and thereby ensure that all medical students receive thorough anatomical training, regardless of the institution attended" (Gupta et al., 2008, p. 336). However, no such policy or curriculum exists in Australia and New Zealand. The AMC and other organisational bodies with a vested interest in anatomy (e.g., the Royal Australasian College of Surgeons) have not produced a set of guidelines or instructions regarding a core anatomy curriculum (Craig et al., 2010) and have not mandated a specific number of teaching hours in anatomy for accreditation purposes (Lawson & Bearman, 2007). However, there are recent trends towards this with the International Association of Federation of Anatomists (IFAA) moving towards publishing core syllabi (ones which would indicate the bare minimum needed for students to practice medicine safely) for all areas of anatomy (Moxham, McHanwell, Plaisant & Dais, 2015; Moxham, Plaisant, Smith, Pawlina & McHanwell, 2014). Of course, the directive offered by the IFAA is merely a guiding tool and not a prescriptive one. This offers the flexibility of how and when schools can adopt the syllabus. Given the vast array of disciplines that students have to cover in medical school, the benefit of a core anatomy curriculum would help to resolve the debate in medical anatomy education.

4.1.4 Lack of Competency-based Assessments in Anatomy

The structure of assessments in the modern medical curriculum also poses many challenges for medical students in training. Using a sample of medical graduates, Smith and Mathias (2011) find that the main motivation for learning anatomy in medical school is for assessment purposes. This indicates that students' motivation for learning is influenced by their need to pass the course and progress to the next year, without necessarily appreciating or acknowledging the connection and importance between anatomy and clinical practice. This problem is further compounded by the presence of integrated assessments.

Students, trainees and specialists recommend practical assessment as the most meaningful method for assessing anatomy because this approach supports students to revise and retain their knowledge of anatomical structures for a longer period (Rowland et al., 2011). Anatomy is mainly assessed in the modern curriculum as a small part of a largely integrated paper consisting of written content using MCQs, EMQs and, in some cases, short-answer questions (SAQs).

In 2010, more than 53% of Australian and New Zealand medical schools used integrated assessments as part of their pre-clinical curriculum and did not have a separate gross anatomy examination. Instead, all basic science disciplines were integrated into "applied, case-based assessments" (Craig et al., 2010, p. 215).

Given that the medical curriculum is now examined through integrated means, there is no minimum level of achievement for the anatomy component of an examination, and this is the case for 11 of the 19 medical schools surveyed in Australia and New Zealand (Craig et al., 2010). Students are only required to pass the integrated examination as a whole, which means that they can perform poorly on, or even fail, anatomy, yet score high on other components of the paper and still pass the assessment through compensation (Gogalniceanu, Fitzgerald O'Connor, & Raftery, 2009; Older, 2004).

With anatomical knowledge being downscaled in the modern curriculum, integrated assessments give students a choice when it comes to passing examinations. That is, they can devote more time to other disciplines within the medical curriculum, and they can avoid learning anatomy (which can seem like a daunting and endless task) because they can compensate for their lack of anatomy knowledge by performing well in other components of the paper. This becomes a problem upon graduation, when students are required to sit postgraduate surgical examinations or, even more concerning, practice on patients. During such assessments and situations, students' poor knowledge of anatomy becomes so evident that it requires recall that may be impossible and/or new learning (Raftery, 2007). This can be dangerous—particularly when it comes to treating patients.

Adding to this dilemma is the absence of a national standardised or medical licensing examination in Australia and New Zealand (Craig et al., 2010) to assess the anatomy knowledge of medical students upon graduation. Without this qualifying step, students can graduate and practice medicine without an explicit standard of anatomy knowledge (Moscova et al., 2015). It is therefore not surprising that clinicians and surgeons are concerned about the perceived lack of anatomical knowledge among medical students in the clinical years and among medical graduates because it is then difficult to teach clinical medicine and surgery (McKeown et.al., 2003; Ramsey-Stewart et.al., 2010). Many senior doctors feel that medical graduates need an anatomy refresher course (Cottam, 1999) because the consequences of poor anatomy knowledge include an increase in surgical errors and malpractice suits (Judson, 2012; Rogers et al., 2006).

Although a national core curriculum is needed in anatomy (Farey et al., 2014), it would be difficult to argue the case for a standard curriculum in one discipline and not others. It would be better to implement a national examination similar to that of the US Medical Licensing Examination (USMLE) to create a benchmark to ensure that graduates have achieved the necessary standards to practice medicine in Australia and New Zealand (Schiller et al., 2011).

The USMLE is an example of a standardised assessment that encompasses three different stages taken at different phases within medical students' training. Students in the US must sit this licensing examination to progress through the medical program and become certified medical practitioners. The USMLE is considered a high-stakes examination and is well known for being challenging because it seeks to ensure an "excellent benchmark standard for graduates" (Schiller et al., 2011, p. 10).

No such structure exists in Australia and Zealand. Instead, the AMC mandates the requalification of overseas-trained doctors through a set of assessments that test medical knowledge and clinical skills. These assessments are constructed at a level that would be attainable and achievable by local medical graduates just before internship. However, it is odd that international doctors sit a seven-hour licensing examination that incorporates MCQs and clinical reasoning, whereas "newly qualified local graduates whose skills supposedly provide the benchmark of this examination are not themselves made to sit it" (Schiller et al., 2011, p. 10).

Additionally, although existing competency frameworks, such as the ACF (CPMEC, 2012) for junior doctors, seek to guide educators, employers and prevocational doctors regarding the expectations of doctors at different stages of their career, there are no specific competencies associated with anatomy. Although knowledge of anatomy is important for meeting some of the learning outcomes within the ‘clinical problems and conditions’ domain of the ACF, this knowledge is inferred and is not explicitly mentioned.

4.1.5 Learning of Anatomy

In a tightly packed and condensed pre-clinical curriculum, medical students must learn a substantial amount of detailed anatomy and try to connect it to an integrated whole within a short amount of time, which is perceived to be challenging for students (Smith et al., 2014; Wilhelmsson et al., 2010). A surface approach to learning is said to result in heavy workloads, a shortage of time in the curriculum and questionable assessment methods that foster superficial learning (Smith & Mathias, 2007). Consequently, many medical students who adopt these approaches to learning anatomy (Moscova et al., 2015) develop mnemonics to memorise branches of arteries, nerves and other structures. However, it has been shown that if students do not enhance their use of mnemonics through a deeper understanding of the content, their long-term retention of knowledge will be affected (Meyer, Armson, Losco, Losco, & Walker, 2015). Therefore, each institution should ask the following question: If students adopt a surface approach to learning depending on their perception of the workload, are we overloading the curriculum too much and not providing a clear framework outlining what material is to be learned and to what depth and breadth?

In research on what improves learning in elementary, junior high and high school students, Hattie (2009) indicates that surface learning must precede deep learning. The problem with this in a time-constrained medical curriculum is that a considerable amount of anatomical facts must be memorised before they can be put into a context in which they can be understood and applied. Subsequently, given the lack of time, students do not develop more sophisticated learning strategies, and they never reach the deep-learning stage because their perception of the large volume of anatomy facts that need to be learned or memorised may be considered a barrier to their learning (Smith et al., 2014). Further, adopting surface approaches is associated with poor retention. Therefore, when students move into the clinical years, the pure recall of information they learned superficially in the pre-clinical years is challenging (Bolander et al., 2008). This could be the driving force behind clinicians' disappointment and students' frustration that they are underprepared for the anatomy that is required during the clinical years. Another challenge is that students who attempt to use both surface and deep approaches quickly run out of time because the fast-paced curriculum of the pre-clinical years moves from one region or system of the body to another within a matter of weeks, giving students insufficient time to master the content and test themselves on it, as is the case with the anatomy curriculum in the MBBS graduate-entry program. An initiative like the testing effect would be useful in this case. This effect is based on the principle that regular testing that is grounded in retrieval-related processes enhances retention more than traditional learning that includes an equivalent amount of additional studying opportunities (Toppino & Cohen, 2009). Participants' views and experiences with learning anatomy will be explored in this study, along with the effect of the anatomy curriculum and the medical curriculum on students' approaches to learning.

Depending on the type of curriculum that a medical school adopts, some students have found the lack of clinical relevance to be a hindrance to their learning because they fail to understand or make the connection between the anatomical structure and the patient. As Ramsden (2003) states, the context in which learning takes place influences the learning approach adopted, and subsequently affects performance in examinations (Smith & Mathias, 2007). If teachers are to impart knowledge to students in the context in which they will apply it (e.g., dissecting in a dissection room), they may motivate students to not only enjoy learning, but also to become better at it (Kerby et al., 2011). Thus, if students understand the relevance of what they are learning, they will become more motivated to learn (Smith et al., 2014). The pre-clinical anatomy curriculum in the graduate-entry program employs this type of approach in that the focus and learning outcomes of the anatomy sessions are clinically oriented. As Ramsey-Stewart (2014) states, emphasizing the teaching of essential clinical anatomical facts is paramount to ensuring safe clinical practice in a time-poor modern medical curriculum. The importance of clinical relevance should be emphasised in the curriculum because it has been shown to positively influence and increase retention of knowledge by increasing students' interest and enjoyment of the course, thereby transitioning students from a surface-learning approach to a deep-learning approach embodied by internal motivation and personal interest (Dahle, Brynhildsen, Behrbohm Fallsberg, Rundquist, & Hammar, 2002; Meyer et al., 2015). This further translates into the clinical environment, where learning occurs through active participation (Billet, 2001). By developing an interest in the topic, students become adept at understanding how to recontextualise basic anatomical facts acquired in the pre-clinical context into real-life situations during their clinical years (Bolander et al., 2008). This perceived need-to-know attitude could affect subsequent efforts to learn in the clinical years.

Moreover, students who heavily rely on 3D and visual images to learn and understand the spatial relationships of the body find it difficult to learn in an environment where access to such specimens is limited or unavailable (Smith et al., 2014). Studies have found that, regardless of the variety of e-learning resources made available to students, many prefer and value access to real cadaveric specimens and textbooks (Davis et al., 2014; McLachlan et al., 2004; Moxham & Moxham, 2007; Raftery, 2007; Ramsey-Stewart et al., 2010). These findings show students' preferences for learning rather than an issue with e-learning resources. This could also be attributed to the quality of e-learning resources and their inability to provide students with anatomical representations that are as realistic as a dissection.

Although dissection has been replaced in most anatomy departments by prosections, plastic models, plastinations, skeletons and computer-generated images (Older, 2004; Sugand et al., 2010), most students believe that dissection fosters deep learning because the act of doing, discussing, deconstructing and reconstructing the body requires students to develop and use active learning strategies (Korf et al., 2008). The lack of such opportunities in the modern medical curriculum poses an additional challenge for students who are trying to learn anatomy within a time-constrained curriculum.

4.1.6 Retention of Anatomy

Contrary to popular belief, there is little evidence in the literature to suggest that all knowledge obtained during pre-clinical years is lost within a short period (Custers, 2010; Custers et al., 2011). In fact, it is estimated that one-third of the knowledge that has been gained but has not been used, revisited or relearned since it was first learned is likely to be forgotten during the first year, followed by 50%–60% loss within two years (Custers, 2010). The few studies that have focused on retention of knowledge past a two-year period suggest that retention declines over time, but at a decelerating pace (Custers et al., 2011; Ellis, Semb, & Cole, 1998; Rico, Galindo & Marset, 1981). A cross-sectional study by Custers et al. (2011) involves three groups of participants: medical students in their final year, medical students who recently graduated and practicing doctors who in some instances had graduated 55 years ago from the time of the study. The participants were examined for their knowledge of basic sciences involving anatomy, physiology, biochemistry and pathophysiology. The study finds a modest decline in basic science knowledge, including anatomy, with students in medical school and recent graduates performing better than doctors who had been out of medical school for many years. The test questions in the study were mailed to participating doctors, who were advised to refrain from using books and computers, and from discussing the questions with others, when completing the test. Since it was impossible to control for cheating on such a test, one could question whether the results of the study represent an honest reflection of the participants' knowledge in the general basic sciences. However, the trend is in the expected direction and is therefore intuitively plausible.

To date, few studies have specifically assessed students' knowledge of anatomy. Rizzolo et al. (2010) highlight the importance of clinical anatomy and its significance in maintaining long-term retention by redesigning a classical anatomy course at Yale University so that their new and shortened version placed a relatively large emphasis on clinical anatomy. They then compared the performance of students from both the classical and clinical courses one and a half years and three years after completing the anatomy course (i.e., before entering clerkship and after completing clerkship respectively) using a computer-graded assessment with 49 MCQs. The results show that, compared with students who undertook the original course, those who were part of the shorter, more clinically focused anatomy course performed as well, or better, on every section of the anatomy examination. Therefore, retention was better in the clinical anatomy group. This supports the evidence that if a course is designed and structured in a way that highlights its relevance to the profession at hand, it can result in high levels of satisfaction and better learning outcomes for students.

In another retention study, Spielmann and Oliver (2005) concurrently examine medical students in the final two years of their five-year degree, as well as junior and senior doctors (including surgical trainees), regarding their knowledge of carpal bone anatomy (eight bones of the hand). They find that junior medical students performed worse on specific knowledge-based assessments than senior clinicians, and 30% of all respondents (the majority of them senior doctors) scored 100%, with medical students displaying the poorest retention. Similar findings are made in a study that examines carpal bone anatomy among second-year (pre-clinical) and fifth-year (clinical) students in a chiropractic course (Meyer et al., 2015). These two studies have quite a few limitations. First, the results are not surprising because one can hypothesise that senior physicians and surgeons, who have had more clinical, focused and repeated exposure and experience, are more likely to perform better on an anatomy test than medical students, who have probably not spent sufficient time learning the material. Similarly, clinical students are more likely to perform better than pre-clinical students. Therefore, exposure is a confounding variable. Further, the carpal bone test administered in this study is a crude measure of assessment. It does not provide a clear indication of students' anatomical knowledge because it only assesses a small region of anatomy, and it does not provide insights into the level of anatomy knowledge present during different stages of students' medical training (Spielmann & Oliver, 2005). In addition, the main clinical significance of the eight carpal bones lies with that of the *scaphoid*, which is the most commonly fractured bone in a fall or accident (Meyer et al., 2015). Coincidently, this bone was correctly identified by 92% of participants in the study, this was followed by the *lunate* and *hamate* as the most identifiable carpal bones, and the remaining five were more difficult for medical students than for the senior house officers. Another limitation of this study is that carpal bone anatomy assesses specific knowledge in students—most of which is not clinically relevant. Therefore, medical students who are faced with the challenge of memorising and assimilating large amounts of information often remember content that has clinical significance rather than content that is purely fact-based and is probably required for specialities such as surgery and radiology.

A longitudinal study that examines retention of anatomy demonstrates that the identification of normal and abnormal radiographic anatomy, which was learned and assessed in the first two pre-clinical years, was extremely poor when medical students were assessed in the fourth year, with more than 90% failing to identify key features (Feigin et al., 2002). Similarly, recall of specific chest radiological landmarks by second-year medical students was excellent at the time and immediately after the teaching was delivered, but the knowledge dissipated two years later, as demonstrated by students’ scores, which were assessed before commencing fourth year. A revision course in the area was then delivered and, not surprisingly, the results show that knowledge that is initially learned and forgotten quickly rebounds in post-test scores following the revision course, and the scores are higher than both the pre-test scores (in fourth year) and the original scores obtained during the second year (Feigin et al., 2007). This supports the rationale that if students are prone to adopting a surface approach the first time around (particularly with specific knowledge), either because of time constraints or a lack of engagement with the material, then the knowledge acquired during that period is quickly forgotten because there has not been sufficient time for consolidation and long-term retention to occur. However, the study also reveals the significance of the testing effect in aiding retention and the importance of vertical integration in the curriculum, suggesting that knowledge that is initially learned and forgotten can be relearned with greater ease if the opportunity and the environment for refreshing the knowledge are appropriately structured—that is, relearning takes place within or alongside the clinical environment.

A similar study investigates the processes of knowledge retention and retrieval in chest radiographic anatomy (Magid et al., 2009). Students who had previously received instruction in radiology during their second year had their pre-test and post-test anatomy scores in the fourth year compared with a group of fourth-year students from another institution. The latter students had not received a formal radiology instruction course in their second year, but they were due to complete a one-month elective in radiology during the clinical years. The students from the second institution were assessed at the beginning (pre-test scores) and end (post-test scores) of the elective course. The results reveal a statistically significant and large difference in post-test scores between students with no formal radiology teaching in the second year (i.e., students scored lower) and students enrolled in the institution that mandated the course (i.e., students scored higher) (Magid et al., 2009). The results emphasise the importance of introducing clinical concepts such as radiology teaching during the pre-clinical years. Although learning new content for the first time might be easily forgotten if the content is not revised or used consistently, the results demonstrate that revision and repetition of prior knowledge enhances the acquisition of knowledge and leads to rapid relearning (Magid et al., 2009), thereby justifying the implementation of a spiral curriculum. It also suggests that curriculum experts should not assume that casual exposure to imaging during clinical years will be sufficient in conveying radiological anatomy to students who have not been exposed to these concepts in the pre-clinical environment. According to Magid et al. (2009), retention of knowledge for initially learned material is 33% at one week, decreasing to 14% at nine weeks. However, if students are encouraged to revise and rehearse existing material, knowledge retention increases to 70%–83%.

Lastly, a pilot study of newly qualified doctors at the University of Aberdeen finds that only 17% had attained the anatomical knowledge required to pass a clinically relevant anatomy assessment (Waterston, Keenan, & Stewart, 2004). The assessment is based on material covered in the first-year anatomy course at the university, and the results challenge the notion that clinically relevant anatomy introduced in the pre-clinical curriculum is sufficient to provide students with the foundations for clinical practice. However, one can argue that the method of delivery during the first-year course needs to be explored further before the results can be generalised. Nonetheless, the study suggests that more vertical integration of anatomy is warranted throughout the medical curriculum to aid students and future doctors in retaining this knowledge. All of the retention studies indicate that knowledge declines over time—particularly when there is no exposure to the discipline during the clinical years. The concept of retention of anatomical knowledge will be explored in this study as it relates to pre-clinical students who are immersed in formal anatomy teaching, as well as clinical-year students whose exposure to formal teaching may be highly varied. The results of this study will provide insights into how much anatomy students learn, when and why they forget anatomy and how the curriculum can be improved to foster better learning and retention.

4.1.7 Anatomy Educators

Trigwell et al. (1999) identify five approaches to teaching that are often used by educators. The first two are teacher-focused and aim to transmit information to students so that they acquire concepts of the discipline. The third approach uses teacher–student interactions to help students grasp concepts. The final two approaches are student-focused and are aimed at students constructing their own knowledge to develop and change their conceptions of the topics under study. The authors find that the strategies used by teachers in their teaching affect how students approach their learning. Teachers no longer stand in front of a class and talk ‘at’ students by reciting ubiquitous volumes of anatomical facts without paying much attention to whether the students assimilate the knowledge. Instead, teachers in the modern curriculum, in addition to being content experts and having a firm grasp of anatomy, must also: have a passion for teaching and learning; develop skills and knowledge regarding the relevant educational theories of how students learn; appreciate strategies to foster understanding; and create or design teaching tools to facilitate students’ learning and adoption of deep approaches to learning (Smith et al., 2014). Additionally, students must be viewed by modern educators as emerging professionals or doctors in the making, and as junior colleagues that require guidance, nurturing and inspiration, but not as empty vessels that need to be filled with large volumes of information (Cottam, 2012). Therefore, it is essential that educators engage with students in the learning process.

Most, if not all, universities and medical faculties aim to produce good-quality research output, since this generates funding and prestige for them. As indicated by several authors, universities must publish or perish (Berman et al., 2014; Monkhouse & Farrell, 1999). There are fewer staff to teach this basic foundational discipline of medicine because anatomy departments have expanded to incorporate research-based staff, faculties have enveloped departments, there are reduced hours in the anatomy curriculum and a diminished cadaver supply, and there has been an increase in student numbers. Qualified anatomists of the past have been sidelined; some face retirement, others have lost their jobs and a few have been moved to less prestigious teaching-only roles (Jones & Harris, 1998).

Non-medical but qualified anatomy teachers are sometimes dismissed in the literature because history indicates that anatomists are keen to impart anatomical knowledge to students in an in-depth fashion, regardless of whether the structure has clinical significance. As one author puts it, “non-medical anatomy teachers are said to have no notion why the subject is taught or why it is relevant from a clinical perspective” (Bergman et al., 2014, p.299), and that students’ anatomical knowledge is negatively influenced by teachers who fail to provide a clinical perspective. This statement is derogatory because it implies that anatomists have no regard for their discipline. However, research has shown that anatomists have positive attitudes towards the changing curricula, and that integrated curricula have allowed them to re-evaluate the anatomical knowledge necessary to practice medicine (Brooks et al., 2015; Chapuis, Fahrer, Eizenberg, Fahrer, & Bokey, 2010; Louw et al., 2009; Patel & Moxham, 2006). In the planning of the modern curriculum, the learning outcomes are the first to be constructed, usually by the curriculum experts or heads of anatomy departments. These outcomes provide a roadmap for teachers or tutors who, regardless of whether they are medically qualified, can use it as a guiding tool to determine the content that needs to be covered and what learners should be able to do upon completion of that content (Berman, 2014; Louw et al., 2009).

In most institutions today, research-based staff—such as cellular and molecular biologists who have little or no experience in anatomy, let alone in teaching the subject—have replaced the experienced anatomists of the past (McCuskey et al., 2005; Older, 2004). While this has been a bold move, it has raised the issue of hiring clinically qualified staff in anatomy departments because the research scientists and the few non-medically qualified anatomists who teach anatomy are unable to offer students a clinical perspective during their anatomy sessions. Moreover, a research-based academic member must prioritise research, with teaching as a secondary responsibility because the latter is valued less than the research outcomes that are generated. Therefore, research-based academic staff often learn to teach on the job (McCuskey et al., 2005). In a condensed curriculum where the extraneous knowledge is being replaced by clinically relevant anatomy, some authors argue that it is time to hire medically qualified anatomists (Older, 2004). Thus, to combat this problem, clinicians and/or surgeons have been recruited on a part-time basis to teach and impart their expert knowledge to medical students in many institutions. However, clinicians who are employed part-time as an educator, and whose genuine interest may be teaching, will likely downgrade instruction as a secondary responsibility in some instances because patient care and administrative duties at their practice must take priority (Bergman et al., 2014). Moreover, the sessional (part-time) tutors who are often employed in anatomy departments are not aware of what has been delivered in other courses, so they cannot allow for integration in the curriculum. For example, clinical skills teaching on the respiratory system often relies on students' knowledge of regional and surface anatomy of the thoracic organs. If anatomy teachers are made aware of the content of clinical skills teaching or the problem-based case for that particular week, they may be able to add clinically relevant anatomy content to assist students in forward-reaching transfer (Bolander et al., 2008), thereby engaging students in a level of integration that is essential for their professional development as doctors.

Another issue related to hiring anatomy educators is the pressure on staff to generate research output. Given that the primary aim of all tertiary institutions is to achieve research targets, with funding geared more towards research development and outcomes (Older, 2004), the few qualified staff who are committed to teaching and who are keen to create useful learning resources for students increasingly must compete for funds to develop these resources. Their plans and creative ideas tend to be overshadowed by other proposals that demonstrate increased potential for generating good-quality research and publications (Bergman et al., 2014; Granger & Calleson, 2005). Combined with a lack of full-time clinically qualified staff and an increase in research-based staff, this is a contributing factor to the decline in anatomy knowledge (Cahill et al., 2000; Fraser, 1991; Monkhouse & Farrell, 1999).

As outlined by Hattie (2009), the best teaching practices are those that strike to the heart of constructive alignment. That is, students must be aware of what is expected of them (through explicit use of learning outcomes), what learning activities will be used to meet these outcomes and how they will be examined (what methods will be used to assess the learning outcomes). Given the many roles required of teachers in medical education, including facilitating student learning, it is important that teachers are supported and guided in developing good teaching skills. While this has been a difficult task in the past, especially in institutions where priorities are ‘to publish’ rather than ‘to teach’, universities worldwide have created initiatives for such individuals by developing and implementing education-focused and teaching-focused academic positions.

4.1.8 Attitudes of Students Towards Anatomy

Medical students around the world are taking part in the debate about anatomy education in the current medical curriculum. When considering the attitudes of students towards this topic, many studies have shown that most students favour clinically relevant anatomy teaching and rate anatomy as highly relevant to clinical practice (Moxham & Plaisant, 2007; Olowo-Ofayoku & Moxham, 2014; Pabst & Rothkotter, 1996; Pabst, Nave, Rothkotter, & Tschernig, 2001; Smith et al., 2014). In one study, junior doctors indicated that 70% of the anatomy they learned in medical school was used during one year in clinical practice (Smith & Mathias, 2007). However, studies assessing students’ and junior doctors’ perceptions of anatomy knowledge during and after medical school have also found that students perceive their level of anatomy to be inadequate and of immediate concern because of insufficient teaching, the quality of the teaching, the lack of summative assessments and the overall design of the curriculum (Farey et al., 2014; Lawson & Bearman, 2007). In fact, most have expressed a need for further anatomy training during the clinical years (Prince et al., 2003), although time for self-directed study is also at a premium. Further, decreased exposure to anatomy has resulted in students feeling less confident in practicing medicine on the wards, and many students have subsequently experienced decreased respect from clinical supervisors as a result of this perceived shortfall (Linacre, 2005; Mitchell & Batty, 2009; Ramsey-Stewart et al., 2010).

In the UK, a study of recent graduates from the University of Nottingham finds that those who were enrolled in the undergraduate medical course (usually a five- or six-year course) perceived their anatomy knowledge to be insufficient compared with those who had enrolled in the four-year graduate-entry medical course (Fitzgerald et al., 2008). The factors believed to account for this difference in opinion were pre-existing anatomy knowledge in graduate-entry students, better teacher–student ratios for the graduate prosection-based anatomy course compared with the undergraduate dissection course and the lower rate of graduate students contemplating surgery as a career. Many students enrolling in a graduate-entry course come from diverse backgrounds, and some possess Masters and Doctoral degrees. When these students decide to enrol in medicine, most, if not all, students steer away from surgery as their field of specialisation because of the extensive training involved following graduation. Given that most of the students who believed their anatomy knowledge was insufficient were those contemplating a surgical career (Fitzgerald et al., 2008), it is not surprising that graduate students perceive their anatomy knowledge to be superior or sufficient when compared with undergraduate students, thereby reflecting a lack of understanding about the importance of anatomy in other areas, as outlined above.

At the University of Birmingham in the UK, only 14% of final-year medical students felt confident in their knowledge of anatomy (Bhangu et al., 2010), while a study conducted at the Penn State College of Medicine in Pennsylvania in the US shows that medical students perceived the transfer of anatomy knowledge from the classroom to the clinical environment to be challenging (Lazarus, Chinchilli, Leong, & Kauffman, 2012). Similar concerns stemmed from a cohort of medical students at Monash University in Australia, who were dissatisfied with the amount of anatomy teaching received. They stated that their limited exposure to dissection and reduced teaching time would impair their ability to practice medicine safely during their intern years and beyond (Smith, 2005).

When considering the importance of anatomy, a retrospective evaluation of the medical undergraduate curriculum was conducted in Germany. It found that 86% of doctors at the end of their residency training from all specialties (general medicine, paediatrics, surgery and radiology) said that anatomy was *fundamental* to practicing medicine, and 13% said that anatomy was *necessary* (Pabst & Rothkotter, 1997). These findings were similar to those made regarding students in a Singaporean medical school, where 77% of students in all five years of the medical course indicated that their gross anatomy course was very relevant to clinical practice (Leong, 1999).

The debate about the reduced anatomy curriculum and its effects on students and clinical practice has led to an outcry within the medical community. In Australia, this outcry has led to a national call for a core curriculum in anatomy, not only by clinicians, but also by medical students. A 2006 survey by the AMSA revealed that 72.6% of responding students (610 students) felt that the number of hours devoted to anatomy teaching in the medical curriculum was insufficient, whereas 53.7% felt that anatomy was inadequately represented in assessment (Mitchell & Batty, 2009) and less than 40% believed that their anatomy knowledge was sufficient to work safely as a junior doctor (Craig et al., 2010; Mitchell & Batty, 2009). These results suggest an emerging perception among medical students regarding a feeling of incompetence because of their anatomy training. In 2014, the AMSA called for explicit guidelines to be made available on the core anatomical knowledge expected of graduates for safe clinical practice given the lack of established curriculum guidelines by the AMC (Farey et al., 2014). In the UK, the GMC does not specify detailed curriculum content for anatomy; thus, the Anatomical Society of Great Britain and Ireland has attempted to resolve the issue of core knowledge by publishing a core syllabus in anatomy. As Hanwell et al. (2007) elaborate, this document:

> …starts with a broad general statement which includes surface anatomy, the interpretation of standard clinical images, and the importance of the knowledge for understanding of common pathologies. This is followed by a more detailed specification of the topographical knowledge required to meet these general aims. (pp. 6–7)

The primary aim behind this document is to ensure that, in the face of a reduced curriculum, the most relevant anatomy concepts required for newly qualified doctors to practice safely are identified (McHanwell et al., 2007). However, to date, no such curriculum exists in Australia and New Zealand.

Following AMSA's report in 2006, the University of Sydney introduced a seven-week elective dissection course to students at the end of their third year to give them an opportunity to engage in dissection and improve their knowledge of anatomy (Ramsey-Stewart et al., 2010). Many proponents of dissection state that the process of dissecting rewards students with the ability to create a 3D mind map of the human body, which ultimately results in an understanding of the relationships between regional anatomical structures—a concept that is difficult to grasp without the tool of dissection. The findings from this seven-week elective course revealed that there was a significant increase in anatomical knowledge and retention, and a general positive attitude towards dissection, with all participants recommending that the course be made available to all students (Ramsey-Stewart et al., 2010; Sarkis et al., 2014). This suggests that students regard dissection as a valuable resource for increasing their knowledge of anatomy, and they consider it a skill that is so fundamental to the practice of medicine that it should at least be reintroduced into the medical curriculum as an elective, if not as a mandatory component.

The literature reviewed above paints a clear picture of a disgruntled student body who have called upon medical institutions to give them sufficient training in anatomy during medical school so they feel competent and confident, and subsequently better trained to practice medicine in the clinical environment. These issues, along with students' attitudes towards learning anatomy, will be explored in this study. Participants will be asked to comment on their perceptions of the adequacy of the anatomy curriculum in preparing them for the clinical years and for medicine, as well as the importance of anatomy in the clinical years and in medicine. Given that students learn through different modalities, educational institutions must provide a variety of learning opportunities to a wide and diverse student body.

4.1.9 Development of Postgraduate Surgical Programs

In the face of today's anatomy teaching and reported declining knowledge, medical graduates are forced to seek further training to advance into specialties and independent practice (Collins, 2008). This is considered necessary for those wanting to undertake surgery as a speciality. Consequently, many graduates enrol themselves in postgraduate surgical training courses to facilitate their knowledge and enhance their skills in the art of dissection (Older, 2004; Ramsey-Stewart, 2010; Smith, 2005). In Australia and New Zealand, 14 accredited postgraduate anatomy courses are currently offered (AOA, 2015). It is evident that the knowledge of graduates entering these training programs is lacking and that, for some, this postgraduate course presents the first opportunity for a student to be in the dissecting room (Briggs, 2014; Standring, 2009).

As Raftery (2007) states, "when and how will candidates gain their knowledge if anatomy is considered largely as a postgraduate subject?" (p. 2). It has been argued that detailed anatomy should only be taught to those who want to specialise in surgery, because students need to have detailed knowledge of anatomy to know what to look for and how to achieve the greatest benefit (Collins, 2008). Therefore, the postgraduate medical education bodies provide a second opportunity for students to learn anatomy and are responsible for ensuring that their graduates have mastered the detailed anatomy required for a particular specialty (Collins, 2008). However, anatomy cannot be taught through the window of surgery because a good basis of anatomy knowledge is needed by all students before they get to the operating table (Raftery, 2007) and medical students must be equipped with sufficient foundational anatomy knowledge to allow them to practice medicine safely (Ramsey-Stewart, 2014; Collins, 2008). As such, this study explores the delivery of the anatomy curriculum in the Monash graduate-entry program and seeks to understand the extent to which the curriculum impacts students' learning of anatomy. The results of this study will provide insights into how teachers can help students to learn and retain anatomy better, and how the anatomy curriculum in a medical program might be improved.

4.2 Hypotheses of the Study

Given the questions raised in the existing literature on anatomy learning and retention, this study will examine and explore the retention of anatomy knowledge and the delivery of the anatomy curriculum among medical students across all four years of the MBBS course at Monash University, with a focus on the graduate-entry medical program at MRH–Churchill.

In Phase One, participants undertook a test with 60 MCQs and/or EMQs encompassing all regions and systems of anatomy. Since students in the clinical years have varied exposure to anatomy and many, if not all, do not receive formal anatomy teaching, the hypothesis is that anatomy knowledge will decline as students progress further away from their pre-clinical year (when anatomy is formally taught). That is, students in the clinical years will have a poorer knowledge of anatomy when compared with students in the pre-clinical year (Year A). This hypothesis is similar to that of previous retention studies (Feigin et al., 2002, 2007), which stated that students who are currently immersed in the learning process of a particular task perform better on assessments administered at the same time compared with a similar assessment administered years later, thereby suggesting that knowledge declines over time. However, the reasons for the decline will be explored through qualitative means (Phase Two). The hypothesised contributors to the loss of retention in anatomy knowledge are a lack of formal teaching and anatomy assessments, a lack of opportunities for vertical integration of learning and a subsequent lack of students' motivation to study or revise anatomy.

Chapter 5: Methodology

5.1 Methodology, Research Design and Research Methods

5.1.1 Introduction to Methodology

The term *methodology* can be defined as “the philosophical framework and the fundamental assumptions” that underpin all research (Creswell & Plano Clark, 2007, p. 4). All research studies contain assumptions about the world (i.e., a particular worldview) and about how to capture the knowledge that is sought. Possessing a worldview or a paradigm is central to the research process because it incorporates a belief system (i.e., how we view the world) and a framework that guides all research (i.e., how we undertake research) (Creswell & Plano Clark, 2007).

Crotty (1998) identified four key elements for consideration when designing a study: the *philosophical assumption* (epistemology, ontology) of how knowledge is acquired; the *theoretical stance* (e.g., social science, feminist) that a researcher may or may not use, which is informed by the former; the *methodological approach* or research design (experiment, mixed methods, ethnography); and the *methods* (interviews, surveys, instruments) used to gather, analyse and interpret data from the study (Creswell & Plano Clarke, 2011).

Given that the purpose of this study is to explore anatomy retention in students enrolled in a graduate-entry MBBS course, two worldviews or assumptions about anatomy retention were made, which ultimately formed the philosophical foundations for this research.

The first follows the epistemological view of *post-positivism*, which states that there is an objective reality that can be measured, controlled and predicted according to patterns of observations. Therefore, the phenomenon observed is “hard, real and external to the individual” (Cohen, Manion, & Morrison, 2007, p. 8). The post-positivist view is primarily based on the assumption of *determinism*, which states that “events have causes and events are determined by other circumstances” (Cohen et al., 2007, p. 11). Therefore, a cause-and-effect relationship takes place in the world, and “these causal links can be uncovered and understood” (Cohen et al., 2007, p. 11). The term *event* refers to anatomy knowledge, *causes* refers to anatomy teaching in the medical curriculum (e.g., time, duration, type), and *effect* refers to retention of anatomy knowledge in medical students. Therefore, under this view, the teaching of anatomy (which is largely determined by circumstances such as program duration, money, time, resources and university initiatives) in the medical curriculum could be seen to affect students’ knowledge and retention of anatomy in the later clinical years; thus, this potential causal link is explored further through appropriate research methods. As Creswell and Plano Clarke (2011) state, “postpositivism is often associated with quantitative approaches” (p. 40), and its aim is that of theory verification through deductive reasoning. The hypothesis tested in this study is that the more anatomy teaching a student is exposed to over the course of their MBBS degree, or the more recent their formal anatomy instruction, the better their retention of anatomy knowledge.

The second epistemological view associated with this study is that of *constructivism*, which is defined by Spratt et al. (2004) as:

> a theory which holds that social phenomena and their meanings are constructed by the people involved in using them, rather than being external objects existing independently of them, in contrast to positivism. (p. 7)

That is, participants’ views and experiences in a situation are important for exploring the interactions and outcomes that these individuals have with the world (Cohen et al., 2007). Thus, the assumption here is that any phenomenon observed can only be understood through the subjective reality of participants and their views. These views are usually shaped by participants' social interactions with the world and their own past experiences (Cohen et al., 2007; Creswell & Plano Clarke, 2011). Therefore, good or poor retention of anatomy knowledge may depend on students' experiences in the pre-clinical and clinical years, as well as their motivation and interest in anatomy and their priorities at the time. Thus, using qualitative methods, an in-depth description and exploration of these issues can be observed from multiple perspectives, and a bottom–up, inductive reasoning approach can be applied to generate broad patterns and understandings of anatomy retention among participants (Creswell & Plano Clarke, 2011).

Using the two philosophical assumptions as the basis for this research, and considering the research questions posed, a mixed-methods research approach is employed to answer the three research questions:

- How does anatomy knowledge differ among students in the pre-clinical and clinical years of the MBBS course?
- To what extent do medical students retain anatomy knowledge?
- What factors may account for the loss or retention of anatomy knowledge across a student's medical degree?

Mixed-methods research dates to the late 1980s and early 1990s, when several authors documented their approach to using both quantitative and qualitative strands in a single study (Brewer & Hunter, 1989; Bryman, 1988; Creswell, 1994; Fielding & Fielding, 1986; Greene, Caracelli, & Graham, 1989) to provide a comprehensive picture of complex research problems (Creswell & Plano Clark, 2011). Despite the incompatibility thesis controversy, which suggests that researchers are doomed to fail when they employ two research methods together because of the incongruity of the principal paradigms underlying each of the methods (Tashakkori, 2003), many researchers have demonstrated that a “peaceful coexistence of multiple methodologies is possible” (Venkatesh et al., 2013, p. 22).

Today, mixed-methods research is known as the “third methodological movement or paradigm” (Venkatesh et al., 2013, p. 21) because more than one worldview can be used in a mixed-methods study. Further, the adoption of multiple paradigms often relates to the type of design chosen in a mixed-methods study (Creswell & Plano Clark, 2011).

5.1.2 Research Design

With the guiding philosophical framework of post-positivism and constructivism established for this study, a mixed-methods research design was selected as the principal model for collecting, analysing and interpreting data from a group of graduate-entry MBBS students, since this represented an opportunity to “move beyond the ideological clashes between the quantitative and qualitative purists” (Trahan & Stewart, 2013, p. 60)—a label assigned to individuals who refuse to mix paradigms (Rossman & Wilson, 1985)—“and instead focus on the pragmatic value of each approach" (Trahan & Stewart, 2013, p. 60).

A mixed-methods research design is defined as “the combination of two or more methods in a single study, which produces both quantitative and qualitative data” (Hall, 2008, p. 119). The reasons underpinning the adoption of a mixed-methods design are numerous and stem from the fact that, in isolation, quantitative or qualitative strands would be insufficient to answer the research question, but by combining the two strands, a more complete picture of the problem at hand can be obtained. That is, a mixed-methods design strengthens the research process by offsetting the weaknesses of either the quantitative or qualitative method alone, and it supplements the information provided by the two strands (Creswell & Plano Clark, 2007, p. 9; Feilzer, 2010). Further, mixed-methods research offers five main advantages: a) *Triangulation:* it allows for corroboration and completeness of results through multiple methods and data sources; b) *Complementarity:* it uses the results from one method to enhance and clarify results from the other method; c) *Development:* it uses the results from one method to develop (the instrument) and inform (select cases) in the other method; d) *Initiation:* it uses the results from one method to question and identify concepts that would have gone unnoticed from a single-method study; and e) *Expansion:* it uses different methods to answer different components of a research question (Creswell & Plano Clark, 2011; Green, Caracelli, & Graham, 1989). Although other authors have documented further reasons for using mixed-methods research, the five advantages listed above provide a general framework for its use today.

Mixed-methods research can be carried out in multiple ways, as outlined in Table 5.1 (Creswell & Plano Clark, 2011, pp. 63–68). However, the epistemological views and research questions are central to the *adaptation* of the type of mixed-methods design adopted for this study. For the purpose of choosing an appropriate design for this research, four criteria had to be addressed: the interaction of data obtained from quantitative and qualitative strands; the importance given to each strand in answering the research questions; when the qualitative and quantitative phases would be implemented; and how data from both strands would be combined to answer the research questions.

Table 5.1

The criteria for developing a mixed-methods research design

Criteria	Description
The level of interaction between the quantitative and qualitative strands	Independent: Results from both strands are mixed towards the end of the study Interactive: Mixing of both quantitative and qualitative strands takes place at multiple phases of the study.
The priority of the strands	Convergent: equal emphasis to both strands. Explanatory: quantitative emphasis Exploratory: qualitative emphasis
The timing of the strands	Concurrent timing: both strands applied at the same time Sequential timing: the second strand can only be executed after the first strand has been fully implemented.
Mixing of the strands (Stage of integration)	Mixing data of both quantitative and qualitative strands. Can take place during any point of the research process: data collection, analysis, interpretation and/or design.

Source: Adapted from Creswell and Plano Clark (2011)

Following careful consideration of the aims of this research, and given the four criteria above, an *independent sequential explanatory mixed-methods design* was selected as the most appropriate methodology to address the research questions. The purpose of this design was twofold: to use quantitative data analysis in the first phase (a test of anatomical knowledge, demographic and background questionnaires) to identify and guide participant selection for the second qualitative phase (interviews); and to use data from the qualitative analysis to explain the initial results obtained from the quantitative analysis (performance on anatomy test). As Creswell and Plano Clarke (2011) state, the sequential explanatory design is "most useful when the researcher wants to assess trends and relationships with quantitative data but also to be able to explain the mechanism or reasons behind the resultant trends" (p. 82).

Under this design, the research began with a Phase One component involving quantitative data collection and analysis to determine the extent of medical students' anatomy knowledge and the difference in this anatomy knowledge between students in the pre-clinical and clinical years. Demographic and background information on how students learn anatomy was collected during this initial phase. Once again, epistemological views formed the basis for each approach. The underlying paradigm for the quantitative phase, as discussed above, was that of the post-positivist. The data collected from participants, although based on an objective reality, would be interpreted with caution, especially regarding one-sided interpretations. Using this perspective, appropriate quantitative instruments were developed for this phase of the research, and they are discussed in the following section. The quantitative phase was later followed up by a Phase Two component involving qualitative data collection and analysis to explore the factors responsible for students' retention of anatomy or lack thereof. The underlying paradigm in this instance was that of the constructivist.

In this way, the integration of both quantitative and qualitative methodologies was considered paramount to exploring the issue of anatomy retention (and subsequently answering the three research questions) because this provided an opportunity to quantitatively collect evidence of anatomy knowledge and retention as it currently stood in a group of graduate-entry medical students. The results from the quantitative strand would be used to *develop* and select the participants for the qualitative strand, and to identify concepts that would be explained by the qualitative strand through the process of *initiation*. Using qualitative measures, the study can develop a deeper understanding of the observed phenomenon—that is, good or poor retention of anatomy through *complementarity* (results of the qualitative phase help to explain quantitative findings), *expansion* (explanation of observations from the quantitative strand), *corroboration* (assessing inferences made from the quantitative strand) and *compensation* (offsetting weaknesses of the quantitative strand) (Venkatesh et al., 2013).

5.1.3 Rationale for the Research Design

A body of knowledge in the literature has highlighted the fact that, over the years, medical students' knowledge of anatomy has declined as perceived by clinicians, surgeons and students themselves (Cottam, 1999; Dawson, Bruce, Heys, & Stewart, 2009; Farey et al., 2014; Fitzgerald et al., 2008; Gogalniceanu et al., 2010; Linacre, 2005; Standring, 2009; Waterson & Stewart, 2005). Consequently, medical students perceive a need for an anatomy refresher course, and universities require a national anatomy curriculum (Cottam, 1999; Craig et al., 2010; Golganiceanu et al., 2010; Herle and Saxena, 2011; Leung et al., 1996; McKeown et al., 2006; Ramsey-Stewart et al., 2010). While a number of related studies have explored anatomy performance by students in the pre-clinical year, and subsequently in the clinical year (Meyer et al., 2015; Rizzolo et al., 2006, 2010), a topic that is yet to be explored relates to how much students have retained and/or forgotten and why. For changes to the curriculum to take place in any institution, a detailed understanding of the phenomenon (retention of anatomy knowledge or lack thereof) must be observed, measured and documented not just through objective reality, but also through the eyes of the subjects under investigation. This requires data to be obtained using both quantitative and qualitative methods. The strength of the research question(s) will dictate which strand takes priority.

This study places a greater emphasis on the quantitative strand; hence, the sequential explanatory design was the most appropriate method to facilitate this research because it provided the best and most practical means to address two of the three research questions. If data were to be obtained only through quantitative methods, the results would only identify the extent to which students retained anatomy and how the pre-clinical students differed from clinical students. There would be no further understanding or insights into the third research question (what factors accounted for students' retention and/or loss of anatomy knowledge), because this could only be achieved by implementing a follow-up qualitative phase. This particular research design therefore helps to "plug the gap"—that is, to explain the results obtained from the quantitative analysis (Creswell & Plano Clark, 2007, p. 30; Feilzer, 2010), thereby providing an overall richness to the entire study (Venkatesh et al., 2013) and a deeper understanding of the research problem(s).

5.1.4 Research Methods—What Did They Entail?

The chosen research methods offered the best potential for answering the research questions. This study consists of two phases: a quantitative phase (Phase One), which was delivered online, and a qualitative phase (Phase Two), which was conducted face-to-face or via telephone.

The quantitative phase (Phase One) was delivered in two parts. Part one consisted of a demographic and anatomy-learning survey that incorporated 13 questions pertaining to the participants' previous background, resources used in learning anatomy, motivation for learning, challenges perceived with studying anatomy, participants' perceptions of the importance of anatomy, usefulness of anatomy to participants in the pre-clinical and clinical settings, and learning approaches to anatomy (see Appendix F). This questionnaire was developed for this study, and no time limit was allotted to this component of the quantitative data-collection phase. Upon completing the questionnaire, participants were directed to part two of this phase—the anatomy assessment task. This assessment consisted of 60 anatomical questions constructed in multiple-choice and extended-matching format. The questions were considered relevant to clinical practice, and the assessment covered content from all regions of the body (i.e., head and neck, back, upper limb, lower limb, thorax, abdomen and pelvis) (see Appendix F). The development and refinement of these questions will be discussed in Section 5.5.

Upon completion of the online questionnaire and assessment, participants received immediate feedback in the form of their overall performance on the test, along with their scores within each of the six regions represented on the assessment task. Once the quantitative data were analysed (using SPSS Statistics version 22), a comparison was made of participants' performance on the anatomy assessment task across the years (cross-sectional approach). This provided an explanation of how the pre-clinical-year students differed from the clinical students in terms of their anatomy knowledge. It also provided comparisons across the different anatomical regions and across the different clinical years.

In addition, participants in the clinical years had their overall score in this anatomy assessment compared with their anatomy score in the Year A VIA paper. Comparing the clinical-year students' anatomy scores on the VIA to their scores on the anatomy assessment task provided insights regarding the extent to which medical students retained anatomy knowledge.

During the recruitment process, participants were advised that, following Phase One, they might be invited to participate in the qualitative phase (Phase Two) of the research. This consisted of a semi-structured interview conducted either face-to-face or via telephone to uncover participants' experiences with anatomy in the pre-clinical and clinical setting, and to obtain insights that could explain participants' loss or retention of anatomy knowledge. The development of the interview questions is discussed in Section 5.6.

5.2 Ethical Considerations and Approval

Research ethics is the practice and monitoring of ethical conduct in research. It ensures that the integrity of the researcher and the university as a whole is preserved and, more importantly, it serves to protect the subjects who are approached to participate in the research. Therefore, it is crucial to ensure that ethical obligations are met before conducting the research.

Prior to commencement, the ethical issues most pertinent to this research had to be considered and addressed in terms of how they could be minimised. Some of the major issues explored are detailed below, and the remaining ones are listed in Table 5.2.

5.2.1 Recruitment, Conflict of Interest, Power Relations

Research participants are an integral component of any mixed-methods study. For this study, the research centred on the recruitment of Monash University graduate-entry medical students from all four year levels of the MBBS course. This presented one of the first issues that had to be addressed, because there was a direct conflict of interest between the student researcher who, as an employee of Monash University, was also involved in teaching the pre-clinical students, some of whom would later form part of the research sample. Close involvement with the teaching and assessment of the first-year students meant that the recruitment of these participants could be construed as coercive, which could ultimately lead to research misconduct. The issue of power relations was also an area that had to be considered because it could result in students feeling pressured or obliged to participate because of their existing or previous relationship with the student researcher (Allmark et al., 2009). Further, the researcher had to account for the fact that the participants might feel that their grades could be affected, or that they would be treated differently if they did not choose to participate.

As Section 4.6 of Victoria University's Research Integrity policy (2012) states: "All persons involved in research must recognise and manage actual, potential and perceived conflicts". Therefore, to minimise this risk, the research team decided to engage a third-party individual—in this case, a professional staff member with no direct involvement in the teaching or assessment of the students—to assist in the recruitment process of all participants in the research.

5.2.2 Anonymity, Confidentiality and Privacy

Other major issues facing the team were that of anonymity, confidentiality and privacy. *Anonymity* in research means that the identity of participants is not known. *Confidentiality* in research refers to not revealing the identity of participants and avoiding the disclosure of such information to the public (Johnson & Christensen, 2004, p. 112).

An ethics procedure guarantees participants' privacy and confidentiality during the research study, and it functions to protect subjects against "unjustifiable deception as well as physical or psychological harm, including loss of dignity, loss of autonomy, and loss of self-esteem" (King & Horrocks, 2010, p. 155). Anonymity, confidentiality and privacy are also extremely important during the interview phase because participants might not provide consent or reveal information if they feel threatened by exposure. Further, they might conceal embarrassing or conflicting statements that they feel could be associated with them out of fear of being identified.

Protecting the participants' rights and maintaining confidentiality is central to Victoria University's Research Integrity policy (2012) and the National Health and Medical Research Council's (NHMRC) Code of Research Conduct (2007); thus, it was paramount to this research. To minimise this risk, research participants were reassured that all information obtained during the research would remain confidential. Although confidentiality would be preserved, the research design required that some participants be identified following the quantitative study to allow the research team to make judgements and decisions about selection for the qualitative phase. Therefore, it was not possible to promise participants that their identity would not be known to the team. However, they were assured that no one outside of the research team would be privy to the information. In the participant information form (see Appendix A), students were advised that their identity would be coded and that all data collected and stored would use only their student ID.

5.2.3 Informed Consent

All research involving human participants must proceed only when the participants have provided informed consent (see Appendix B). Further, in a mixed-methods study, the researcher must obtain consent to use and publish data collected from both quantitative and qualitative research. Brewer and Hunter (1989) state that:

> Researchers…need to make sure that their respondents are aware that the data they provide, say on a survey, may in fact be used in yet a second study and that in some cases, they may be re-contacted for a follow-up interview. (p. 151)

To obtain informed consent for this research, it was imperative that students were given all necessary information to make an informed decision, because the facts could influence a subject's willingness to participate (Johnson & Christensen, 2004, p. 102). To that effect, a participant information form that documented the purpose of the study, what it entailed, the methods employed and the risks and benefits associated with participation were emailed to those who expressed initial interest in the research. This included advising students that all information obtained from the research would be presented at conferences, as well as published in journals after all identifiers had been removed. The information form also emphasised that all individual data would remain confidential.

Participants were also advised that they were free to withdraw up until a pre-specified stage of the research process. For the quantitative phase, withdrawal had to take place via email or telephone within one week of participation, whereas in the qualitative phase, participants were given the option to withdraw four weeks following participation. To further ensure accuracy of the transcribed conversation, and to prevent misinterpretation by the researcher (Allmark et al., 2009), participants were informed that they would be given a transcript of their interview (Creswell, 2008b, p. 267) to allow them to check the transcribed comments for accuracy.

5.2.4 Data Storage and Handling

Data management and protection approaches are essential for appropriate research conduct (NHMRC, 2007). As this study engages human participants, all information acquired during the research process had to be handled in a secure way to protect participants' rights and confidentiality. Thus, all data collected during the research (consent forms, questionnaires, test results, recordings, transcripts) were catalogued and stored securely on Victoria University's R: drive and on an external hard drive with encryption. Further, they were protected from damage so that materials could be accessed in a retrievable form at a later period (NHMRC, 2007).

As part of Victoria University's Research Integrity policy (2012), the university provides its students with a repository where data can be stored. To manage the data collection and storage process, a 'Research Data and Materials Plan' was drawn up and recorded with the Office of Research at Victoria University during the research. The document detailed how and where the data were to be stored, who the research team members were and which individuals could manage and access the information. Also included were procedures on when the data should be destroyed and whether the data could be shared with any external parties. As indicated by the NHMRC (2007) and Victoria University's Integrity policy (2012), the standard retention rate is five years. At this point, the data will be maintained for this period unless specified otherwise by the research team.

Table 5.2 lists the remainder of the ethical issues that were of concern in this research, along with the steps taken to minimise them.

Table 5.2

Ethical Issues Prevalent in the Research

ISSUE	WHY IS IT CONTENTIOUS?	APPROACHES TO MINIMISING ISSUES
Sample Size	The quantitative study required a much larger sample size compared to that of qualitative study thus posing the issue of sampling bias.	Criteria (performance, prior educational background, student engagement) for sample selection of the qualitative phase were specified prior to commencement of the study along with the maximum number of participants for the qualitative study (16-20).
Data Security	The research involves administration of an online anatomy assessment task to participants. Thus, there was the possibility of replicating material and passing information to other participants, which could taint the results.	The anatomy questions were newly constructed and delivered online via a secure site, which had a timed-feature so as to maintain the integrity of the data as much as possible. The copy and paste functions on the webpage were also disabled (Buchanan & Hvizdak, 2009).
Disclosure of Ethical Dilemmas	Qualitative research can expose participants to emotional harm. It can reveal sensitive information such as conflict in the workplace, discrimination, harassment, abusive power relations etc.	Protocols were set up for dealing with such sensitive ethical issues. Participants were provided with contact details of the research team along with details of a psychologist at Victoria University. Participants were encouraged to contact any member of the team should any distressing issues arise (Johnson & Christensen, 2004, pp.111; Allmark et al., 2009.
Research Misconduct	Research data must be protected from fabrication, falsification, plagiarism etc. as this can jeopardize the reputation of the researcher, research team and institution whilst diminishing confidence in the findings within the scientific community (NHMRC, 2007).	All data analysis was substantiated by conferring results with the research team to avoid biased conclusions. Participants were provided with transcripts from interviews so as to confirm data.

5.2.5 Ethics Approval

Given that the research focused solely on Monash University medical students and involved the use of human participants and the acquisition of private and confidential information from these participants, it was important to ensure that ethical and professional standards were met prior to the commencement of the study. Further, as this research formed the basis of a thesis for a Victoria University PhD student, ethics approval was sought from two professional bodies (see Appendix C).

The research was considered low risk and was first approved by the Victoria University Human Research Ethics Committee in 2014 and subsequently by the Monash University Human Research Ethics Committee in the same year. The approval process at Monash University had to be sanctioned by the Dean of the Faculty of Medicine, Nursing and Health Sciences in the first instance, prior to approval by the Monash University Ethics Committee.

5.3 Participants

The participants of interest in the research were first-year (Year A), second-year (Year B), third-year (Year C) and fourth-year (Year D) medical students who were enrolled in the four-year graduate-entry MBBS program at Monash University. These students had commenced their MBBS degree between 2011 and 2014. Regardless of which year they commenced, all cohorts went through Year A studying the same anatomy curriculum. That is, every participant was exposed to the same number of teaching hours, teaching methods, lectures, practicals, workshops, tutorials and specimen days. Except for two tutors, who left mid-way through this period and were replaced, all anatomy personnel remained the same across the four years. In a research study, many of these external factors (curriculum, teaching methods, teaching time, personnel and available resources) have the potential to alter the findings of a study such as this. To minimise these issues, one medical school was selected as the site of interest for this research.

The maximum number of students that could be sampled from all four cohorts of the graduate-entry course was 300. However, only 144 students (48%) expressed an interest in participation (78 males and 66 females). Of these, 140 participants (97%) returned signed consent forms, and 138 students (96%) progressed to complete Phase One—the anatomy-learning questionnaire and assessment. Two participants did not log on to complete the assessment on the allocated dates because of personal commitments and hence were excluded from the research. Two participants in the sample were repeating students (having re-attempted one of their clinical years)—that is, they were enrolled in the fourth year of the graduate-entry program (Year D) and hence were accepted into the research. However, they had commenced the MBBS program in 2010, and their experience of Year A was similar to that of subsequent cohorts.

Figure 5.1 shows the representation of participants in each cohort compared with those who did not participate.

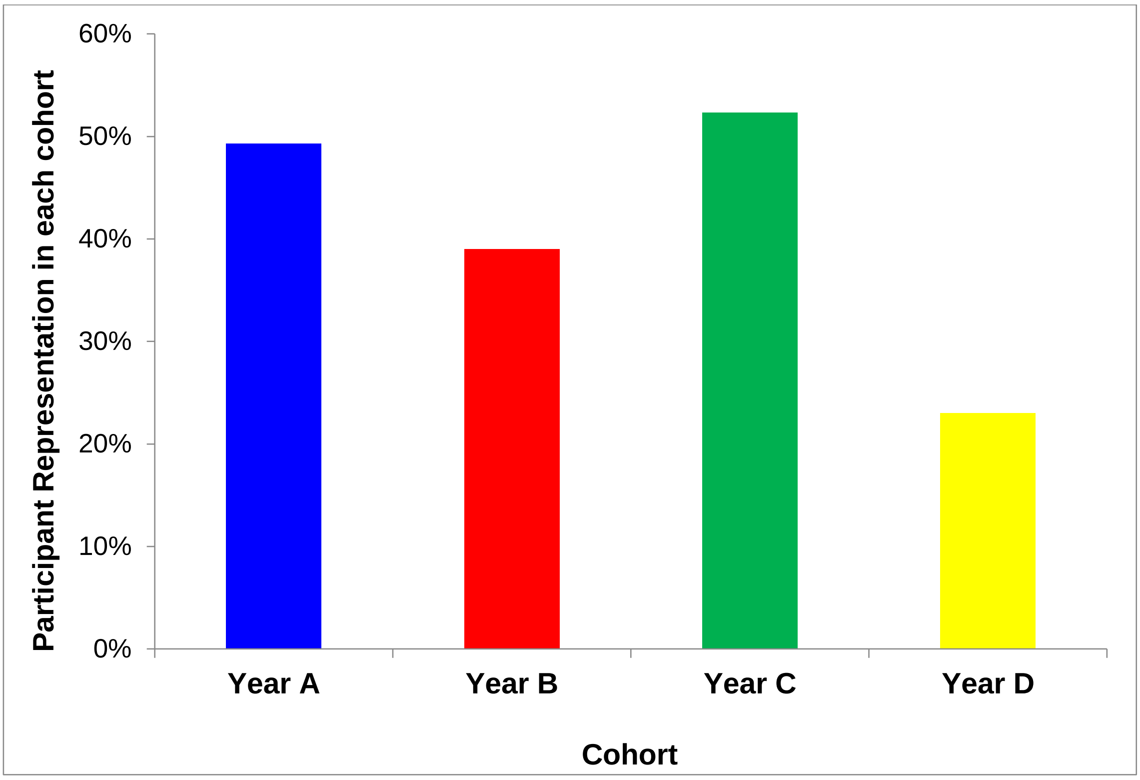


Figure 5.1: Participant representation relative to each of cohort (Years A–D).

Approximately 50% of Year A and Year C students were represented in the sample, followed by 40% of Year B and 23% of Year D students.

As evident from the participant distribution across the four cohorts of the MBBS graduate-entry degree in Figure 5.2, the Year A and Year C cohorts were highly represented within the sample of 138 participants, with 40 and 45 students recruited respectively. This was because students wanted an opportunity to practice their anatomy knowledge prior to their upcoming summative assessments. Recruitment was slightly lacking for the Year B cohort, with 32 students volunteering their participation, and the numbers were highly deficient for the final Year D cohort, with only 21 students recruited despite many efforts to encourage participation.

5.4 Recruitment

Convenience sampling was used to recruit participants. This type of sampling, which involved choosing participants who were available and accessible at the time (Cohen et al., 2007), was selected because students in the clinical years were scattered across various clinical sites and, depending on their current workload and priorities, gaining access to them would have been problematic. The recruitment process took place via an email invitation sent by a professional staff member at Monash University to students in all four year levels of the graduate-entry MBBS program. The email was drafted by the researcher and was entitled 'Test your anatomy knowledge and help contribute to new research'. In the email, students were advised of the title of the research and the makeup of the research team, and they were notified that the study consisted of two phases: a learning anatomy survey and a formative anatomy assessment task to be delivered online in late 2014, with a potential invitation for an interview in early 2015. Further, a flyer was embedded in the email (see Appendix D) that gave students non-financial incentives to participate, such as an opportunity to revise for examinations and to test their knowledge, and an opportunity to understand the strengths and weaknesses in their anatomy knowledge.

Students who wanted to participate in the research were asked to contact the main researcher for further information via a separate email address (anatomy.retention@gmail.com) that was dedicated specifically to the project.

The recruitment process commenced in September 2014, approximately eight weeks prior to the scheduled Phase One data collection. The assessment task in Phase One was due to take place a few weeks prior to the students' summative written examinations; therefore, the reason for recruiting later in the year was to keep students motivated and committed to participation. Consequently, three emails were sent to all participants over a span of four weeks to maximise recruitment. During recruitment, there was an influx in participant numbers in the Year A and Year C categories, with approximately 50% of each cohort expressing an interest in the research. This was expected, because the students in these cohorts were to be engaged shortly thereafter in high-stakes summative written assessments—part of which would test the anatomy knowledge covered in Year A. Unfortunately, only 17% of the Year B cohorts and 8% of the Year D cohorts registered their interest. Although there are integrated assessments in Year B and Year D that would require anatomical knowledge, these students do not sit a formal anatomy assessment or receive an anatomy score from the integrated assessments during this period; hence, it could be argued that there was little incentive for them to participate. Therefore, a separate email highlighting the opportunity to participate in the research was sent to each of the Year B and Year D students by the clinical site administrators to attempt to increase recruitment. The resulting influx of 18 additional students from the Year B cohort (22%) and 14 additional students from Year D cohort (16%) was added to the pool of participants for this study.

Overall, 144 students responded to the call for participants. After the initial expressions of interest had been received, the researcher using the research email address (anatomy.retention@gmail.com) provided students with further information on the research via a participant information form and a participant consent form that were sent via email. Students were advised that if they wanted to participate after having read the information form, they should email their signed consent form and student ID to be formally accepted into the research study. The method of receiving consent forms via email was selected to facilitate the ease with which consent could be obtained from students scattered across Victoria and overseas.

There were 140 students who provided a signed consent form to participate in both phases of the research. Four students did not consent or respond to further emails; hence, they were omitted from the study. Two of these students were overseas at the time. Although consent was obtained for participation in Phases One and Two of the research, participants were made aware that only a selected few would be invited to participate in Phase Two.

5.4.1 Participant Selection for Phase Two

The purpose of Phase Two was to allow the research team to gain further insights into the findings obtained through the quantitative data analysis. The selection process for the qualitative phase could only take place once all participants had completed the online anatomy questionnaire and assessment.

Once the quantitative data were analysed, the research team employed a purposive sampling technique to guide the development and refinement of Phase Two—the qualitative strand (Creswell & Plano Clark, 2011, p. 84.).

To explore the learning, forgetting and retention of anatomy knowledge by participants, the research team identified the top and bottom performers from each year level, and from as many different backgrounds as possible—i.e., previous learning in anatomy (from a prior degree) in a *professional course* or a *biomedical science course*, little to no anatomy in a *biological science* or *other science course* and no anatomy exposure at all in a *non-science course* (Cohen et al., 2007). Given the aim of the qualitative phase, it was imperative to select participants who engaged sufficiently with the online learning and assessment process. Consequently, a criterion for exclusion of participants in Phase Two was included, with the ‘time taken to complete the test’ as the key variable. The rationale for this was that a short response time could be associated with a lack of effort or engagement on the participant’s behalf (although this could also be seen as a surrogate for poor performance). Two students were excluded on the basis of this criteria. Detailed information regarding this has been presented in section 6.1.

The analysis of the quantitative data guided the recruitment of the participants for Phase Two. To fulfil the final selection process, the research team decided on three criteria that participants had to meet to be invited for an interview: performance, educational background and student engagement on the anatomy assessment task. Student performance was judged using overall scores on the anatomy assessment, while background information was obtained through the survey in part one of the quantitative phase—the learning questionnaire. Student engagement was factored in using student response time (i.e., the time taken to complete the test), which was recorded as part of the online tool. The chosen participants had to have spent an average of 25–30 minutes or more on the anatomy assessment (the mean time for completion, as calculated for their cohort).

Subsequently, four participants from each year level (two top performers and two bottom performers) were chosen for this phase, with a total of 16 participants across the four cohorts. An email invitation was sent out to these 16 individuals to invite them to participate in Phase Two of the research, which was to consist of one 60–90-minute semi-structured interview.

Of the 16 invitations that were emailed, 12 participants accepted, and a private face-to-face or phone conversation was scheduled. The top performers in all four cohorts accepted the invitation. While they represented the five different educational backgrounds, it was not possible to meet this criterion with the bottom performers, as both students in this category in Year D declined to participate as well as one student in Year A and one in Year C failed to respond, despite many efforts to contact them. In this instance, the next students identified as meeting the three criteria were selected and invited to participate in an interview. However, it became very challenging to source sufficient participants; many were unable to take part because of personal and professional commitments at the time. Therefore, the prior educational background of the bottom performers represented those who came from a biological science, other science and no science degree. Ultimately, 13 interviews were scheduled, as outlined in Table 5.3.

Table 5.3

Participant Selection for Qualitative Strand

Cohort	No. of Top Performers interviewed	No. of Bottom Performers interviewed
Year A	2	1
Year B	2	2
Year C	2	1
Year D	2	1
Total Participants	**8**	**5**

5.5 Development and Administration of Test Instrument

5.5.1 Development of Anatomy Assessment (Phase One)

It is widely accepted that assessments drive student learning (Newble & Jaeger, 1983). Hence, it is important to assess concepts relevant to the student's profession to ensure their learning progresses in the right direction (Vorstenbosch et al., 2014).

Using this concept, the anatomy questions constructed for this task were derived from *clinically relevant* anatomy objectives that were formally taught to all students in Year A and that were similar to what students would have been exposed to in the Year A VIA. Clinical anatomy is defined as "anatomy that is indispensable to a good understanding of the medical physical examination, modern imaging techniques, diagnosis and many invasive and non-invasive procedures" (Prince et al., 2003, p. 16).

Therefore, clinically relevant objectives are those that emphasise the importance of anatomy as it pertains to a clinical condition—whether it is diagnosis or management of a presenting problem.

Given that “valid assessments that approximate real-world situations result in valid and meaningful behaviour” (Van der Vleuten, 1996, p. 108), real-world clinical vignettes in the form of MCQs and EMQs were drafted according to Year A objectives and reviewed by expert consultants in the area, thereby ensuring content validity (Aday & Cornelius, 2006; Schuwirth, van der Vleuten, & Donkers, 1996). Further, validity was also ensured through blueprinting and sampling widely across the course content and learning objectives. All students had access to the objectives because they formed the basis of their weekly tutorials in Year A. Questions previously administered on summative assessments in Year A were not used for this task to preserve the security and integrity of examination material. As Vorstenbosch, Klassen, Koolos, Bolhuis and Laan (2013) indicate in their research, image-based questions test different skills; thus, the validity of the test items was affected. Therefore, these questions were not used for this assessment because the skills required to answer correctly on these questions require students to extract information from the image first, which is different to the skills required to extract information from a provided list of options.

While numerous objectives were covered in the first pre-clinical year, 70 random objectives were selected for this task, and questions around these objectives were constructed. Following the general principles of the scientific method (objectivity, reliability and validity) to make an assessment ethical, a standard set process was implemented, whereby the 70 anatomy questions constructed for the research were reviewed by six individuals: two colleagues in the field of medical education (both anatomy lecturers) and four clinicians who also teach the Year A program as anatomy and clinical skills tutors. The purpose of this was to minimise the subjective nature of 'blooming' examination questions and to ensure that the questions were testing the learning objectives and targeting the cognitive level appropriate for the learner (National Research Council [NRC], 2001; Thompson & O'Loughlin, 2015). Using two reviewers or less when assessing examination questions for taxonomy leads to disparate results (Thompson & O'Loughlin, 2013). Therefore, by using more than two observers and reaching a consensus for the taxonomy bracket of each question, this issue is resolved. The standard setting procedure "is a judgemental process involving arbitrary, but not capricious decisions of what is considered good enough" (Pell & Roberts, 2006, p. 92). It has a significant place in education and is most commonly used in the assessment of professional competence by assigning a score to each assessment item. As Nedelsky (1954) states:

> The passing score is to be based on the instructor's judgement of what constitutes an adequate achievement on the part of the student and not on the performance of the student relative to his/her class or to any particular group of students. In that sense, the standard to be used for determining the score is absolute. (p. 3)

Among the many options available within the standard setting, the method used by our group of experts was the modified Angoff approach. During this process, each judge was called to assess each question according to the proportion of borderline students who would answer that question correctly (Friedman, 2000). That is, each judge assigned a borderline score that ranged from 0 to 1. A question that was assigned a borderline score of 0.3 indicated that the item tested a difficult concept; hence, only 30% of the struggling students would answer that item correctly. In contrast, a high borderline score of 0.8 represented an easy question, which 80% of struggling students were judged as being capable of answering correctly. Therefore, a criterion-referenced (absolute) standard was applied by each judge, which ultimately determined the cut-off point on a scoring scale. The estimates of each judge were averaged for each question. The borderline scores for all questions were summed and divided by the number of items to determine the final cut-off score (recorded as a percentage), which was later used to distinguish competent students from non-competent students (Friedman, 2000). Table 5.4 presents an example of how the borderline score is achieved using the modified Angoff approach.

Table 5.4

Calculation of borderline score using modified Angoff method

Test item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Total sum of scores	Borderline (Av)
1	0.3	0.4	0.3	0.5	0.4	1.9	0.4
2	0.6	0.7	0.7	0.6	0.8	3.4	0.7
3	0.5	0.5	0.6	0.5	0.6	2.7	0.5
4	0.3	0.5	0.4	0.4	0.4	2	0.4
5	0.4	0.5	0.6	0.5	0.5	2.5	0.5
						Total	**2.5**
Borderline for entire test (Total borderline score/No. of test items)							50%

In addition to using this process to establish a valid and reliable assessment, the questions were critiqued for their content, clinical relevance, ambiguity and categorised according to their taxonomy. Items that were rated poorly on all of the above criteria were refined or removed altogether from the question bank.

Taxonomy refers to the framework classification for learning instituted by Benjamin Bloom in 1956. According to Bloom’s framework, there are six categories, which are designed in the form of a hierarchal pyramid, through which students develop their learning skills. The categories are classed from simple to complex and concrete to abstract and named as: ‘knowledge, comprehension, application, analysis, synthesis and evaluation’. For students to progress and develop higher-order thinking skills, mastery of the simpler category preceding each is seen as a prerequisite (Krathwohl, 2002). Under the guidance of instructional theorists and cognitive psychologists, the framework was revised in 2001 to incorporate action words such as ‘understand’, ‘remember’, ‘apply’, ‘analyse’, ‘evaluate’ and ‘create’ (Anderson et al., 2001). The basis for such a revision was to guide both students and teachers in establishing a pedagogical approach to the learning objectives and outcomes, and to assist educators in designing valid assessment tasks centred around the processes through which students encounter and work with new knowledge (Crossley et al., 2002; Krathwohl et al., 2002). For the anatomy assessment, the three taxonomy levels assessed were those of remembering, applying and analysing (see Figure 5.2).

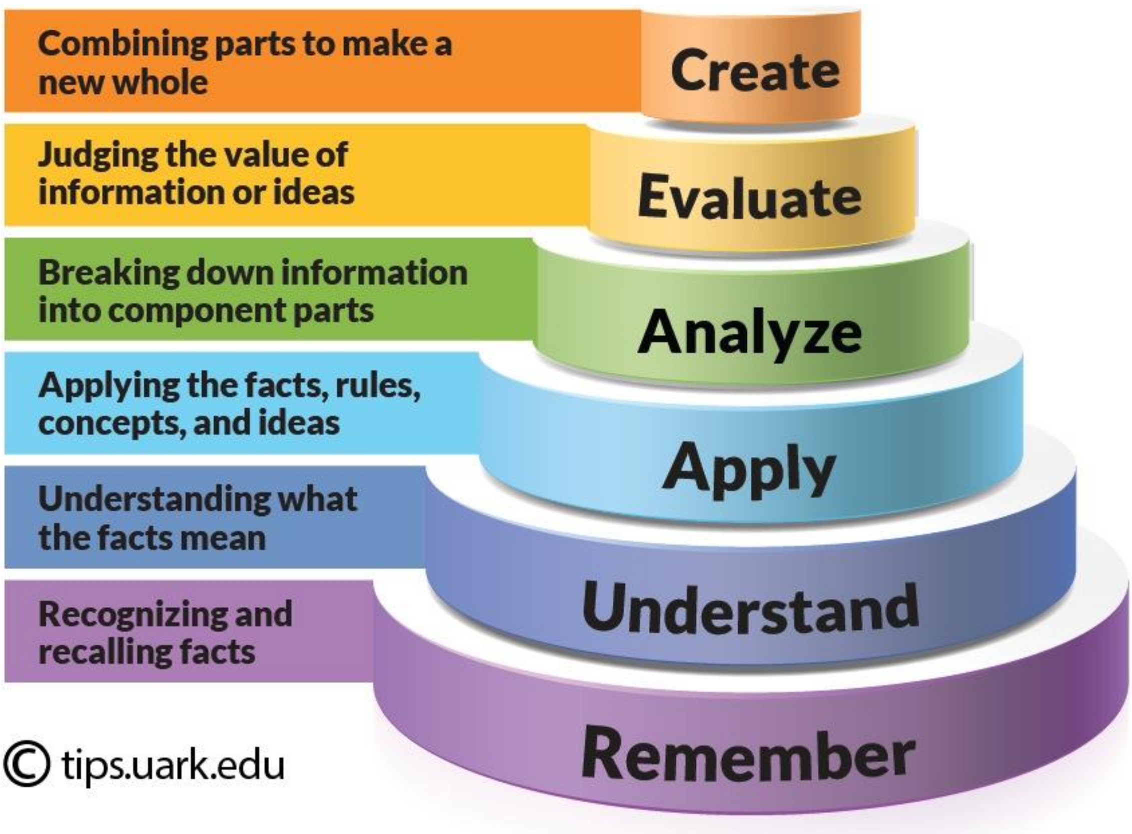


Figure 5.2: Bloom’s Taxonomy.

Source: http://tips.uark.edu/using-blooms-taxonomy/

Following the standard setting process with the clinicians and anatomy tutors, 60 anatomy questions were selected for the assessment task using the relevant objectives to which each question was matched. Ten questions that were initially constructed were deleted from the final question bank because of a lack of clinical relevance and importance, as identified by the clinicians. To illustrate the purpose of clinical relevance in the assessment, these 60 topic areas/objectives are outlined in Appendix E. The questions used in the online assessment are listed in Appendix F. Ultimately, a common borderline score was attributed by all reviewers to each of the 60 anatomy questions, bringing the overall cut-off point for the assessment to 50.2%. This value was used in conjunction with the standard error of measurement to establish clear pass scores for the assessment.

As stated by Brown (1999), “the standard error of measurement is related to test reliability in that it provides an indication of the dispersion of the measurement errors when you are trying to estimate students’ true scores from their observed test scores” (p. 21). A student’s observed score is the raw score obtained by that student on a test, whereas a true score is part of the student’s observed score that is uninfluenced by random events such as fatigue. To determine the effect of measurement errors on an observed score, the standard error of measurement (SEM) must be calculated (Tavakol & Dennick, 2011). This is done using the SD of the test scores and the reliability (r) of the test. The calculation of these values can only be determined following data collection (see Chapter 6. However, the formula used for the calculation is
$SEM = SD\sqrt{(1-r)}$.

When determining a cut-off score for a test, as has been established with our standard setting process and borderline score of 50.2%, one must be 95% confident that students on one side of the cut-off point might fluctuate to the other side if they have an opportunity to re-take the test (Brown, 1999). To do so, the SEM must be considered. Using this value, the clear pass score is calculated as the borderline score plus the SEM, and the clear fail score is calculated as the borderline score minus 2*(SEM). The decision to utilise BL – 2(SEM) was to maintain consistency with the approach utilised by Monash University in their analysis of assessment data so as to allow a fair comparison of assessment results when obtaining the clear pass and clear fail scores. Students scoring in between these two points are referred to as borderline students.

5.5.2 Test Administration (Phase One)

Given that participants were scattered across many regions of Victoria, it was impossible to ask students to attend the assessment in person, which would have been the case in a summative written examination. Therefore, the administration of the anatomy-learning questionnaire and assessment was delivered online to facilitate the ease with which students could enrol and participate in the research. This gave students the opportunity and flexibility to access the assessment in their own time on a given day, either from a computer, laptop or mobile device.

Development of Online Site

The site was designed with the assistance of a site developer. The questionnaire and anatomy questions were securely emailed to the site developer, who then began the process of constructing the web page. The limitations and flaws associated with delivering an online tool had to be considered. These included opportunities for students to ‘cheat’ by accessing other resources, to sit the assessments with other students or friends, or to exit the system and make multiple attempts. Given the aims of this research, it was imperative for the team to ensure, as best as possible, that honest data could be obtained that were reflective of participants’ current anatomical knowledge.

Thus, the online tool was developed with these considerations in mind. Other than the anatomy-learning questionnaire, the assessment component of Phase One was set up as a timed system. Participants were instructed that they had a maximum of one minute to respond to each question, with a maximum total time of 60 minutes to answer 60 questions. The strict time limit of one minute per question was added as a feature of the online tool to prevent participants from using online or other resources to answer questions. It was also used as a surrogate measure to gauge students' engagement. When assessments are designed to require students to tap into their higher-order cognitive skills, it allows them to develop a deeper understanding of the content and to increase their engagement in learning (Vogler, 2002). Given that the assessments were constructed around real-life clinical vignettes that require students to think deeply, if students answered each question within a few seconds, their engagement during the assessment could be in question. Students were also informed not to press the 'back' button on their web browser or mobile device, because this would prevent them from continuing with the assessment task.

The assessment was clinically relevant and incorporated content from all regions of the body. The 60 anatomical questions were grouped into six categories pertaining to: back (5), head and neck (10), upper limb (10), lower limb (10), thorax (10), and abdomen and pelvis (15). The site was constructed so that participants would view the questions within a block system. That is, all questions pertaining to one region (e.g., head and neck) would be followed by all questions within another region (e.g., thorax). The order in which the block of questions was presented varied for each participant. Each participant would have a different set of regional questions appear as the first block on the assessment task; thus, if two participants were to sit the test together, there was an 83% chance that each student would have a different regional block of anatomy questions appear first. The aim of designing the online tool in this fashion was to prevent collusion when attempting the test, and to limit the opportunities for participants to be dishonest in their reflections.

5.6 Development and Administration of Learning Anatomy Survey and Interview Questions

The learning anatomy questionnaire was developed from a similar tool that was pilot tested on a previous cohort, from which findings were presented at conferences.

The qualitative approach to Phase Two of the research involved conducting an interview session with participants to explore their experiences with learning, forgetting and retention of anatomy knowledge. The interview questions utilised for this research were developed as part of an existing research project and modified for the purposes of this study.

The purpose of the tool was to explore the research questions and to gain a better understanding of the data obtained through the quantitative analysis. The interview aimed to focus on topics relating to how students learned anatomy; what approaches and teaching methods they preferred for mastering anatomical knowledge (particularly in Year A), how much anatomy they felt they had retained, how much anatomy they had used in the clinical setting and how important they perceived anatomy to be in the clinical setting.

Using Seidman (2013) and King and Horrocks' (2010) guide to interviewing and qualitative research, a set of questions was formulated for use during the interviews, as listed in Appendix G.

5.7 Data Collection

5.7.1 Phase One

Once consent had been obtained, participants were given an approximate timeframe and advised that, one week prior to commencement of the data collection for Phase One, they would receive an email containing a link to the secure online anatomy assessment site, along with their user ID and password. The user ID for accessing the online tool was the participant’s student ID. Each student was also assigned a randomly generated password. Participants were instructed that the link could only be accessed on the specified day for a period of 24 hours, and if they tried to access it before then, the site would display ‘This page is not available’.

The clinical-year students (Years B–D) had upcoming summative assessments in early November, and the Year A students were due to complete their final week of classes in early November. Therefore, two separate dates were nominated for the data collection for this quantitative phase. The data collection for participants in Years B–D took place in the last week of October, whereas the data collection for participants in Year A took place in the first week of November.

On the date prior to that specified for Phase One, participants were emailed a reminder advising them that the site would be open in less than 24 hours. A similar email was sent on the ‘go live’ date, with participants able to access the online site by entering their user ID and password. Once logged in, participants were introduced to the research tasks and the research team via a welcome message. The purpose of the study was highlighted once again, and participants were informed about the two parts associated with this phase. Thereafter, participants commenced the anatomy-learning questionnaire. Upon completion, participants were directed to part two—the anatomy assessment task. An example screen displayed the style in which the questions would appear, and the location of the countdown timer enabled students to visualise the appearance of the site, the placement of the questions and their options, and how to monitor their time for each question. Subsequent to this, students began the online assessment.

During the ‘go live’ dates, the student researcher and the site developer monitored students’ participation on the site. Those who had not yet logged on were sent a further email reminder to do so before the assessment task and site closed.

As with any online system, there were implementation issues. Participants would be unable to complete the task if they clicked on the ‘back’ button on their web browser; therefore, the research team implemented rules in case a student encountered this issue. It was decided that if the student had completed fewer than ten questions, they would be allowed to re-enter the site and complete the task. As was expected, four participants were accidently locked out of the site and were unable to progress further on the assessment task. The participants immediately notified the research team and, because they had not advanced very far on the task, their access to the site was reinstated and they were able to log on and complete the assessment. When analysing the data for these students, no changes were noted in their responses from their first attempt to answer the questions.

5.7.2 Phase Two

In a sequential explanatory mixed-methods study, the key purpose of the quantitative data collection, in addition to answering part of the research question, is to guide the *development* and selection of participants for the second follow-up phase, which involves the collection of qualitative data. Participants selected for Phase Two were emailed an invitation to meet for a face-to-face or phone interview. Ultimately, 13 interviews were conducted with participants from the four cohorts: three from Year A, four from Year B, and three each from Years C and D. During the interviews, participants were advised that all information would remain confidential. All interviews were recorded and later transcribed verbatim. Each interview lasted approximately 45 minutes to one hour. The shortest interview was 32 minutes and the longest was two hours.

5.8 Data Analysis

5.8.1 Phase One

All Phase One data (i.e., the learning anatomy questionnaire and the anatomy assessment scores) were downloaded as two separate Excel files by the site developer. These files contained raw data, so a clean-up of the data was carried out using SPSS Statistics version 22. To collate the responses from both the learning anatomy questionnaire and the anatomy assessment, the information from both files was transferred and merged into one SPSS document. This ensured that subsequent analysis could be carried out using a number of key variables, and that comparisons could be inferred between the variables. The main areas of focus within the analysis included the following:

- examination of original data to determine extreme outliers and the subsequent exclusion of participants' data
- statistical analysis of anatomy questions, including the calculation of reliability, SD and SEM
- overall performance of participants on the anatomy test and comparisons between the four cohorts
- regional performance of participants on the anatomy test and comparisons between the four cohorts

- effect of the three different types of questions (taxonomies) on participants' performance on the anatomy test
- comparison of participants' original Year A VIA scores and their performance on the anatomy test
- comparison of Year A participants' performance on the anatomy test and the effect this had on their subsequent summative assessment (VIA)
- comparison of participants' prior educational background and performance on the anatomy test
- teaching resources mostly used by participants in learning anatomy
- best approaches used by participants in learning anatomy and their relationship to performance on the anatomy test
- participants' perceptions of anatomy.

The statistical tests utilised in the analysis of data involved a range of parametric tests such as ANOVA and paired t-tests where the data met the assumptions for normality (as assessed by skewness, kurtosis, Shapiro-Wilk, Q-Q plot and boxplot). This is followed by post-hoc tests for pairwise comparisons (Tukey-Kramer) and Pearson correlations for statistical significance. Where data did not meet normal assumptions, the analyses were undertaken using a series of non-parametric tests involving the Chi-square test of independence, Spearman's rank correlation, Mann-Whitney test and Kruskal-Wallis H test followed by appropriate post-hoc tests for pairwise comparisons (Dunn's procedure using Bonferroni correction). The results of the above analysis are presented in Chapter 6.

5.8.2 Phase Two

The qualitative data were analysed using thematic analysis (King & Horrocks, 2010) to determine which aspects provided insights into the quantitative data. Thematic analysis is the process of identifying, analysing, interpreting and reporting patterns (themes) within qualitative data (Boyatzis, 1998; Braun & Clarke, 2006). This method allows for flexibility because it can be applied to a variety of theoretical frameworks and shaped or constructed in a way that is useful and that suits sequential designs (Braun & Clarke, 2006). Four decisions had to be made in relation to approaching the data to determine the form that the thematic analysis could take (Braun & Clarke, 2006).

The first criterion necessary to shape the analysis was to determine the content from the data set that could be categorised as a *theme*. A theme captures data that are essential in answering the research question. It contains prevalent and meaningful patterns of responses that can be found within a particular data item or across the whole data set (Trahan & Stewart, 2013). A *data set* refers to all individual data items that are collected within a *data corpus* (i.e., all data collected in a research project, such as quantitative and qualitative data) and that are important and relevant to the topic at hand. Therefore, the data set for Phase Two referred to all 13 interviews that were recorded, and the data item referred to each individual interview recording and transcript (Braun & Clarke, 2006). It is unclear how prevalent a concept must be to be classified as a theme. In the recent body of literature on thematic analysis, a void still exists around establishing universally accepted standards for recognising the relevance of a pattern. Instead, researchers are advised to use their own judgement in this process, and to pay particular attention to issues that are relevant to the research question and/or issues that help explain the quantitative results and, in both cases, to ensure that a consistent style is applied to the entire process (Braun & Clarke, 2006; Trahan & Stewart, 2013). Using this approach, the data set was explored for repeated patterns of meaning, and a set of themes was identified and established. These themes are discussed in Chapter 7.

The second criterion involved the description of the data and whether it would consist of detailed accounts of the entire data set or only certain aspects of it. As Trahan and Stewart (2013) state, “In mixed methods research, the scope of thematic analysis should be guided primarily by the research model” (p. 66). Given the nature of the sequential explanatory model, wherein qualitative data were used to explore and explain the quantitative results, the data were examined for themes that related to the research questions and for themes that helped elaborate the specific findings of the quantitative data. That is, the description of the data as documented in the subsequent chapter does not contain a detailed account of each participant’s journey; rather, it highlights specific issues as they relate to the study.

The third criterion involved determining whether the themes identified should be determined via an inductive or deductive approach. An inductive or bottom–up approach ensures that the themes identified are linked directly to the data; therefore, they may have little significance to the research questions. In contrast, a deductive or theoretical approach is explicitly driven by the research questions and the researcher’s interest in the area, and it often calls for engagement with the literature prior to thematic analysis (Braun & Clarke, 2006). Once again, the research model for the study assisted in this decision; accordingly, the sequential explanatory design was best served by a deductive approach to thematic analysis. This is because “the quantitative antecedent can be used to identify the most salient concepts and test relationships between them. The subsequent qualitative study can then be used to identify these concepts in the qualitative data and elaborate on their interactions” (Trahan & Stewart, 2013, p. 67).

The final decision to be addressed involved determining the ‘level’ of thematic analysis (i.e., sematic or latent analysis). A semantic approach involves identifying themes within the explicit and surface-level meanings of the data. These themes can then be organised, described or summarised and interpreted to generate an explanation of a particular concept or pattern and its broader implications. However, a latent approach involves looking beyond the semantics to examine, analyse and theorise the themes identified within the data (Braun & Clarke, 2006; Trahan & Stewart, 2013). For this study, a semantic approach was used to generate themes across the entire data set.

Following the decisions made on the above four criteria, a six-step procedure to thematic analysis was followed, as outlined by Braun and Clarke (2006):

1. Familiarisation with the data: This involved engaging in a process of active reading and re-reading of the data to allow repeated patterns of meaning to be identified. The process began at the outset of data collection because the primary researcher was involved in conducting interviews with the participants. All 13 interviews were transcribed verbatim and then printed and compiled into one data set. During the reading phase, notes and coding ideas were listed against the transcripts for future use and analysis.
2. Generation of preliminary codes: Once familiar with the data, a set of initial codes was listed. These codes (semantic in nature) alert the researcher to data that are of interest to the study. As Boyatzis (1998) describes, codes offer "the most basic segment or element of raw data or information that can be assessed in a meaningful way regarding the phenomenon" (p. 63). Each data item (i.e., interview transcript) was read, and code words were generated manually using a theory-driven approach—that is, considering the research questions and the quantitative results. The key issues identified within each data item were then reviewed, and further codes for the entire data set were developed.

Data extracts (individual chunks of information from a data item) were coded from each data item, and all data extracts for a particular code across the data set were collated. Some data extracts were coded more than once.

3. Creation of themes: Following a review of all codes generated in the previous step, a search was conducted for repeated patterns or themes. This involved analysing the codes from a broader perspective to identify general patterns (themes) and subthemes within those patterns across the data set. It also involved organising the data extracts under such themes.
4. Revision of themes: During this phase, the reliability and accuracy of the themes identified in the previous step were examined (Trahan & Stewart, 2013) to ensure that the apparent patterns could indeed be classified as themes. Two criteria (internal homogeneity and external heterogeneity) had to be verified to ensure that the patterns constituted themes (Patton, 1990). *Internal homogeneity* refers to data within a theme that coheres in a meaningful way, whereas *external heterogeneity* refers to clear and identifiable differences that exist between the different themes. To assess these criteria, the data were analysed at two levels, as recommended by Braun and Clarke (2006). The first involved re-reading all of the data extracts for each theme to determine whether a meaningful pattern existed between them. If this was the case, then internal homogeneity was maintained. However, if the data did not fit into the general pattern of the theme, the data were either reassigned to another existing theme, a new theme was created to accommodate the data, the existing theme itself was reworked or the data were discarded from the analysis. The

final step in this stage of the analysis was the creation of a thematic map to capture the contours of the coded data. The second level of analysis involved re-examining (i.e., re-reading) the entire data set to ensure the validity of each theme in relation to the data, and to code any additional data that might have been missed the first time around. As Trahan and Stewart (2013) write, “the themes are considered heterogeneous if, without intersecting, they precisely reflect the content of the data without missing any important concepts” (p. 70).

5. Defining of themes: This stage involved further refinement of the themes that would later be presented for analysis by creating definitions that captured the essence of each meaning. The purpose of this was to create a detailed analysis of each theme to build a broader picture of its significance to the research questions, and to ensure that there was no overlap with other themes. Braun and Clarke (2006) suggest that if the analysis has been undertaken correctly, it should be possible for the researcher to describe the content of each theme and its implications in only a few sentences.
6. Write-up of analysis: This phase, which is presented in Chapter 7 conveys the results of the analysis as clearly and concisely as possible. Evidence of the story obtained through the data is organised in a logical and non-repetitive way. Data extracts and vivid examples are used to illustrate the essence of the story being told. The chapter not only describes the qualitative results, but also provides an analytic narrative for the data to demonstrate how the results answer the research questions (Braun & Clarke, 2006).

In order to ensure triangulation data obtained through thematic analysis (Creswell & Plano Clark, 2011), all researchers in the study were consulted in the data analysis of the interview transcripts and agreed on the themes identified. In employing these stages of thematic analysis—namely, *descriptive coding*, which involves highlighting relevant material and assigning descriptive codes; *integrative coding*, whereby one groups and makes sense of the descriptive codes and their significance in relation to the research question; and *overarching themes*, which identify key themes across the entire data set (King & Horrocks, 2010)—a relationship was found between the main themes, which provided insights into the importance of anatomy teaching, retention and knowledge in clinical performance. The results of the quantitative and qualitative strands were explored together to determine the outcomes of the research questions.

Chapter 6: Quantitative Results

This chapter presents the results of the data analysis from Phase One, whereby data were collected and analysed in response to the three research questions posed in this study. This research aims to explore the retention of anatomy knowledge across all four cohorts of the graduate-entry MBBS program, as examined cross-sectionally, with the ultimate aim of understanding what causes students to retain or lose their anatomical knowledge as they transition from student to doctor.

Accordingly, the quantitative data analysis presented in this chapter is separated into five major sections, as outlined below.

Section 6.1 elaborates on the exclusion criteria of student scores undertaken following the preliminary data analysis. The ‘exclusion criteria’ were set as *a priori*. This was a process of identifying and dealing with outliers and with implementing the rationale underlying the decision to exclude the results of some students from the analysis.

Section 6.2 discusses the approach taken to analyse the psychometric properties of the questions developed as the assessment task for the study (i.e., to test students’ knowledge of clinically focused anatomy). It presents statistical analysis, including the reliability of the anatomy questions, SD of the test scores and SEM. This allows for the borderline scores to be determined, as well as the clear pass and clear fail scores. In addition, this section includes the overall participant results and a comparison between high performers (HPs) and low performers (LPs).

Section 6.3 uses data from the formative anatomy assessment to run a comparison across the four cohorts and determine whether there are any differences in anatomy retention, to assess where these differences (if any) lie and to explore patterns of responses across all cohorts on the framework classifications (recall, application and analysis) for learning.

Section 6.4 compares the anatomy scores of students in the clinical years from two assessments: the formative anatomy assessment administered in 2014 and the summative VIA examination from their pre-clinical year. The purpose here is to compare students’ knowledge of anatomy from when anatomy was formally taught to them as pre-clinical students to their current position as a clinical student or intern, where formal teaching in anatomy is highly variable.

Section 6.5 analyses the pre-clinical-year participants’ performance on the formative and subsequent summative assessment, highlighting the importance of the testing effect.

Section 6.6 analyses students’ responses to the questions on the learning anatomy survey.

The findings presented in this chapter demonstrate certain trends relating to students’ retention of anatomy knowledge, which could have implications for the future of anatomy education. The implications are explored in Chapter 7.

6.1 Exclusion Criteria

6.1.1 Identifying and Managing Student Outliers

All data collected through the online site from the 138 participants were downloaded in Excel format and organised according to cohort, overall scores, regional scores and response times. Prior to conducting any further analysis, the first task was to scan the data for evidence of incomplete results, duplicate results, data-entry errors and measurement errors.

There were four duplicate entries corresponding to the four participants who were accidently locked out of the system. This occurred either because the participants clicked the ‘back’ button on their web browser or they exited the browser completely, thereby locking themselves out of the system. The four participants contacted the researcher on the same day to gain access to the site again. When examining the data from these participants, it was evident that their responses to the few questions they had answered on the first try did not change during their second attempt. As a result, the completed data from the second attempt were retained, and the incomplete entries from the first attempt for all four participants were deleted during analysis. No other data-entry errors were observed or recorded.

Given that student engagement is strongly associated with performance on assessment tasks (Bae & Kokka, 2016), it was imperative to ensure that students were engaged throughout the test, because this would potentially allow for the collection of information that was objective, useful and reflective of students’ capacity to recall, recognise or reason out their knowledge of anatomy. Therefore, the response time for each question, which was recorded as part of the online tool facility, was incorporated into an overall completion time for each participant and was used as a surrogate measure of participants’ engagement with the anatomy assessment. The time taken to complete the assessment was then analysed across all four cohorts.

The preliminary analysis of participants’ engagement revealed two outliers. To investigate these further, a normal Q-Q plot (see Figure 6.1) and a boxplot analysis (see Figure 6.2) were constructed using completion time and cohort as the two comparison variables. The purpose of this was to explore how participants’ data would appear compared with the rest of the sample.

The Q-Q plot forms a dark straight (diagonal) line when the observed values conform to the hypothetical distribution (Garson, 2012). If the data are normally distributed, all cases for that variable will align closely with or on the diagonal line.

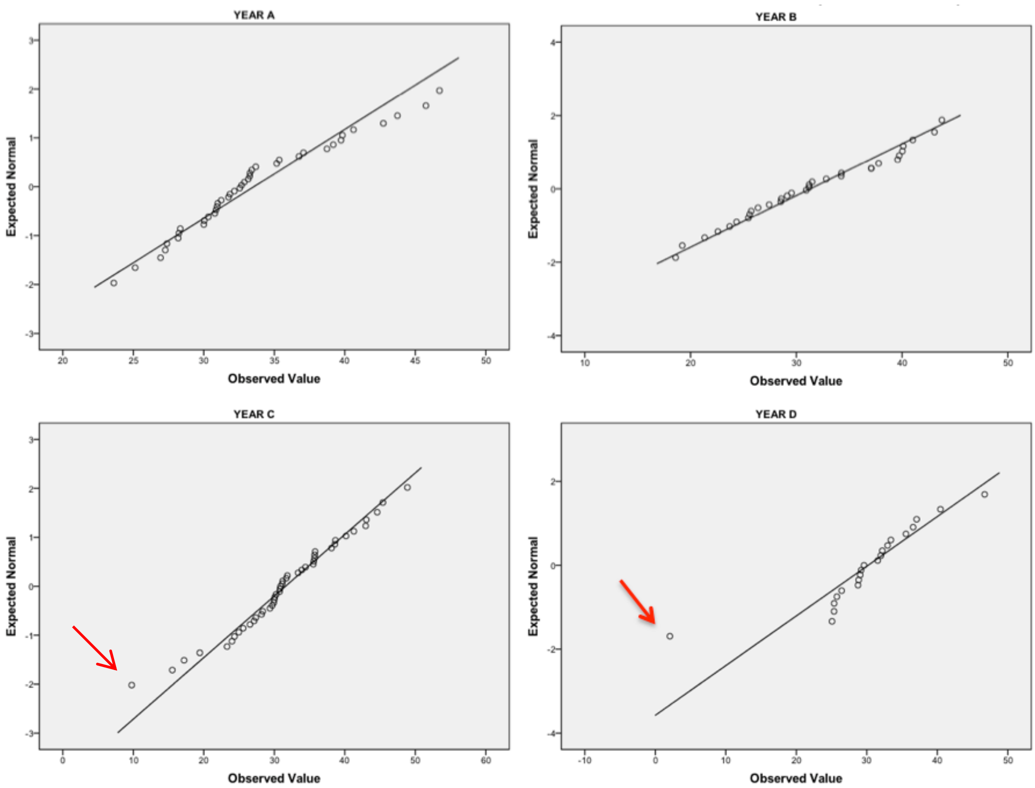


Figure 6.1: Total time to complete anatomy test in each cohort.

The boxplot shows the median of each cohort as a dark horizontal line. From there, the interquartile range (25th–75th percentile) is depicted as the length of the box. The line extending from either end of the box (known as whiskers) represents the minimum and maximum values for that cohort when they are within 1.5 times of the interquartile range. Any values greater than 1.5 times this range are depicted as circles (o) and are considered outliers. Any values that are three times greater than the interquartile range are depicted as asterisks (*) and are considered extreme outliers (Ghasemi & Zahediasl, 2012).

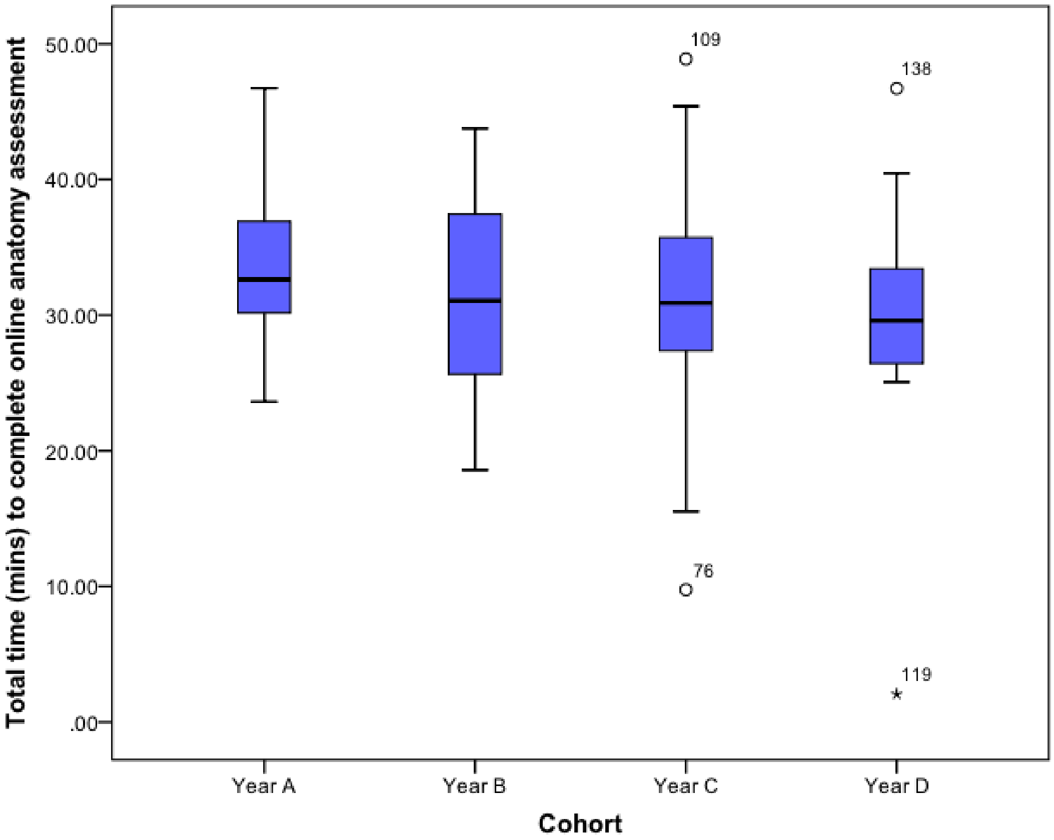


Figure 6.2: Completion time on online assessment by cohort.

A visual inspection of Figures 6.1 and 6.2 confirms the presence of two outliers on the Q-Q plot (indicated by the red arrow), whereas the boxplot identifies one participant (119) in the Year D cohort as an extreme outlier and the other participant (76) in the Year C cohort as an outlier. Although the Year C participant was not a distant outlier, the research team decided to look into these participants' data.

Further investigation of their values showed that both participants completed the assessment in a very short time—less than three minutes for the Year D student and nine minutes for the Year C student. Looking through the regional performance, the Year D participant spent approximately 30 seconds on each of the six regional blocks of questions, which comprised a minimum of ten questions, whereas the Year C participant spent as little as one second on numerous questions to a maximum of 20 seconds on others. The overall scores for these two participants were 25% and 28%

respectively. The short amount of time devoted to completing this task is clear evidence of a lack of engagement with the assessment. Further, including these participants' data in the analysis would compromise the results because it could lead to a false judgement of these participants' knowledge. Given that the mean time for completion of the assessment was approximately 30 minutes across all four cohorts, and the fact that far outliers have a significant effect on small sample sizes (Ghosh & Vogt, 2012), the research team decided to exclude these individuals' results from the analysis.

Therefore, all results presented henceforth relate to a sample of 136 participants (97% of the sample initially recruited).

While two other outliers (participants 109 and 138) were also detected, inspection of their values did not reveal them to be extreme. These two participants spent a significant amount of time (approximately 48 minutes each) on the assessment relative to other participants, indicating that they were engaged with the tool in a maximum capacity, and perhaps spending more time considering their choice of answers. Their overall performance was 48% and 58% respectively, suggesting that they were engaged with the assessment task and were attempting to recall and apply their anatomy knowledge. They did not do significantly well or poorly compared with others; therefore, their data were retained in the analysis.

6.2 Test Statistics and Question Analysis

As documented in Chapter 5, a standard set process was implemented following construction of the anatomy questions, where each question was carefully reviewed by a team of experts for content, question ambiguity, clarity and checking of answers to ensure there was only one correct response. The overall process resulted in 60 out of the 70 questions initially written being selected for the formative anatomy assessment. The borderline *(BL)* score for this test was 50.2%.

Following data collection, each question was initially subjected to item analysis according to the percentage of correct versus incorrect responses. The process set in place for any item that performed poorly (when compared with the borderline score for that question) was to have the question reviewed by the anatomy tutors and/or clinicians for ambiguity. Accordingly, the question was eliminated if there was a level of uncertainty and retained if it was unambiguous. Of the 60 questions on the test, four (Upper limb – Q.4 and Q.8; Head, Q.1; Thorax, Q.9) were reviewed because of poor performance (<20% of participants answered the questions correctly). These questions were on a higher level of Bloom's taxonomy (application or analysis); therefore, they challenged all participants. No ambiguity was found with the content of the question and its options; hence, all questions were retained in the analysis.

6.2.1 Reliability, Validity, Borderline Score and Standard Error of Measurement

Reliability and validity are fundamental components of a test instrument and often go hand in hand. The extent to which an instrument measures what it is supposed to is known as validity, whereas reliability is a measure of internal consistency that "describes the extent to which all items in a test measure the same concept or construct" (Tavakol & Dennick, 2011, p. 53). An instrument must be reliable before it can be valid (Venkatesh, Brown, & Bala, 2013). Therefore, the question bank was tested for internal consistency using the responses of all 136 participants to the 60 questions. According to Downing (2004), for assessment data to have a meaningful interpretation, they must be reproducible (i.e., good internal consistency or reliability). Without this, generalisations made from assessment data are limited. Cronbach's alpha (α) coefficient was used to assess internal consistency within written examinations. The resulting product of the test is a value that ranges from 0 to 1. A value of 0.70 or greater indicates that the written test has good internal consistency and reliability (Cronbach, 1951; Tavakol &

Dennick, 2011). However, when the analysis involves a comparison between groups, as is the case with this study, the minimum standard of reliability that is acceptable can be lower (i.e., 0.50–0.70) (Aday & Cornelius, 2006). Using SPSS Statistics version 22, the alpha coefficient for the four cohorts of participants across all questions was calculated as 0.75, indicating a good level of internal consistency for the formative anatomy assessment. When examining the alpha for the scale as a whole against each individual item, there was no change when an item was removed. This suggests that its correlation with other items was unaffected. Therefore, all items were retained in the sample (Aday & Cornelius, 2006). Calculations were also performed for each individual cohort. Thus, Cronbach's alpha for the Year A (n = 40), Year B (n = 32), Year C (n = 44) and Year D (n = 20) cohorts were 0.73, 0.76, 0.71 and 0.68 respectively.

Using participants' overall anatomy scores on the assessment, the SD for the sample was calculated at 11.1%. With a Cronbach's alpha of 0.75, the SEM was calculated using the formula $SD*(\sqrt{1-\alpha})$. The resulting *SEM* score was 5.6%. As Tighe, McManus, Dewhurst, Chis and Mucklow (2010) state, "the greater the reliability, the smaller the *SEM* and hence the more accurate the examination, which is a desirable outcome" (p. 2). The SEM scores and the borderline score of 50.2% were then used to identify the clear pass mark for the test, which was 55.8% *(BL+SEM)*. Similarly, the same two scores were used to calculate the clear fail mark for the test, which was 38.9% *(BL − 2*SEM)*.

Therefore, participants who scored at or above 55.8% obtained a clear pass in the assessment, whereas participants who obtained a clear fail scored below 38.9%, and the remaining participants, who scored between 39% and 55.7%, were classified as borderline students.

6.2.2 Overall Performance of Participants

Overall, 52% of students obtained a clear pass, 41% were in the borderline category and 7% failed the assessment. These data were further segregated into performance by each cohort within the three categories.

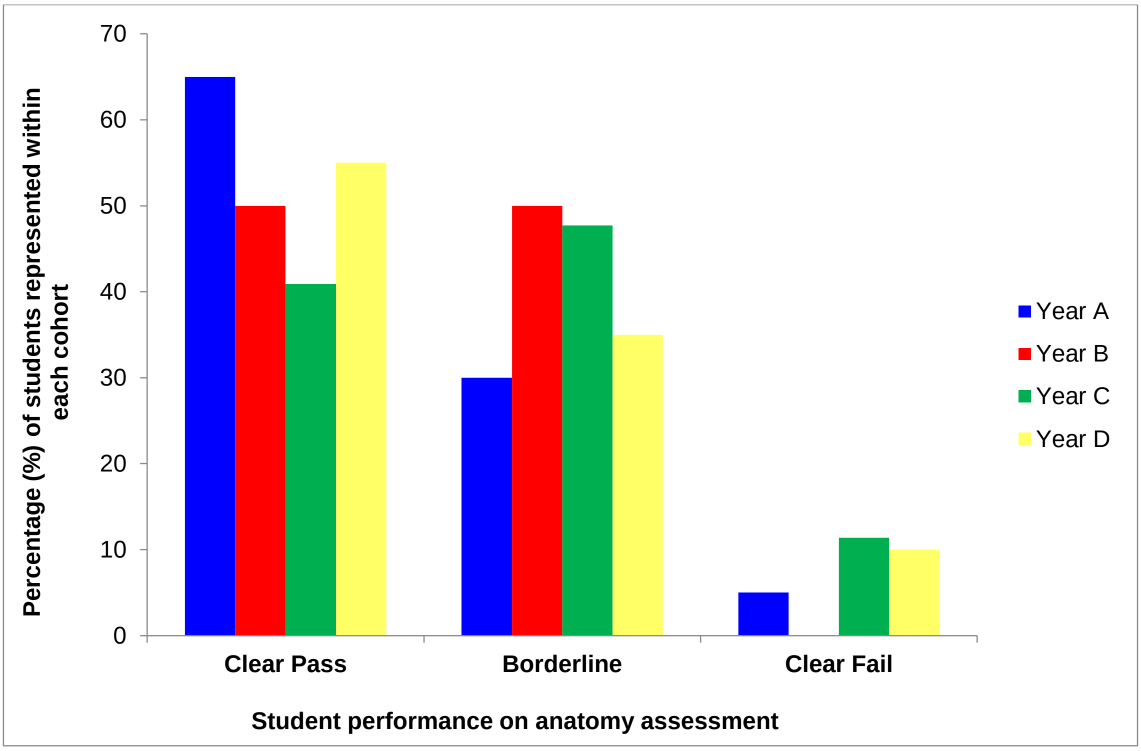


Figure 6.3: Overall performance on anatomy assessment by cohort.

As shown in Figure 6.3, most Year A students passed the assessment. There was an equal spread of Year B participants across the clear pass and borderline categories. Across the 3 categories of performance, a higher proportion of Year C students had borderline scores, and a larger number of Year D students passed the formative anatomy assessment than were classified as borderline or failed.

6.3 Cross-sectional Data and Analysis

Following preliminary analysis of the data, it was necessary to examine the research questions to determine the statistical methods that could be used to answer them. One of the questions posed was: How does anatomy retention differ among students in the pre-clinical and clinical years of their MBBS course? To answer this, the formative anatomy assessment scores obtained from all cohorts during the Phase One data collection allowed for a cross-sectional comparison of knowledge to be made across the board using one test instrument, thereby providing evidence for how students in all cohorts differed in their anatomy knowledge. Therefore, in answering the research question, the data were explored from multiple perspectives. In the first instance, the overall scores across all cohorts were analysed while looking for statistically significant differences between the cohorts. The regional anatomy scores across all cohorts were then analysed to determine the same, and finally, the performance of cohorts as per the classification system of questions (i.e., difficulty of questions posed) was explored to identify whether the pre-clinical and clinical students performed better in one category of question than another.

6.3.1 Overall Anatomy Scores

To answer the research question, a one-way analysis of variance (ANOVA) was conducted using the participants' overall anatomy scores on the formative anatomy assessment to determine whether there were any statistically significant differences between the means of students enrolled in different year levels of the graduate-entry MBBS degree (Schmider, Ziegler, Danay, Beyer & Bühner, 2010). This test was selected over independent t-tests for each cohort because multiple t-tests increase the Type I error rate (rejecting the null hypothesis when it is actually true; i.e., false positive) by 5% each time, whereas an ANOVA controls for this so that the Type I error rate remains at 5% (Laerd Statistics, 2015).

Testing for Assumptions of Normality, Outliers and Equal Variance

Since the output of most statistical tests requires that data be normally distributed (Field, 2009), the data was checked for normality and significant outliers since their presence may affect the overall results and any inferences made from the analysis (Ghasemi & Zahediasl, 2012). Once detected, the outliers was either transformed or removed from the analysis.

Both numerical and graphical methods were used to assess normality of the data distribution. The numerical methods involved calculating a z-score for skewness (symmetry of data) and kurtosis (tailedness of data) and using the Shapiro–Wilk test, whereas a normal Q-Q plot and boxplot analysis were employed as graphical tools for assessing normality (Field, 2009).

The overall anatomy scores in the online assessment task were normally distributed for all year levels as outlined by the skewness and kurtosis values in Table 6.1

Table 6.1

Tests of Normality: Skewness and Kurtosis values for each cohort

Cohort	Skewness	Kurtosis
Year A	−0.290 (SE = 0.374)	−0.097 (SE = 0.733)
Year B	0.137 (SE = 0.414)	−1.399 (SE = 0.809)
Year C	0.096 (SE = 0.357)	−0.653 (SE = 0.702)
Year D	−0.500 (SE = 0.512)	0.288 (SE = 0.992)

The second test for normality—a Shapiro–Wilk test—was run for each group of the independent variable. As Field (2013) states, this test is a good indicator for testing normality, but it should always be used with visual inspections and skewness and kurtosis measures. As evidenced by the Shapiro–Wilk test ($p > .05$), Table 6.2 shows that the anatomy scores in the assessment task were normally distributed for Years A, C and D participants, whereas the null hypothesis was rejected for Year B students because the data were not normally distributed ($p = .030$).

Table 6.2

Tests of Normality: Cohort and Anatomy Score on Online Test

Cohort	Shapiro-Wilk		
	Statistic	df	Sig
Year A	.985	40	.854
Year B	.926	32	.030
Year C	.972	44	.346
Year D	.942	20	.262

However, as indicated above, visual inspection through a normal Q-Q plot (see Figure 6.4) and a box plot (see Figure 6.5) were explored as additional methods of confirmation to determine whether there was normal distribution within each of the cohorts.

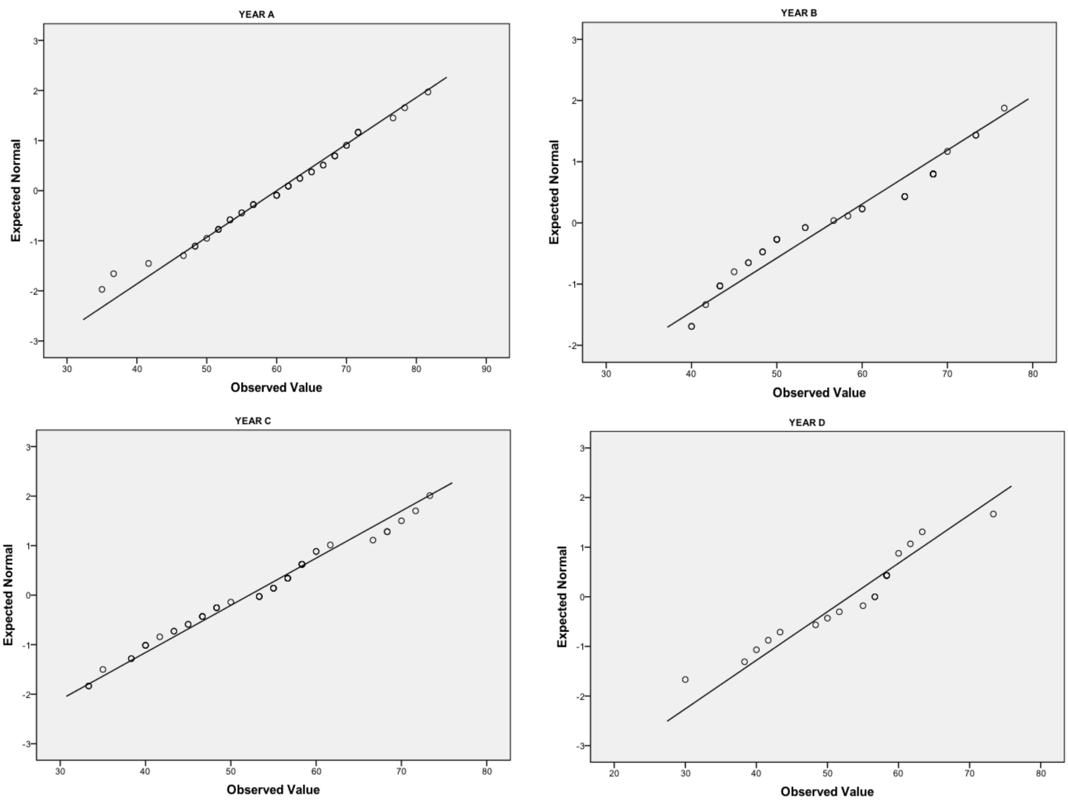


Figure 6.4: Anatomy scores on online assessment by cohort.

As the Q-Q plot in Figure 6.4 shows, data points for all cohorts were positioned approximately along the diagonal line.

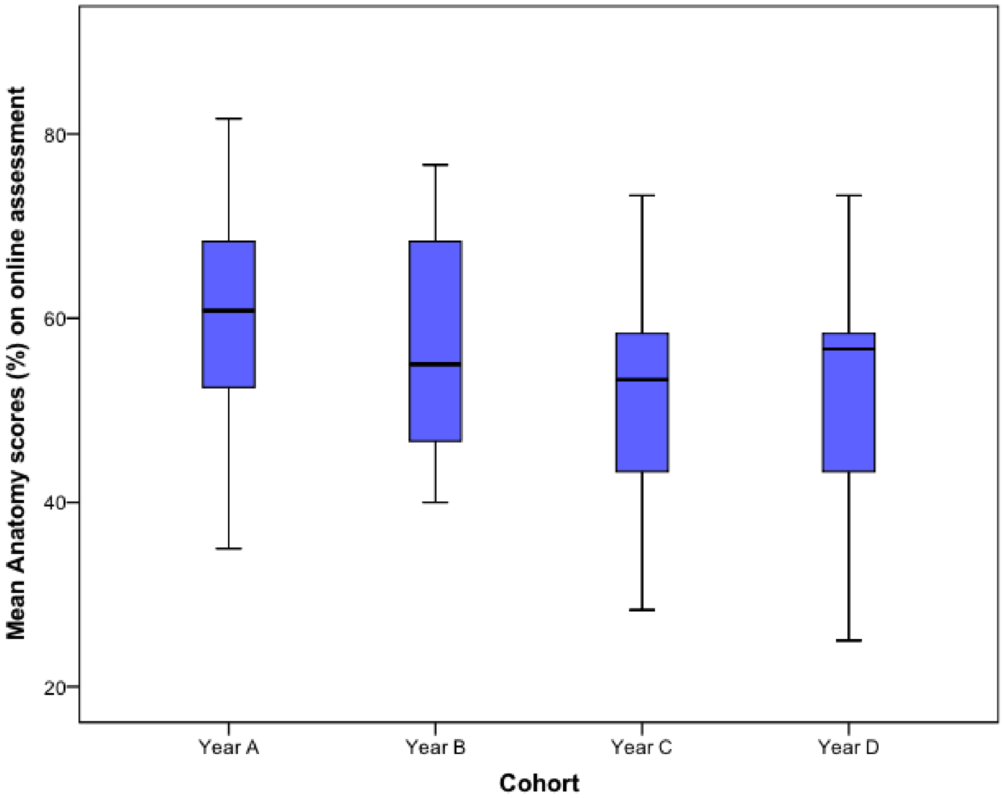


Figure 6.5: Anatomy scores on formative assessment.

Figure 6.5 does not show evidence of any outliers for the formative anatomy scores within the participant sample. Therefore, through visual inspection, it was concluded that anatomy scores were normally distributed for all four cohorts.

Furthermore, for this sample of participants, there was homogeneity of variances and therefore equal variance, as assessed by Levene's test for equality of variances (p = 0.614). Given that all assumptions were met, the data analysis for the anatomy assessment scores was carried out on a group of 136 participants.

Descriptives

The results from the formative anatomy assessment administered online show adequate performance by the students in terms of their anatomical knowledge. When comparing the borderline score for the assessment (50%) to the score of the entire sample of participants (n = 136), performance (%) was neither too high nor too low (M = 55, SD = 11.1), 95% CI [53.7, 57.5], suggesting that the test was challenging and of moderate difficulty—that is, not all participants did well because the test was easy, nor did everyone fail because it was too difficult. The lowest score achieved was 30% and the highest was 82%.

When comparing the scores of the Year A cohort to those of Year B, Year C and Year D cohorts, it is evident that, on average, students in the clinical cohorts did not perform as well as students in the pre-clinical year. (see Figure 6.6).

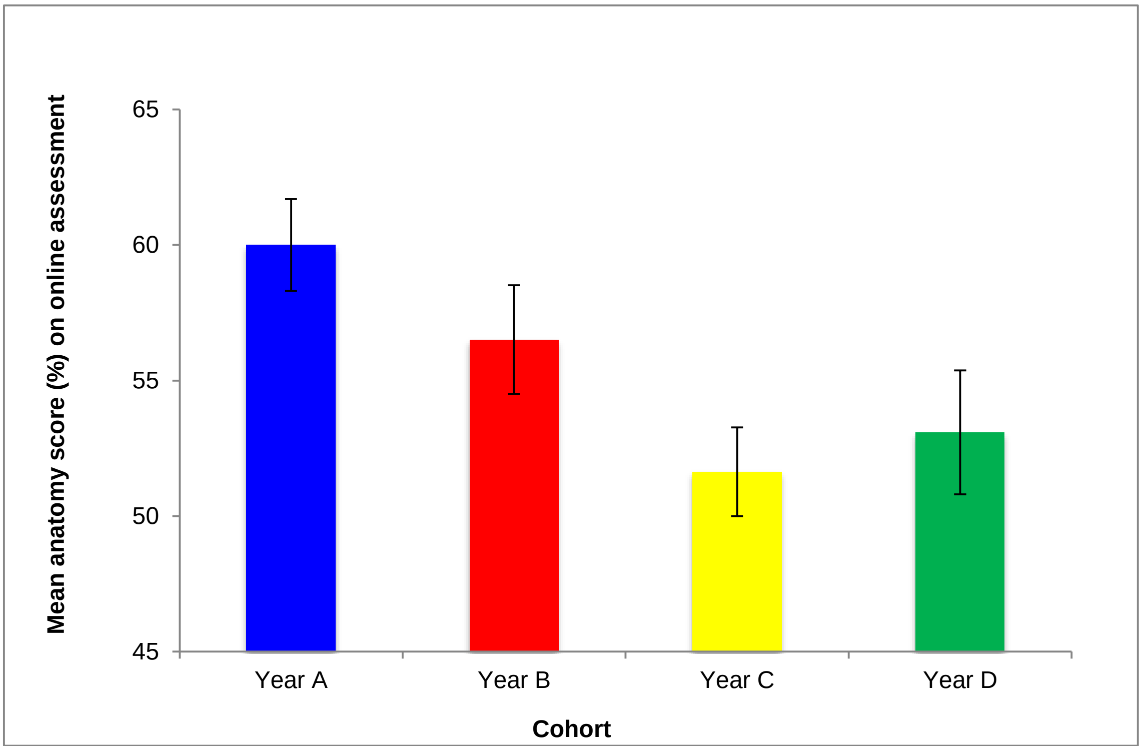


Figure 6.6: *Mean performance of cohorts on online anatomy assessment (%).*

ANOVA

The ANOVA revealed that there was a difference in mean anatomy scores for participants within the four year levels of the MBBS program, and this difference was statistically significant: $F(3,132) = 4.190$, $p = .007$, $\eta_p^{2} = .087$.

A Tukey–Kramer post hoc test (see Table 6.3)—was automatically run using SPSS Statistics version 22 (Hayter, 1984).

Table 6.3

Tukey–Kramer Post Hoc Test: Comparison of Mean Anatomy Scores

(I) YEAR	(J) YEAR	Mean Difference (I-J) (%)	Std. Error (%)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
YEAR A	YEAR B	3.49	2.54	0.52	-3.14	10.2
	YEAR C	7.84*	2.34	0.006	1.74	13.9
	YEAR D	6.92	2.94	0.09	-0.73	14.6
YEAR B	YEAR A	-3.49	2.55	0.52	-10.1	3.14
	YEAR C	4.35	2.49	0.31	-2.14	10.8
	YEAR D	3.43	3.06	0.68	-4.53	11.4
YEAR C	YEAR A	-7.84*	2.34	0.006	-13.9	-1.74
	YEAR B	-4.35	2.49	0.31	-10.8	2.13
	YEAR D	-0.924	2.89	0.99	-8.46	6.61
YEAR D	YEAR A	-6.92	2.94	0.092	-14.6	0.73
	YEAR B	-3.43	3.06	0.68	-11.4	4.53
	YEAR C	0.924	2.89	0.99	-6.61	8.46

The results show that the pre-clinical students performed the best when compared with their clinical counterparts. As shown in Table 6.3, there was a statistically significant decrease of 7.84%, $p = .006$, 95% CI [1.74, 13.9] in the mean anatomy scores from the Year A to the Year C group of participants. All other comparisons were non-significant ($p > .05$). Therefore, knowledge appears to decline in the latter half of the clinical years and this difference is most evident and statistically significant in the group that is highly represented in the sample (Year C).

6.3.2 Regional Anatomy Scores

The next component in answering the research question was to analyse cohort performance according to the different regional anatomy blocks to determine whether any statistically significant differences could be reported.

Descriptives

The initial results were examined and categorised according to general or overall performance within regions. The mean score (*M*), *SD* and 95% confidence intervals of all participants ($n = 136$) within each of the six regional components of the anatomy assessment are listed in Table 6.4. As shown, participants performed best on abdomen and pelvis (although there were only three questions on pelvic anatomy), lower limb anatomy and thoracic anatomy. Conversely, performance on the upper limb, back, and head and neck regions was quite poor.

Table 6.4

Overall Mean Score (%) of Participants by Regions

Region	(M ±SD)	95% Confidence Interval (CI)
Abdomen/Pelvis	(65.0 ± 14.9)	[62.5, 67.5]
Back	(46.0 ± 21.8)	[42.3, 49.7]
Thorax	(58.8 ± 15.5)	[56.2, 61.5]
Head & Neck	(45.8 ± 18.3)	[42.7, 48.9]
Lower Limb	(64.0 ± 17.3)	[61.1, 66.9]
Upper Limb	(44.6 ± 16.4)	[41.7, 47.3]

These overall scores were further broken down into performance within cohorts. As depicted in Figure 6.7 and similar to the overall findings, it is evident that within each cohort, students did particularly well on the abdomen, lower limb and thorax sections, but poorly on the upper limb and back and head regions, although there is some variability in the order of performance within each cohort. There appears to be a gradual decline in regional anatomy knowledge when comparing pre-clinical students to clinical-year students—particularly for the back and head, and neck anatomy. However, further investigation is required to determine if these results are statistically significant.

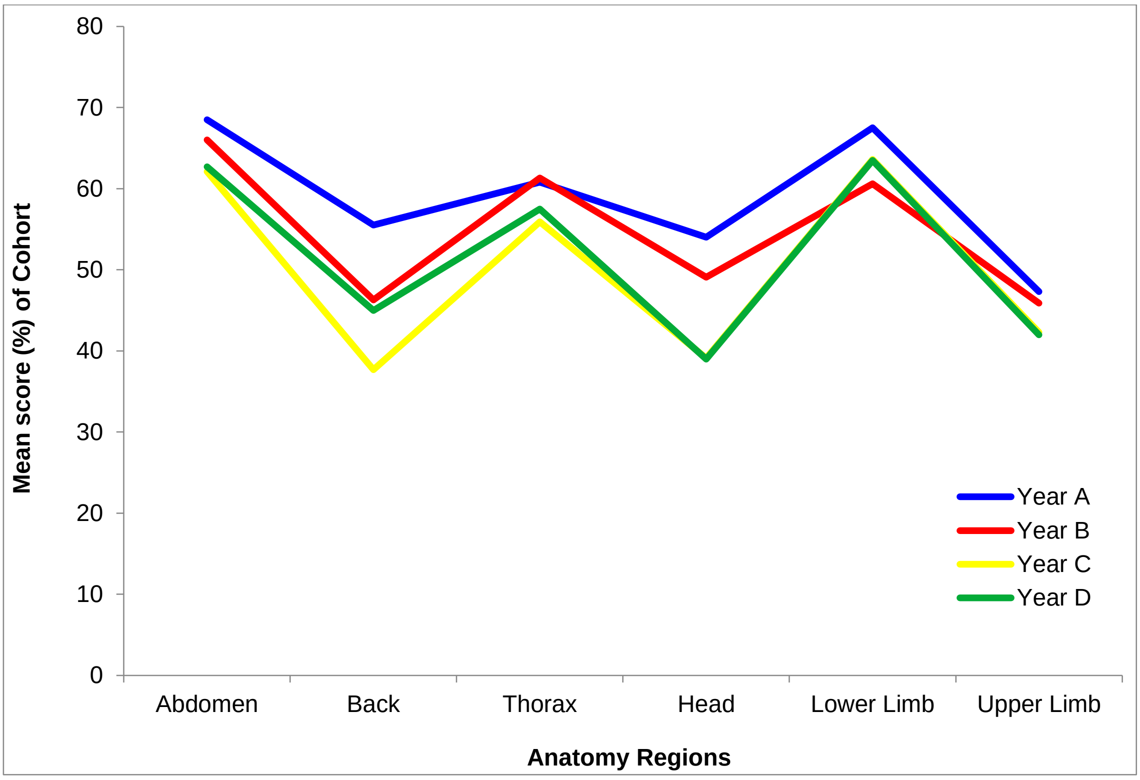


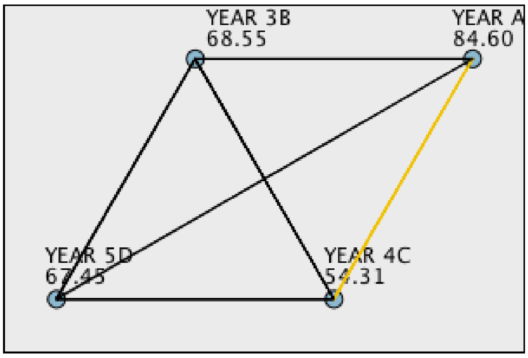
Figure 6.7: Mean performance of cohort across six regional anatomy blocks.

Analysis

A non-parametric test—a Kruskall–Wallis H-test was run to explore the differences in the medians on each of the regional scores between the four cohorts: Year A (n = 40), Year B (n = 32), Year C (n = 44) and Year D (n = 20). The results, which are presented below, indicate that the cohort scores for the four anatomical regions (thorax, abdomen, upper limb and lower limb) were not significantly different.

The two regions that produced a statistically significant difference ($p < .05$) were the back and head and the neck components of the formative anatomy assessment, with the difference in median scores being χ^2 (3) = 13.374, p = .004 and χ^2 (3) = 18.188, p = .000 respectively.

A post hoc analysis (see Figure 6.8) using Dunn's procedure with Bonferroni correction for multiple comparisons revealed a statistically significant difference in back scores between the Year A (*Mdn* = 60) and Year C (*Mdn* = 40) cohorts, but not for the Year B (*Mdn* = 40, p = .447) or Year D (*Mdn* = 50, p = .593) cohorts or any other combination.

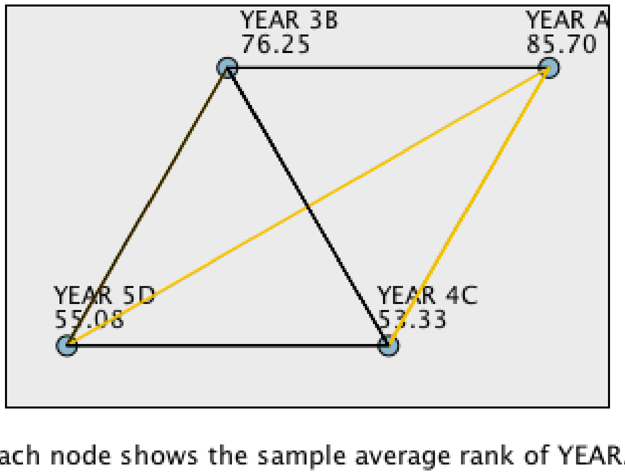


Each node shows the sample average rank of YEAR.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
YEAR 4C-YEAR A	30.293	8.289	3.655	.000	.002

Figure 6.8: Pairwise comparison of back scores across all cohorts.

Similarly, pairwise comparisons for head anatomy (see Figure 6.9) scores using Dunn's procedure and Bonferroni correction for multiple comparisons revealed statistically significant ($p < .05$) differences in performance between the Year A (*Mdn* = 50) and Year C (*Mdn* = 40) (p = .001) cohorts and between the Year A and Year D (*Mdn* = 40) (p = .024) cohorts, but not for any other combination.



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
YEAR 4C-YEAR 5D	-1.745	10.484	-.166	.868	1.000
YEAR 4C-YEAR 3B	22.920	9.032	2.538	.011	.067
YEAR 4C-YEAR A	32.370	8.493	3.812	.000	.001
YEAR 5D-YEAR 3B	21.175	11.081	1.911	.056	.336
YEAR 5D-YEAR A	30.625	10.646	2.877	.004	.024
YEAR 3B-YEAR A	9.450	9.220	1.025	.305	1.000

Figure 6.9: Pairwise comparison of head scores across all cohorts.

Therefore, there appears to be a statistically significant difference in head, neck and back anatomy knowledge between the pre-clinical and later-year clinical students.

6.3.3 Cohort Performance Across Difficulty

During the standard setting process, each question was assigned to one of three taxonomic classifications levels—remembering, applying or analysing—which are categorised according to the cognitive skills involved in responding to a question. These three categories of questions were similar to what students would have been exposed to in Year A examinations, with each classification increasing in the level of difficulty and the effort required by the student to generate the right answer. Therefore, the final component of assessing the differences between pre-clinical and clinical students was to detect whether there were any significant distinctions in how the students responded to the three different types of questions that comprised the anatomy assessment.

Descriptives

Of the 60 questions, there were 23 recall questions (38%), 29 application questions (48%) and eight analytical questions (14%). The overall mean performance (n = 136) for questions involving remembering knowledge was (M = 61.2, SD = 14.6). Performance decreased by approximately 6% for application-type questions (M = 54.8, SD = 12.8) and by 18.5% for analysis-type questions (M = 42.7, SD = 17.6). These data were further broken down, and the mean scores from each cohort were clustered according to the framework classification (see Figure 6.10).

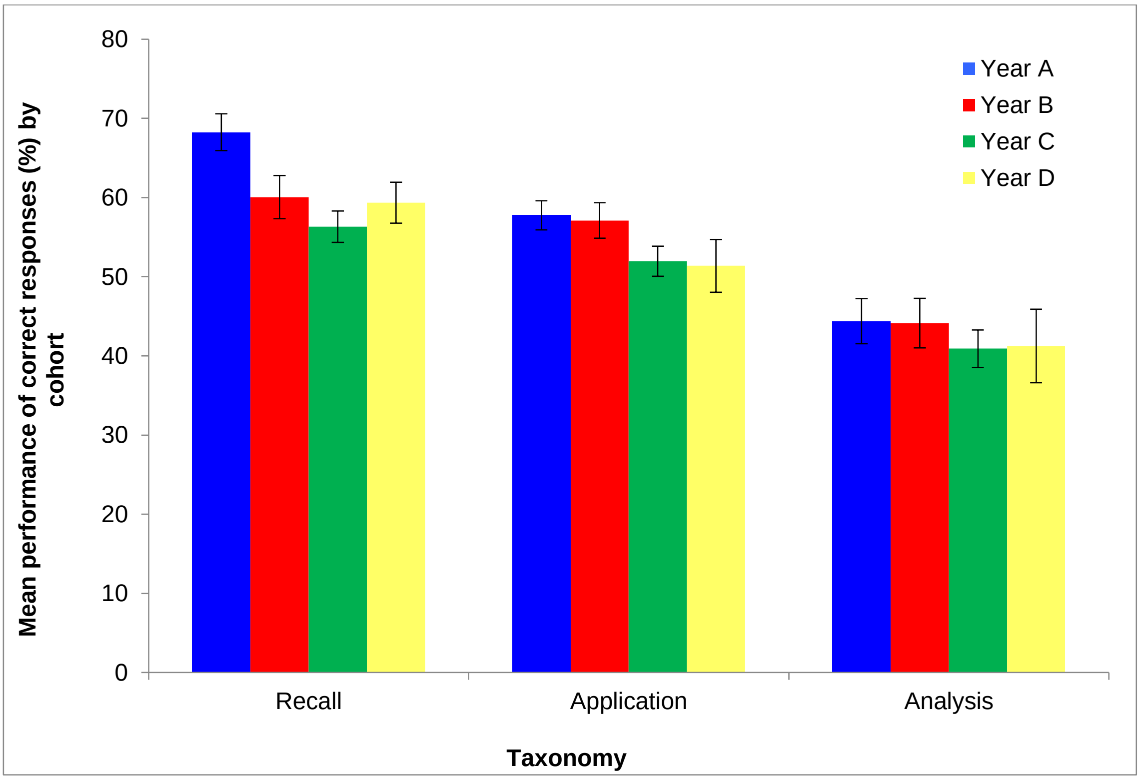


Figure 6.10: Mean performance of cohort according to taxonomy.

Analysis

A non-parametric test—Kruskal–Wallis H-test—was run to determine whether the median scores of the four cohorts for responses across the three different types of questions were equal (H_O) or different (H_A).

All four assumptions for this test were met, and the shapes of the distribution for each group of the independent variable (cohort) on the dependent variable (scores by taxonomy) were similar, as confirmed through visual inspection of a boxplot.

Initial analysis revealed that there was a statistically significant difference on the recall questions, with the difference in median scores among the cohorts of χ^2 (3) = 14.630, p = .002.

Pairwise comparisons for each cohort on the recall scores were run using Dunn's procedure with Bonferroni correction for multiple comparisons. The findings revealed statistically significant differences in performance between the Year A (*Mdn* = 69.6) and Year C (*Mdn* = 56.5) (p = .001) cohorts. The differences between the medians of all other combinations of variables were not significant.

Therefore, the null hypothesis for these groups was retained—that is, the distribution of performance on the application and analysis questions was the same across all cohorts.

6.4 Comparison of VIA scores with anatomy assessment scores

The other research question posed in this study was: To what extent do medical students retain anatomy? The purpose here was to identify differences in the retention of anatomy knowledge from when students were formally taught in Year A to when they were retested in their later clinical years on the content covered during their first pre-clinical year.

In an ideal world, best-practice measures for analysing the retention of knowledge would be to have participants assessed on the same test every year until they graduated, similar to a study by the research team at the Yale University of Medicine (Rizzolo et al., 2010). However, the longitudinal approach to this design would create delays in collecting the required data, and this was not the primary goal of the research, which, in addition to exploring anatomy retention, was to obtain a snapshot of anatomy knowledge across medical students in the pre-clinical and clinical settings.

One of the options initially considered to assess retention was to have the clinical cohorts (Years B–D) sit the same anatomy paper from their Year A VIA examination. This examination, which takes place at the end of Year A, assesses the anatomy objectives formally taught in Year A. Although the objectives remain the same every year, the questions assessed on the VIA were slightly modified from year to year to maintain examination security. Hence, to preserve the integrity of the examination material, it was not possible for the research team to acquire and administer these questions.

Consequently, the option selected was to construct anatomy questions at a similar level of difficulty which students would have been exposed to in Year A, using objectives that all cohorts would have covered in Year A, and to then compare the scores with participants' anatomy scores in the summative Year A VIA paper.

Given that the aim of this research question was to test how much anatomy knowledge participants had retained from Year A, participant data from the 2014 Year A cohort was excluded from the analysis because these individuals had not sat the VIA examination prior to the anatomy assessment. Therefore, only data from the three clinical cohorts (Years B–D) were used to explore anatomy retention among participants.

Descriptives

Table 6.5 depicts the anatomy assessment scores for all clinical cohorts, as well as the VIA scores for these participants, the VIA scores for the non-participants, the cohort mean on the VIA and the borderline of the VIA paper for each cohort.

Table 6.5

Descriptive scores of the clinical cohorts on Anatomy Assessment (AA) and VIA

Cohort	Mean AA scores (%) (Participants) (BL=50.2%)	Mean VIA scores (%) (Participants)	Mean VIA scores (%) (Non-participants)	Mean VIA scores (%) (Cohort)	Borderline VIA (%) (Cohort)
Year B (2013)	56.5 (SD=11.3)	54.2 (SD=17.7)	49.5	50.9	41.2
Year C (2012)	52.2 (SD=10.5)	63.6 (SD=13.9)	59.1	61.6	46.5
Year D (2011)	53.1 (SD=10.2)	72.8 (SD=14.1)	64.8	66.9	50

By comparing the VIA scores of participants in each cohort to that of the non-participants and the cohort mean, it is evident that the stronger students in anatomy participated in the research. This does represent as an apparent bias within the study. However, if the results show that the stronger students in anatomy perform less well than their pre-clinical counterparts, then it could be surmised that a similar pattern would exist for the poorly performing individuals.

Furthermore, the cohort mean scores for the VIA reveal large differences between the three cohorts. While this could be attributed to the level of anatomy knowledge varying significantly between cohorts at the Year A level, examination of the VIA borderline score for each cohort provides evidence of the inconsistency in difficulty of the assessment from year to year, therefore resulting in lower cohort means when the examination was more difficult (low borderline) and higher cohort means when the examination was less difficult (high borderline). Given that the overall borderline for the anatomy assessment (50.2%) was similar to or easier than what other cohorts would have sat in Year A, the VIA score could arguably be used as a baseline comparison point for each cohort.

Analysis

To answer the research question, separate paired t-tests were conducted for each cohort using participants' anatomy scores on the VIA and on the formative assessment.

To detect the presence of outliers, a normal Q-Q plot and boxplot analysis of the differences between the anatomy assessment and VIA scores was plotted for each cohort of participants. This was further compared with Shapiro–Wilk's test of normality to identify whether the differences were normally distributed. The results and data analysis for each are presented for each cohort.

6.4.1 Year B Results

For the Year B cohort, one outlier was detected on the Q-Q plot. However, when comparing the differences in scores between the formative anatomy assessment and the summative anatomy VIA in Year A, two outliers (participants 41 and 72) were detected more than 1.5 box-lengths from the edge of the box in a boxplot (see Figure 6.11), with values at two ends. Inspection of their values revealed that one of them (participant 72) was extreme, with a difference of −39%. The other participant had a difference of + 33%, which was considered small relative to the other scores. The differences in the scores for the anatomy assessment and VIA were normally distributed, as assessed by the Shapiro–Wilk's test (p = .332). This test is usually recommended for small sample sizes (< 50), and when the researcher is not confident with visual interpretations of Q-Q plots (Laerd Statistics, 2015).

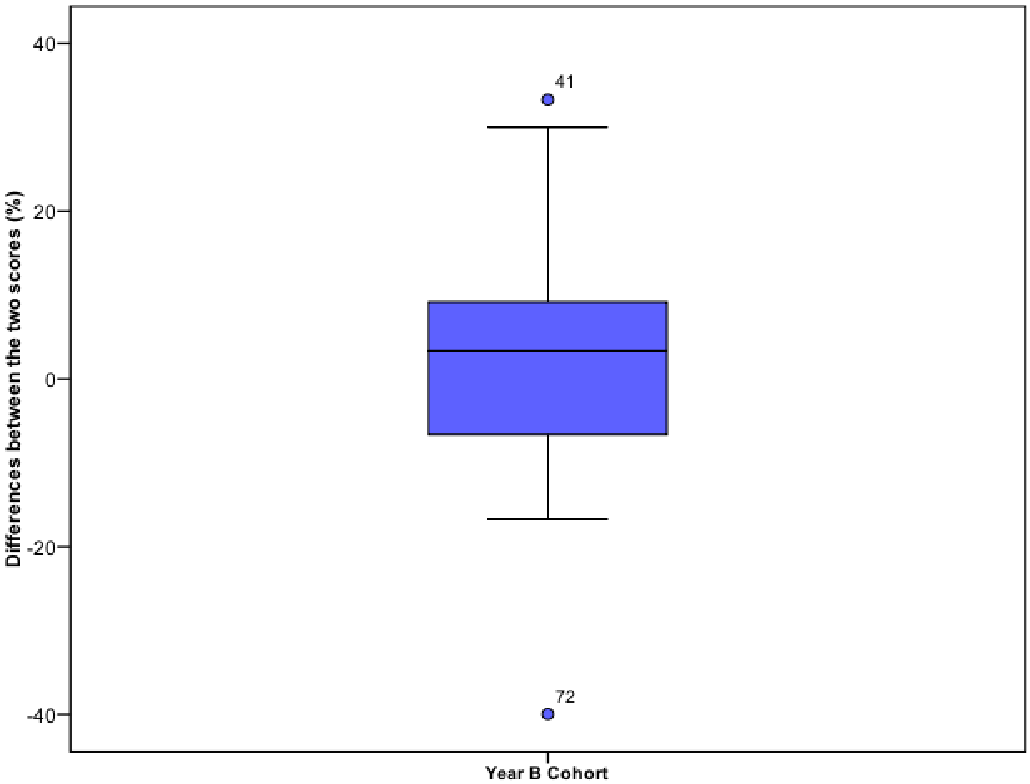


Figure 6.11: Differences in Year B performance between anatomy assessment scores and anatomy VIA scores (AA–VIA).

Given the normal distribution, a decision had to be made regarding the far outlier (participant 72). To assess whether the presence of this outlier would have a substantial effect on the overall results, the analysis was run with and without these outliers.

In excluding the far outlier from the data (participant 72), the mean for the formative anatomy assessment was relatively the same (M = 56.5, SD = 11.5), whereas the mean for the summative anatomy VIA score decreased by 1% (M = 52.9, SD = 16.4). Shapiro–Wilk's test of normality was also met, as indicated by p = .179

Further analysis through the paired-sample t-tests did not reveal any statistically significant difference between the two scores in the absence of the outlier.

As part of the analysis, a correlation output was generated between the two scores, which revealed a statistically significant moderate correlation (see Figure 6.12) between anatomy scores on the summative Year A VIA and scores on the formative assessment sat in Year B, as indicated by $r(32) = .541$, $p = .001$. This increased to a larger correlation when the far outlier was removed, $r(31) = .615$, $p = .000$.

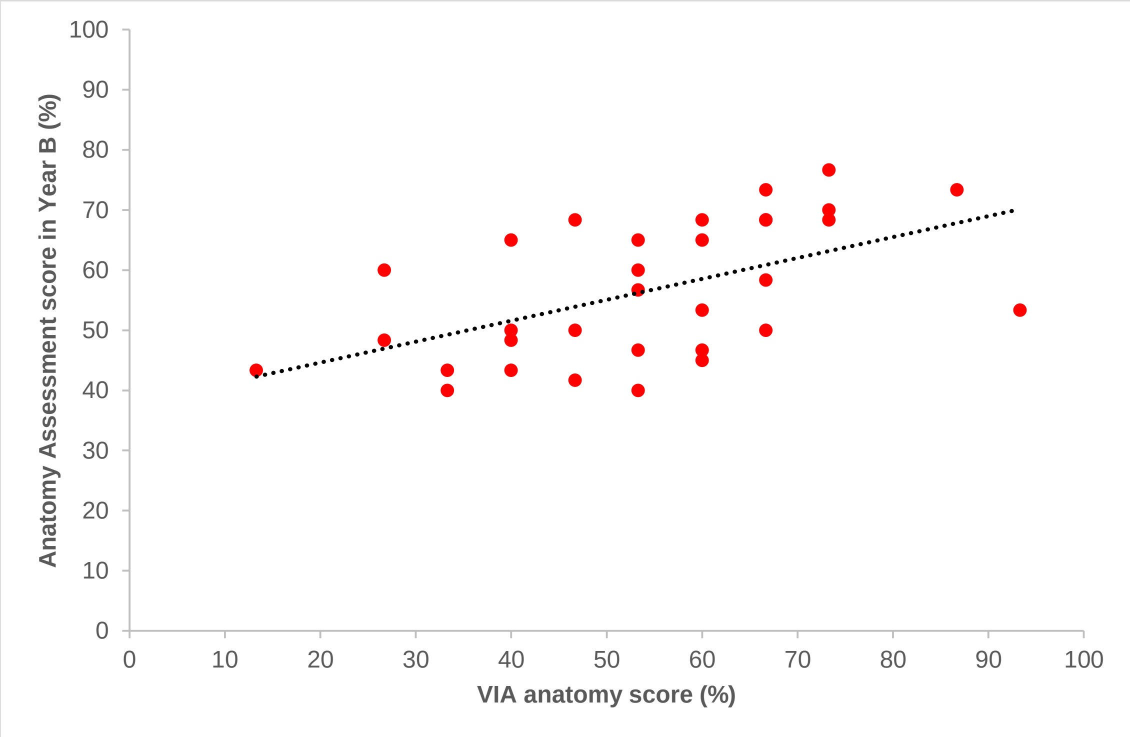


Figure 6.12: Comparison of participant performance on the VIA assessment in Year A *v*. the anatomy assessment in Year B.

Although the outlier elicited an increase in variability, it did not unduly influence the mean difference or alter the conclusion of the paired-samples t-test; therefore, its value was retained in the analysis.

6.4.2 Year C Results

Similar findings were evident for the Year C cohort, with the Q-Q plot and boxplot analysis detecting one outlier (participant 95) more than 1.5 box-lengths from the edge of the box in a boxplot. The difference in scores between the anatomy assessment in Year A and the anatomy VIA in Year A for this outlier lay at one extreme (-49%), as shown in Figure 6.13.

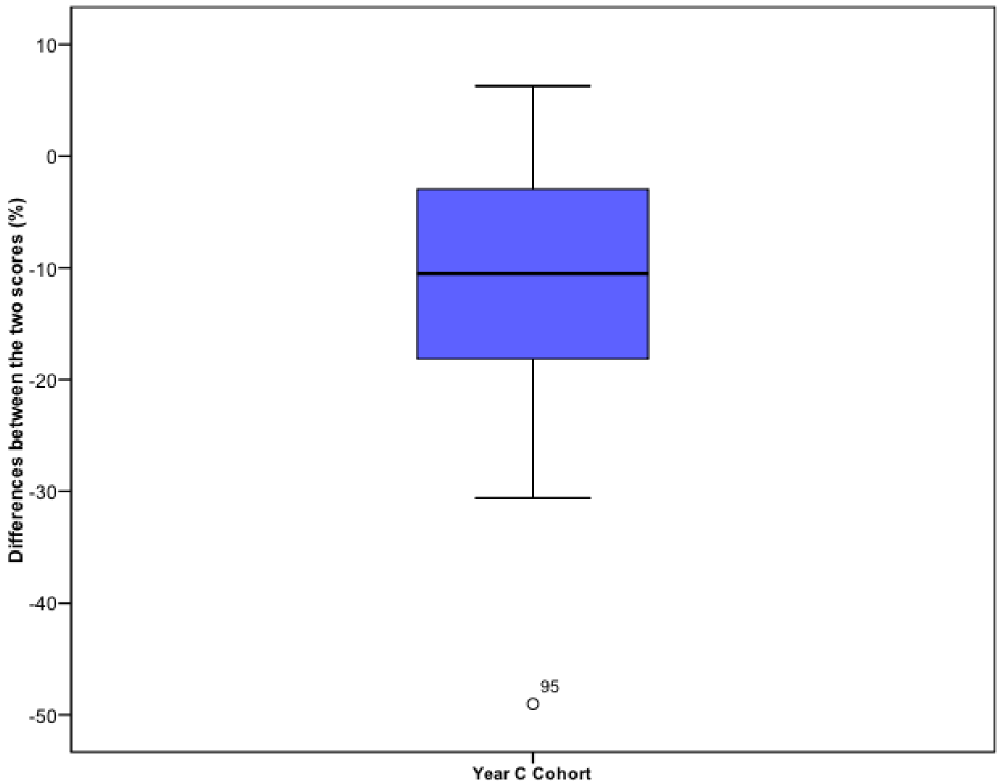


Figure 6.13: Differences in Year C performance between anatomy assessment scores and anatomy VIA scores (AA–VIA).

Additionally, the assumption of normality was violated; hence, the differences in the scores were not normally distributed, as assessed by the Shapiro–Wilk's test (p = .023). Given that the paired t-test is quite robust to deviations from normality (Laerd Statistics, 2015), a paired-samples t-test was run with and without the outlier to determine whether its presence altered the outcome of the test.

As is evident from the initial analysis of all Year C participants, there was a statistically significant mean decrease in performance of 11.5% (SD = 10.5), 95% CI [−14.6, -8.3], $t(43) = -7.310$, $p = .000$ in the anatomy assessment sat in Year C compared with the anatomy scores in Year A VIA. There was also a strong positive correlation between the two scores, which was statistically significant, $r(44) = .666$, $p = .000$.

When the outlier was excluded from the analysis, the assumption of normality was no longer violated, and the data appeared to be normally distributed, as assessed by the Shapiro–Wilk's test (p = .721). The mean anatomy score for the formative assessment for the Year C participants increased by 0.4% (n = 43, M = 52.6, SD = 10.2), whereas that of their summative Year A VIA decreased by 0.4% (M = 63.2, SD = 13.7). The correlation between the two scores remained strong, positive and statistically significant, $r(43) = .770$, p = .000 (see Figure 6.14).

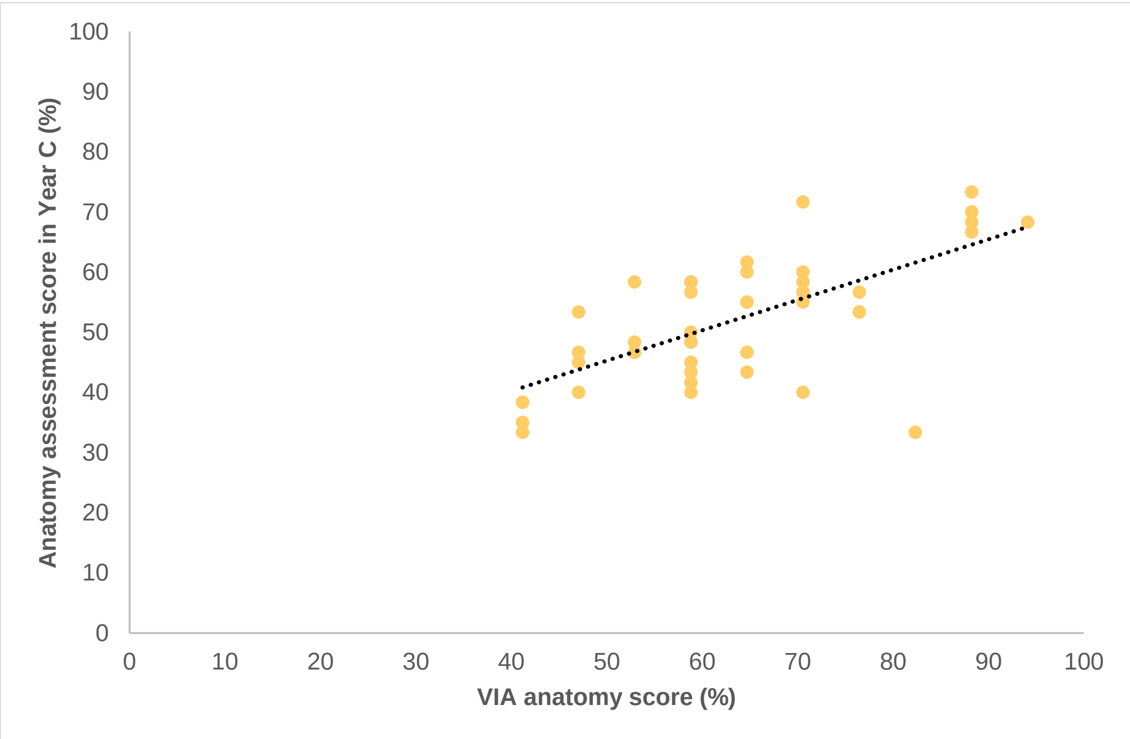


Figure 6.14: Comparison of participant performance on the VIA assessment in Year A *v*. the anatomy assessment in Year C.

With the exclusion of the outlier, the resulting mean difference between the formative and summative anatomy scores was -10.6% (SD = 8.8), 95% CI [−13.3, -7.9], $t(42) = −7.939$, p = .000, which was statistically significant.

Therefore, it was questionable whether the data for participant 95 should be excluded from the analysis. One could argue that outliers contain useful data with vital information about a student's knowledge of anatomy as they progress from the pre-clinical years to the clinical years. Given that the conclusion was not altered with the exclusion of this participant's results, it was decided that the data should be retained.

6.4.3 Year D Results

No outliers were identified through the Q-Q plot or boxplot analysis for the Year D participants. In addition, the assumption of normality was not violated; hence, the data of the differences between the formative assessment and summative anatomy VIA scores were normally distributed, as assessed by the Shapiro–Wilk's test (p = .265). The paired-samples correlation between the two scores also indicated a strong positive correlation, which was statistically significant, $r(20) = .709$, p = .000 (see Figure 6.15).

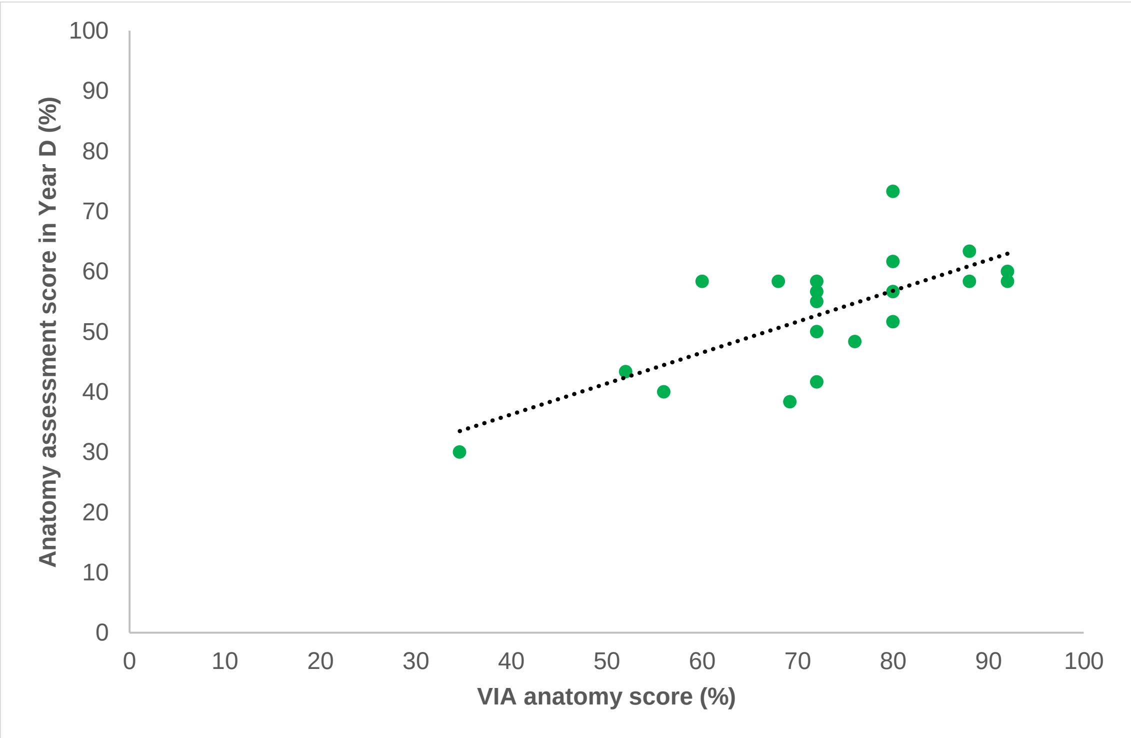


Figure 6.15: Comparison of participant performance on the VIA assessment in Year A *v*. the anatomy assessment in Year D.

When examining the mean differences between performance on the anatomy assessment in Year D versus performance in the anatomy VIA paper in Year A, there was a mean decrease of −19.7% (SD = 10.0), 95% CI [–24.3, –15.1], which was statistically significant, $t(19) = -8.840$, p = .000.

Therefore, we can retain the null hypothesis for the Year B cohort because the mean difference between the paired values is equal to zero, and we can reject the null hypothesis for the Year C and Year D cohorts.

Conclusion

Although the VIA was an imperfect baseline because it was not the same for all groups and appeared to vary in difficulty, it did provide a point of comparison within each cohort because of the identified similarities between the assessment tools. Therefore, using the VIA as a non-equivalent baseline for each cohort the results suggest that students who have recently received formal anatomy teaching tend to either retain or only slightly forget their anatomy knowledge, with most students improving on their pre-clinical-year results, whereas those who are two or more years removed from formal teaching are more likely to forget their knowledge. Although the examinations during the year in which the students sat their VIA might have been easier or more difficult compared with the anatomy assessment, thereby resulting in a higher or lower mean VIA score for that year, paired-sample correlation outputs generated between the two scores for each cohort seemed to indicate a moderate to strong positive relationship between the two variables. This indicates that a student who performed well in the Year A VIA was more likely to perform well on the anatomy assessment, whereas a student who performed poorly on the VIA would have a similar result on the anatomy assessment.

To conclude, anatomy knowledge appears to decline as students' progress from the pre-clinical to the clinical years. However, this decline in knowledge is more evident and significant during the last two clinical years (Year C and Year D) of the MBBS program, the cohorts most distant from formal instruction in anatomy. The phrase 'use it or lose it' could be applicable in explaining the decline in anatomy knowledge.

However, this retention or lack thereof will be explored further in the qualitative phase of this research.

6.5 Testing Effect

Prior to the summative VIA examination in 2014, the Year A (pre-clinical) students sat the formative anatomy assessment, for which their mean performance was (M = 60.0%, SD = 10.8). When these students undertook their VIA examination a month later (BL =52%), their mean anatomy performance was much higher (M = 75.2%, SD = 13.7) relative to that of the entire cohort (M = 71.2%) and non-participants (M = 67.1%).

Analysis

To further investigate this, a paired-sample t-test was performed to compare the difference between the means of two paired observations and determine whether the difference is statistically significant from zero.

For this test, the null hypothesis (H_0) was that the mean difference of the population between the paired values is equal to zero ($\mu_{diff} = 0$). The alternative hypothesis (H_A) was that the mean difference is not equal to zero ($\mu_{diff} \neq 0$).

Assumptions one and two have already been met, as illustrated by the dependent (anatomy performance) and independent variables (formative anatomy assessment *v.* VIA anatomy score). Assumptions three (no significant outliers) and four (distribution of the differences between the two related groups on the dependent variable should be approximately normally distributed) were tested using a boxplot analysis and Shapiro–Wilk’s test of normality respectively.

To detect the presence of outliers, a normal Q-Q plot and boxplot analysis of the differences between the anatomy assessment and VIA scores were plotted for each cohort. This was further compared with Shapiro–Wilk’s test of normality to identify whether the differences were normally distributed. For the Year A cohort, there were no outliers in the data, as assessed by the inspection of the boxplot for values greater than 1.5 box-lengths from the edge of the box.

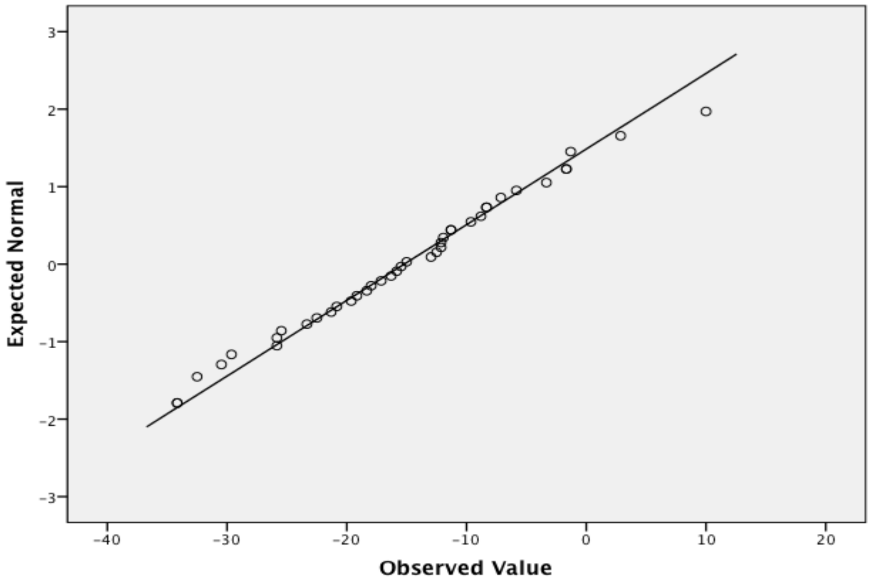


Figure 6.16: Difference in scores for Year A cohort between formative and summative assessments.

The differences in the scores for the anatomy assessment and VIA were normally distributed, as assessed by the visual inspection of a normal Q-Q plot (see Figure 6.16) and the Shapiro–Wilk's test (p = .901).

The paired t-test showed that the VIA assessment elicited a statistically significant mean increase of 15.21%, 95% CI [11.93, 18.48], p = .000 in the summative anatomy score compared with the formative anatomy assessment. As part of the analysis, a correlation output was generated between the two scores, which revealed a statistically significant large correlation (see Figure 6.17) between the two scores, as indicated by $r(40)$ = .672, p = .000.

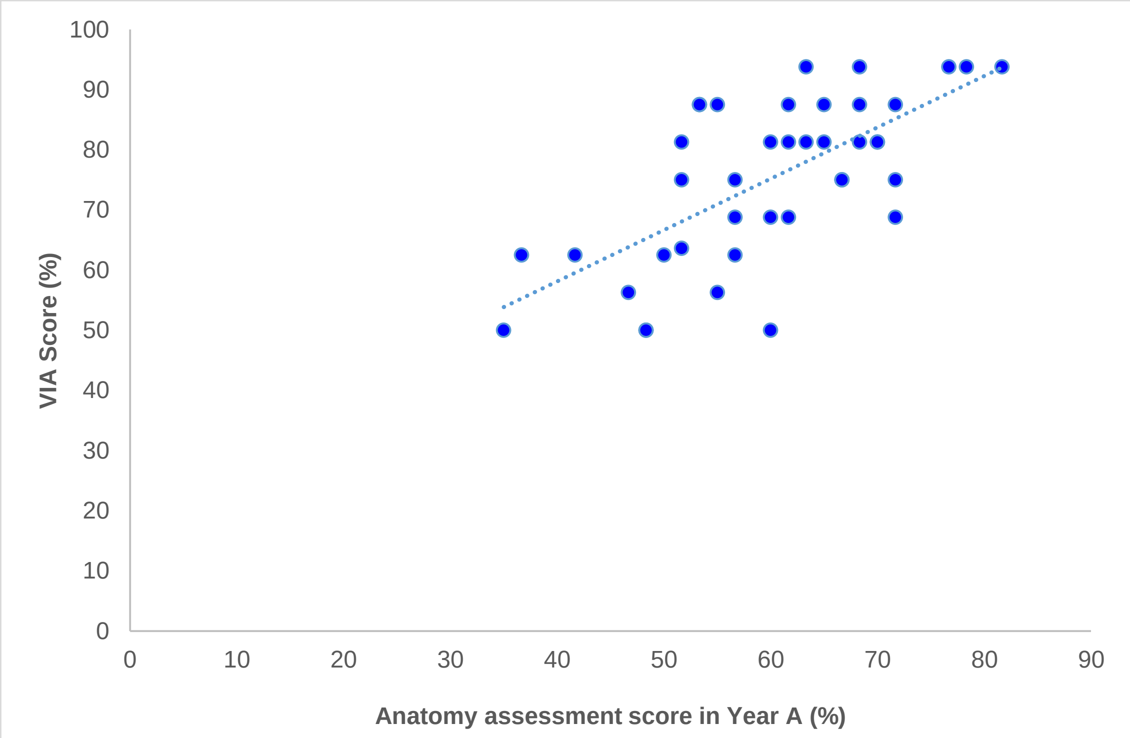


Figure 6.17: Comparison of participant performance on the formative assessment in Year A *v*. the summative anatomy assessment in Year A.

6.6 Learning Anatomy Survey Results

This section outlines the participants' prior educational background and the results of the learning anatomy questionnaire. Some aspects are compared with the anatomy scores in the formative assessment in 2014 and with differences of scores from the VIA to determine significance between variables.

6.6.1 Demographics

For this research, students' prior undergraduate degrees were classed into five categories depending on the amount of anatomy exposure they had: anatomy in a professional course (physiotherapy, occupational therapy), anatomy in a biomedical science course, biological science (botany, zoology, genetics, forensic science), other science (chemistry, physics, engineering) and no science (law, philosophy, music).

Of the 136 students, 12% had studied anatomy in a professional course, 30% had studied anatomy in a biomedical science course, 18% had a biological science degree and very little anatomy or no anatomy at all, 25% had an ‘other’ science degree but no anatomy and 15% had a prior degree that was not science-based. Figure 6.18 shows the participants’ educational background within each cohort.

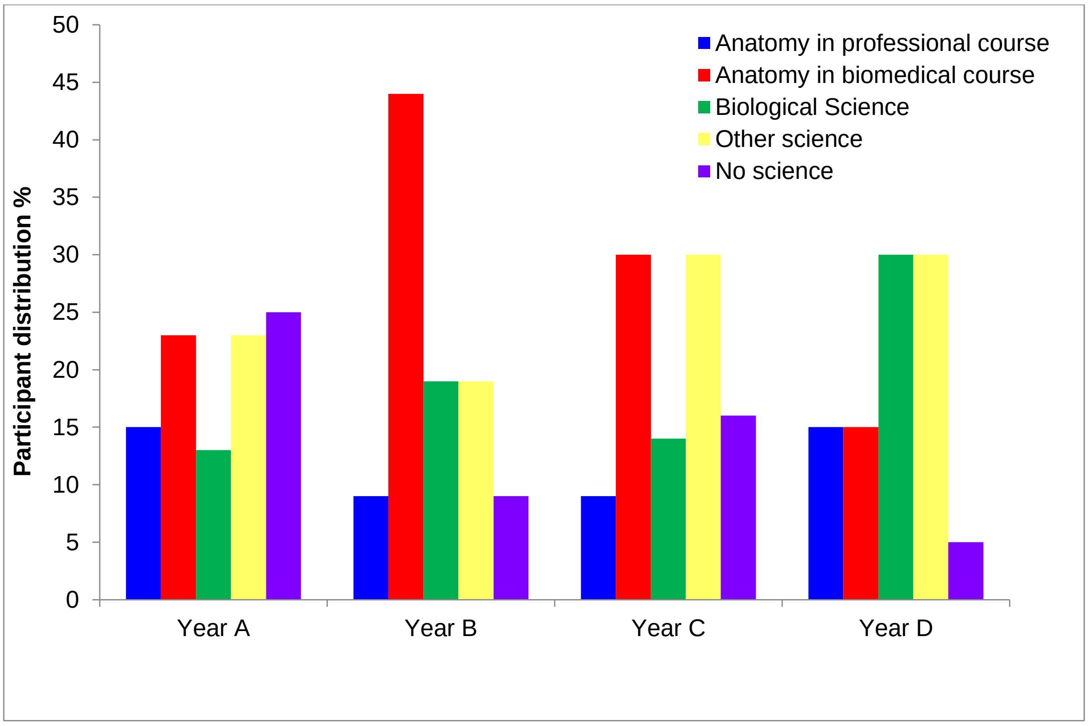


Figure 6.18: Distribution of participants’ prior degree within each cohort (Years A–D).

There is high variability in the prior educational background of participants within each cohort. Although most participants had a biomedical science degree, which is largely represented in each cohort (except for Year D), Figure 6.19 also shows that a large proportion of students came from a background with no anatomy exposure at all (as represented by other science and no science degrees), and this is most evident in the Year D cohort. Therefore, it would be interesting to measure any trends in anatomy performance across the educational backgrounds. To do so, the participants were split into high and low scorers. Participants who scored at or above 55.8% and obtained a clear pass were categorised as high scorers, and the remaining participants (i.e., those who scored below 55.8% according to the test features outlined at the outset) were categorised as low scorers. Although the low scorers could be broken down further into a borderline and clear fail category, for the purpose of comparing performance, the participants were divided into two groups. Overall, 52% were high scorers (M = 64.3, SD = 6.35) and 48% were low scorers (M=*46.1*, SD = 6.31).

Participant backgrounds were analysed against these two groups to analyse performance on the anatomy assessment.

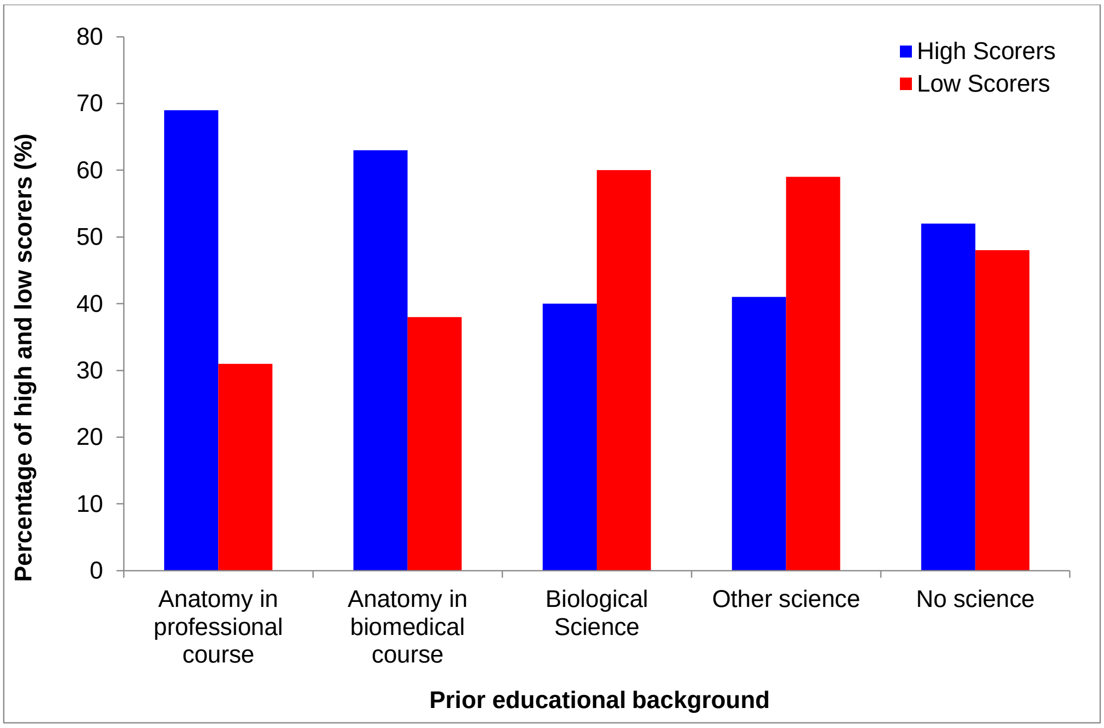


Figure 6.19: Effect of participants' educational background on performance.

Of the 12% and 30% of participants who studied anatomy in a professional course and biomedical science respectively, most obtained a clear pass in the anatomy assessment, with the remaining individuals scoring below 55.8%. Participants in the 'biological science' and 'other science' categories were more likely to perform worse on the anatomy assessment than any other group, with 60% of participants in each group classified as low scorers. Finally, students who had no anatomy or science exposure whatsoever were almost equivalent in their spread across the high scorer and low scorer categories.

The mean scores on the anatomy assessment across the five groups (see Figure 6.20) shows no statistical significance (p >.05) as examined by the Kruskal-Wallis H test, although the trend was for participants with prior anatomy knowledge to perform better. This suggests that prior educational background does not necessarily play a role in how much knowledge is retained by students.

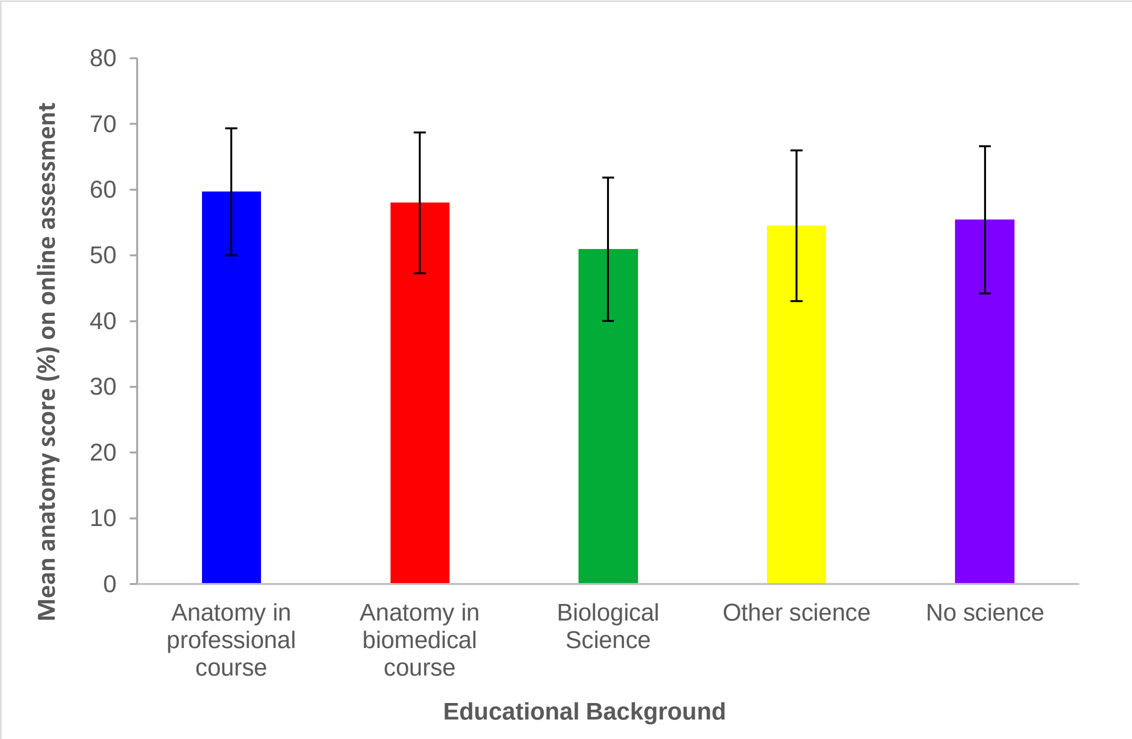


Figure 6.20: Mean anatomy score on online assessment across the five educational backgrounds.

6.6.2 Learning Anatomy

In relation to the resources used the most by participants for learning anatomy, 40% chose textbooks, 26% selected anatomy tutorials and 21% used online anatomy software An@tomedia. A few students selected lectures (4%), while 2% opted for study groups and 2% for specimen days as their main learning resource. Those who selected the ‘other’ category (8%) indicated that resources used for learning anatomy involved the internet, Acland’s DVD and anatomy apps, and one student used a combination of all resources, as shown in Figure 6.21.

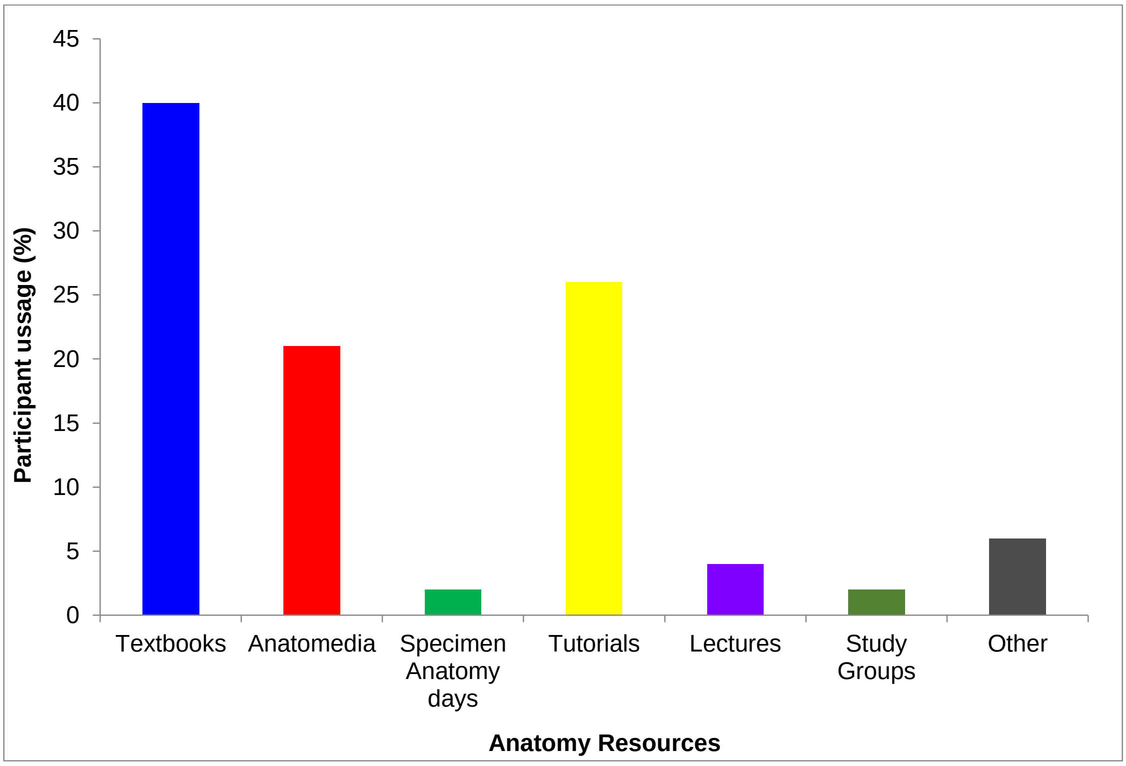


Figure 6.21: Resources used the most by students for learning anatomy.

Students were also asked to select the one resource they found the most useful for learning anatomy. It was expected that the results would mirror those of the previous question regarding which resource they used the most for learning anatomy. However, this was not the case. As shown in Figure 6.22, the anatomy tutorials were reported to be the most useful resource, as selected by 29% of participants. This was followed by textbooks (21%), anatomy specimen days (16%) and study groups (10%).

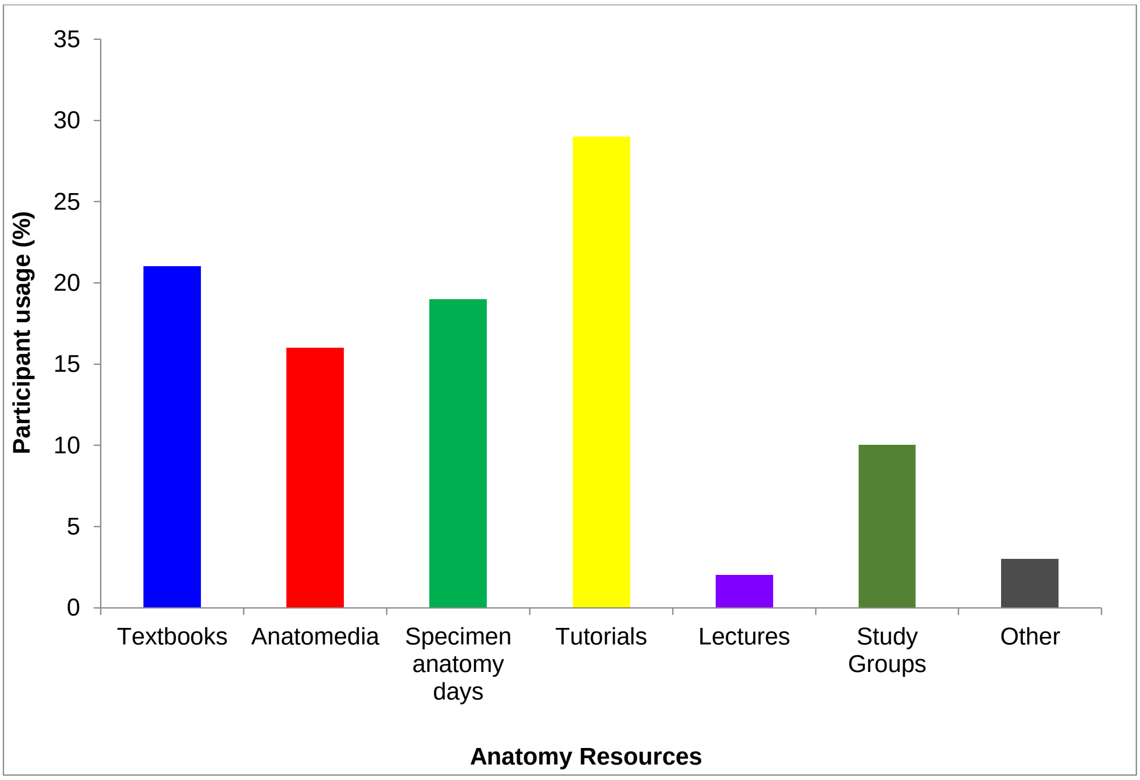


Figure 6.22: Most useful resources for learning anatomy.

A chi-square test of independence was run to determine if there was any significant association between high and low scorers and the resources identified as the most useful for learning anatomy. While all resources were selected in higher proportion by the high scorers, there was no statistically significant association between the two variables. However, given that tutorials appeared to stand out when compared to low scorers and hence was explored further in the qualitative analysis.

Students were also asked to indicate their approach to learning anatomy to determine whether they preferred one learning approach to another and whether the learning approach adopted affected their overall performance on the anatomy assessment.

Although students can adopt either deep (searching for meaning) or surface (memorisation) approaches when engaging in a learning task, 70% of participants adopted both approaches extensively, with most (50%) searching for meaning first and then memorising (see Figure 6.23).

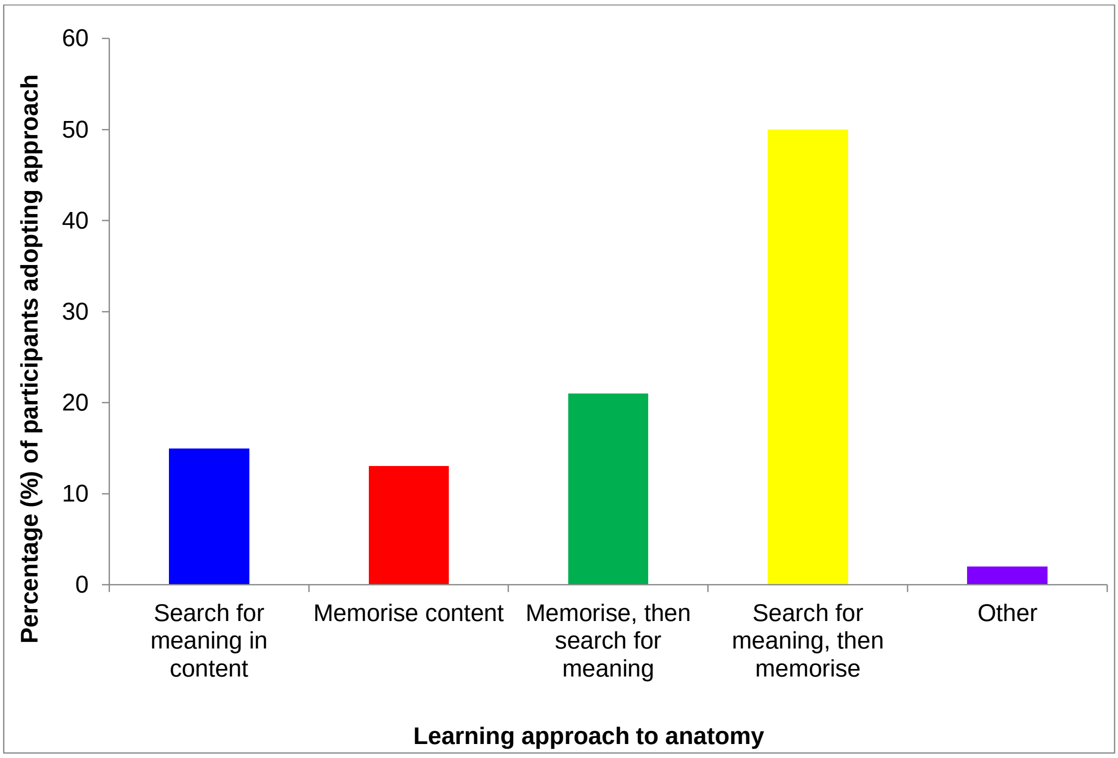


Figure 6.23: Approaches mainly used to learn anatomy.

Students who approached learning through pure memorisation of content (n = 17) had a mean score of 50.3% (SD = 3.2), whereas those employing a search for meaning approach (n = 20) or search for meaning followed by memorisation (n = 68) had a mean score of 56.1% (SD = 2.2 and 1.4 respectively). Students who memorised anatomical content first, followed by an attempt to search for meaning (n = 29), appeared to perform slightly better, with a mean of 56.7% (SD = 1.9). Two students selected the ‘other’ approach to learning but did not specify what this was. Their mean score was 64%, but because they did not meet the criteria for the qualitative phase, it is not clear what they meant by ‘other’. There does not appear to be any significant relationship between the learning approach adopted and students’ mean scores as demonstrated by the Kruskal-Wallis H Test. This contrasts with other studies (Pandey

& Zimitat, 2007), as evident by the 40% of high scorers and 32% of low scorers who adopted a combination of surface and deep-learning approaches (see Figure 6.24).

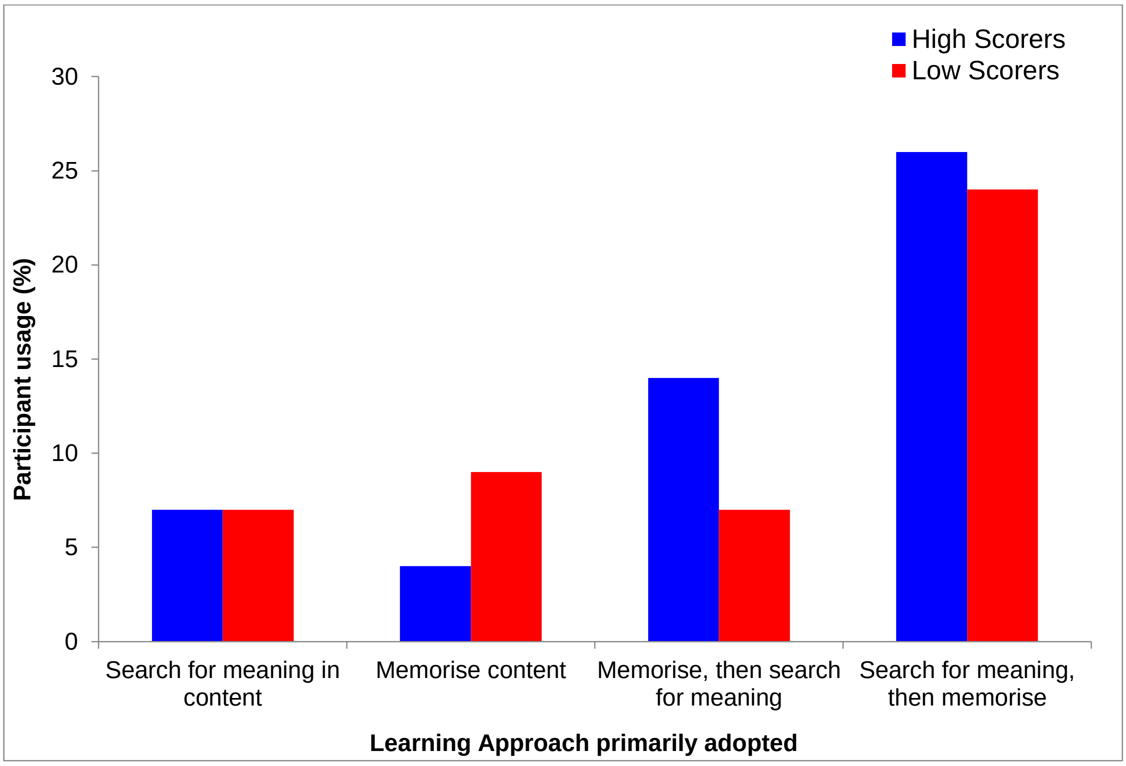


Figure 6.24: Performance of high and low scorers by learning approach.

6.6.3 Attitudes Towards Anatomy

Figure 6.25 depicts students' attitudes towards their anatomy experience through a stacked bar chart. The percentage of respondents who agreed with the statement are shown to the left, whereas the percentage who disagreed are shown to the right and the percentage who neither agreed nor disagreed are shown in the midline in grey. Overall, most students agreed that the volume of anatomy in Year A was daunting. When asked what they perceived to be the challenges to learning anatomy, 60% indicated that the amount needed to be learned was the biggest hurdle, and 24% stated that visualisation of structures was challenging. Given that the emphasis on anatomy in Year A is on clinical relevance, most students considered the volume necessary for clinical practice, while 14% were unsure. When comparing students' attitudes towards learning anatomy, almost half of the participants disagreed that their motivation for learning anatomy was to pass examinations; however, 40% indicated that this was their intent. Cross-tabulation with chi-square statistics did not reveal any statistically significant results between anatomy performance and the above mentioned variables.

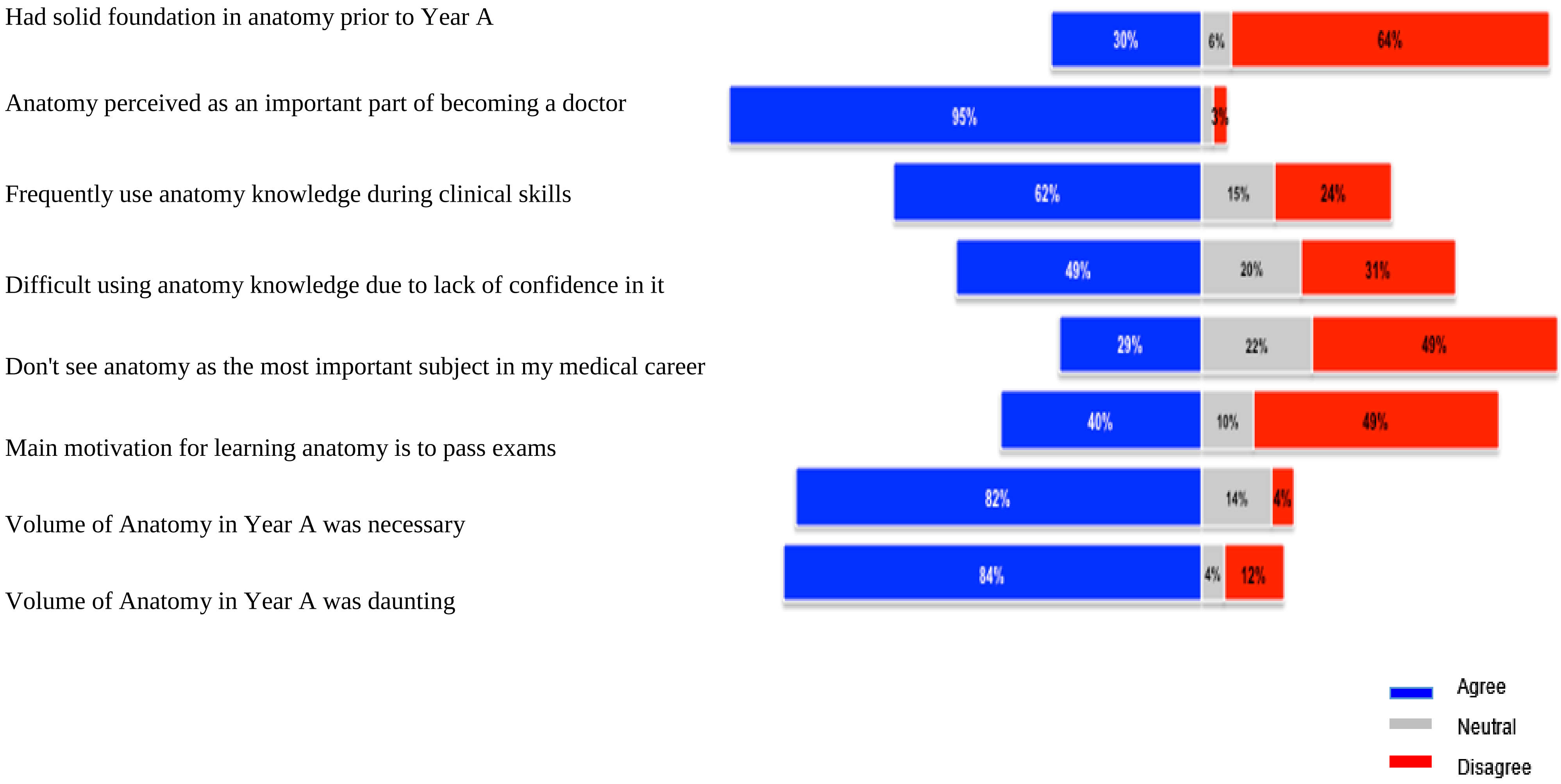


Figure 6.25: Anatomy perceptions by participants

The relevance of anatomy to clinical skills is apparent when viewing participants' responses, with 62% indicating that anatomy knowledge is frequently used during clinical skills sessions (see Figure 6.26). However, 22% found it difficult to use their anatomy knowledge because of a lack of confidence. A Spearman's rank-order correlation was run to assess the relationship between frequency of use in clinical skills and difficulty using anatomy because of a lack of confidence in anatomy knowledge. The preliminary analysis showed the relationship to be monotonic, as indicated by the visual inspection of a scatterplot. There was a weak negative association between participants' frequent use of anatomy in clinical skills and their confidence in using anatomy, and this was statistically significant, $r_s(134) = -.298$, $p < 0.01$.

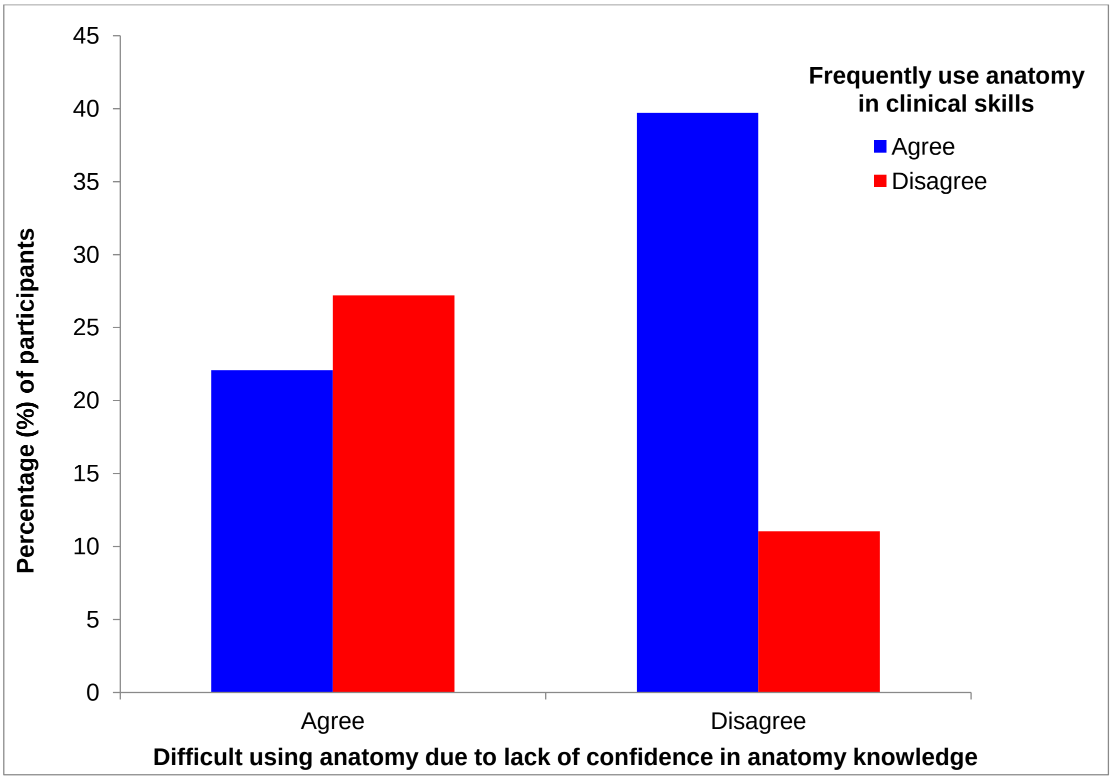


Figure 6.26: Participants' use of anatomy in clinical skills *v*. their confidence in use of anatomy knowledge.

When examining participants' perceptions of anatomy in medicine, 26% felt that anatomy was not the most important subject in their medical career, with 49%

disagreeing and the rest unsure (see Figure 6.27). However, a large proportion of students (95%) viewed anatomy as an important part of being a doctor. Statistical analysis (Spearman's rank-order correlation coefficient test r_s), showed that there was a moderately negative association ($r_s = -0.331$) between viewing anatomy as important for becoming a doctor, but not as an important subject in their medical career ($p < 0.01$). These findings will be explored further in the qualitative interviews.

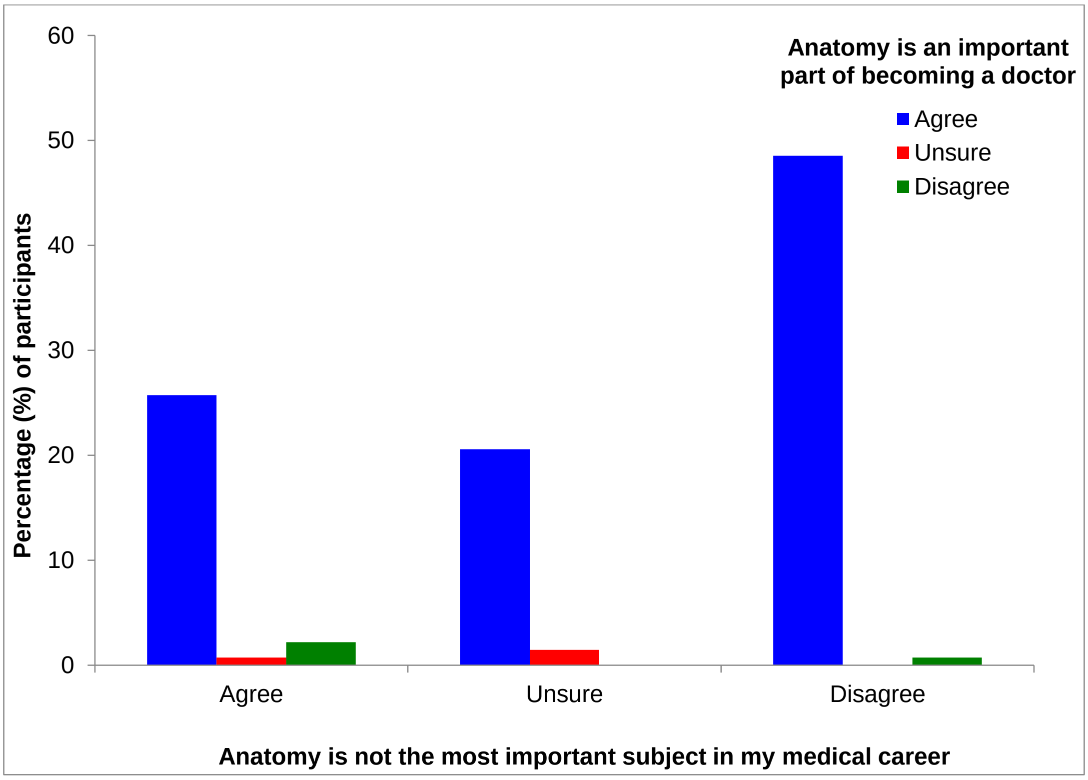


Figure 6.27: Participants' perceptions of importance of anatomy.

Conclusion

The quantitative phase of this research addresses two research questions: How do medical students from all four cohorts of an MBBS program differ in their anatomy knowledge, and how much knowledge is retained by medical students as they progress from the pre-clinical to the clinical years? In exploring the data further, some unanswered questions have arisen:

- Why did the pre-clinical (Year A) students perform better than the clinical students (Year B–D) in terms of anatomical knowledge?
- Why is knowledge of some regional sections of anatomy, such as abdomen, thorax and lower limb, generally better retained than knowledge of other regions, such as upper limb, back, and head and neck?
- Why were tutorials seen as the most useful resource for learning anatomy, and how does this resource affect retention?
- Why do students perceive anatomy as being important for a doctor, but not as an the important subject in their medical career?

These issues and others surrounding the learning of anatomy will be explored further in the sequential qualitative phase of this research.

Chapter 7: Qualitative Results

This chapter documents the analysis arising from Phase Two of the research study—the interviews. The findings demonstrate students' perceptions of the anatomy program both in the pre-clinical and clinical years. They provide insights into the retention and learning of anatomy knowledge by students and outline implications and students' suggestions for the future of anatomy education.

Data analysis from the 13 interviews was undertaken using a deductive approach driven primarily by the research questions and the analysis of quantitative data guided by the existing literature. The overarching research question guiding the qualitative phase was: What factors may account for the loss or retention of anatomy knowledge across a student's medical degree?

Issues that arose from the quantitative research, and some of the issues posed by the literature, are addressed by the findings from this phase:

- horizontal and vertical integration of anatomy teaching and learning
- teaching via dissection or prosection
- teaching via body painting
- attitudes of clinicians towards medical students' knowledge of anatomy
- assessment of anatomical knowledge.

To understand the issues associated with the loss or retention of anatomical knowledge, it was necessary to explore the teaching and learning of anatomy as it occurred in the pre-clinical years, as well as subsequent exposure to anatomy in the clinical years. After analysing all 13 interviews, four major themes and multiple subthemes were highlighted as being pertinent to providing insights into the questions posed (see Figure 7.1). Each of these themes is discussed in the subsequent sections.

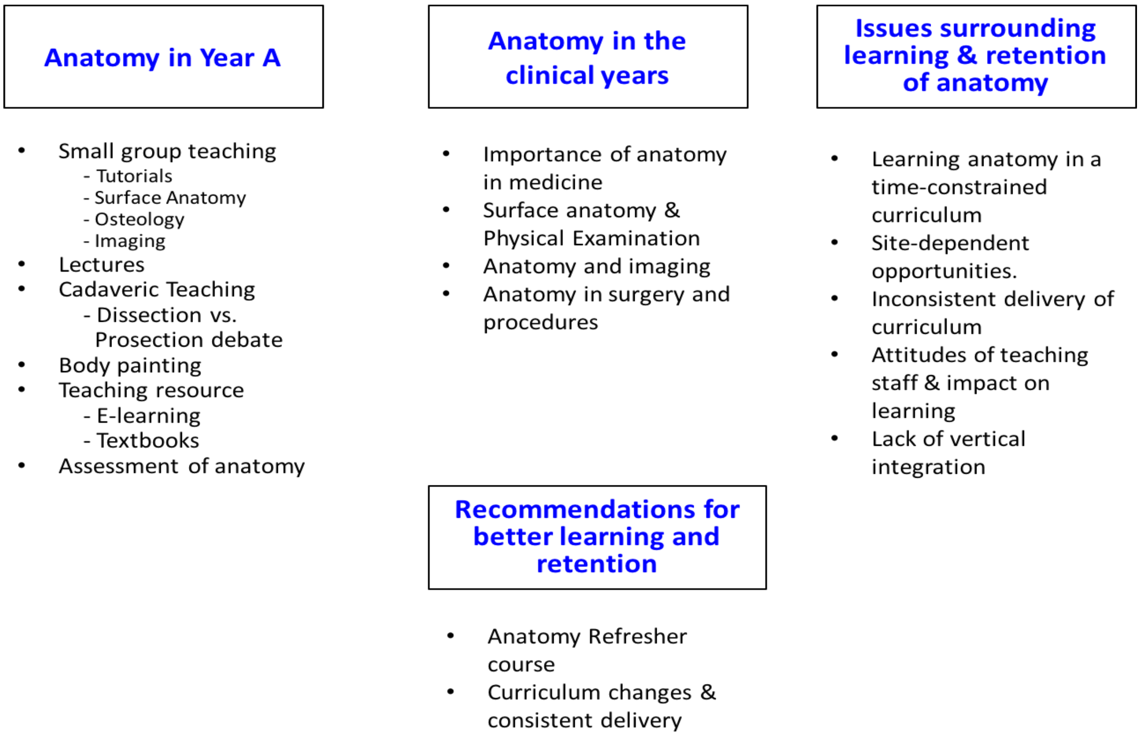


Figure 7.1: Four themes and subthemes that emerged from participant interviews.

Since all participants had progressed into the next year or graduated from the MBBS program during the collection of the qualitative data, all excerpts listed in this chapter cite participants in the year they were in when the interviews were conducted (see Table 7.1). Therefore, although the interviews are referenced according to the year in which they were conducted, they were partly retrospective because they related to the students' previous experiences in addition to their current experiences in their existing clinical year.

Table 7.1

Participant's progression through the MBBS at the time of Phase I and II of study

Phase of Study	Cohort			
I: Anatomy Assessment	Year A	Year B	Year C	Year D
II: Interview	Year B	Year C	Year D	Intern

. In addition, all excerpts from interviews are listed as that from a high performer (HP) or low performer (LP). During the thematic analysis, there was no apparent pattern of difference between responses from high and low performers. Consequently, information presented in this chapter has been pooled together under the various themes.

7.1 Anatomy in the Year A Program

This section highlights participants' views about the pre-clinical (Year A) anatomy program, including teaching, resources available to students and the assessment of anatomy. The theme provides insights into why participants in the pre-clinical year generally performed better on assessments than their clinical counterparts. It also provides a deeper understanding of the different ways in which anatomy is taught and learned, as well as its effect on retention of anatomical knowledge in the subsequent clinical years.

Most participants (69%) were very satisfied with the teaching of the Year A program. They acknowledged that the amount of time devoted to anatomy teaching within the whole Year A curriculum was quite extensive (and therefore beneficial for participants without an anatomy background), especially when compared with other disciplines, and that not much more could be added into an already-packed program. The clinical focus of the anatomy curriculum was also considered valuable in helping students to learn the important concepts in a condensed curriculum. As one participant in the final clinical year stated:

> I liked the fact that the coordinator of the anatomy teaching program, given his medical and anatomy background was able to blend the two quite nicely and come up with these clinical applications of anatomy. And I've come across quite a few of these as well during my placements. (HP, Year D)

The remaining 31% of participants who were moderately or not very satisfied were the LPs of the group. These participants found the Year A anatomy program intense and overwhelming, given the “sheer amount of content that was being covered…in a very short period of time”. One student indicated that he had to “learn how to learn anatomy” (LP, Year B); that is, he had to learn how to manage his time better between the different regions that were covered. Nonetheless, most participants (85%) agreed that anatomy in Year A provided a good grounding for the first clinical year (Year B), with the remaining 15% stating that anatomy was not sufficient and that they would have liked more of it. From the interviews, six major subthemes emerged regarding the Year A anatomy program, and these are presented below.

7.1.1 Small-group Teaching

Students spent a large proportion of the year learning anatomy in small-group sessions. As such, the feedback from participants on the different small-group learning opportunities provides an insight into what worked well and what improvements could be made for the future.

The small-group teaching sessions usually involved students participating in a variety of anatomy-related activities in groups of 10–12 individuals guided and/or led by the tutor as a facilitator. In the Year A anatomy program, small-group teaching occurred as part of tutorial sessions, surface anatomy classes and imaging/osteology workshops. During the interviews, participants highlighted certain aspects of these workshops that were either beneficial or problematic.

Tutorials

The tutorial sessions in anatomy followed a flipped classroom approach wherein students were responsible for learning information prior to the session through assigned pre-reading material, and the in-class time was devoted to developing critical thinking and reasoning skills through the discussion and application of anatomical concepts and principles to a set of clinically oriented anatomy questions. Given that the tutorial setting was used as a platform for learning clinically relevant anatomy, all participants valued small-group teaching within tutorials: “Clinical relevance is the most important thing when studying anatomy because it’s what cements it. You have to have a reason why you need to know it” (HP, Year C). However, some participants argued that clinical anatomy is just one aspect of anatomy, and although tutorials are good for studying clinically relevant material, they did not agree that they had a sound grasp of anatomy:

> The anatomy is very clinically oriented so it is very relevant. But it’s good to have a bit of the wet specimens as well otherwise you’d end up having holes in your knowledge. If the only thing you know about the perineal nerve is that it can be impinged at that spot, then you don’t know the rest of it or what else is going to happen. So you’re very well prepared for a common scenario and have absolutely no knowledge about anything else. That’s the problem with clinically oriented anatomy—It’s very helpful for most situations but it leaves you having no idea about large sections of anatomy which you will face at some point and you’ll have no clue. (HP, Intern).

Since the tutorials involved answering a set of questions, this was considered different to exploring the anatomy around those questions. As a high-performing participant in the final year stated: “Because it’s very directed and there’s lot of work to do, more people will google a quick answer but what you need is time to explore the body” (HP, Intern).

Additionally, the outcome of the tutorial depended on the tutor. Participants stated that some tutors would take over a session and showcase their knowledge with long PowerPoint presentations on the detailed anatomy of the region rather than allow students to discuss the questions and state the clinical significance and importance of the topic at hand. Tutors that had a clinical background were valued more highly than those who were pure scientists or anatomists.

Surface Anatomy

In the surface anatomy workshops, each group of students and their tutor gathered around the bedside in a simulated ward. One student volunteered to be drawn upon, examined and palpated for surface landmarks, and the others engaged in carrying out the tasks set out for that session. All participants indicated that surface anatomy teaching in Year A was valuable—especially when clinical tutors were involved. A high-performing participant in the final clinical year stated:

> I felt my Year A anatomy knowledge helped me in the clinical years…Felt confident with most things. Doctors were impressed when they asked me about landmarks. They love landmarks you know and rightly so, because it's how you can tell where you are without using imaging modalities. (HP, Year D)

Overall, the surface anatomy workshops were perceived as being very useful to learning anatomy. However, one of the pitfalls of these sessions was the issue of students volunteering as participants. A student in their intern year elaborated on this issue:

> The issue I had, that is, that it seemed that the same people would have to volunteer and everyone else would back off…You have to have a degree of trust and everyone has to just strip down to their undies and just do it...just get over that fear. I think that would have made everything a bit more worthwhile. Because, I think it makes it more interactive and then people are more likely to actually look at things...I think if you're expecting your patients to have that

> trust in you, then you should have that trust in your colleagues as well. I know it's very confronting but the more comfortable people are at doing it, the less the stigma and barrier is. (LP, Intern)

Osteology

These workshops involved students examining a set of bones as they relate to the region being covered that week (e.g., forearm, arm and hand bones during upper limb sessions) and identifying the different features of those bones. Most participants found the osteology workshops to be beneficial, but they also stated that too much time was allocated to these during the year, which resulted in students becoming disengaged with the tasks that subsequently seemed to be repetitive:

> We'd be looking at a bone from one limb and then next week, we'd be looking at a bone from a different limb. That's important because you have to know some of the anatomical landmarks but there's not that much difference between bones and it would have been better to learn more specific things that could be used clinically such as focusing a bit more on imaging. (HP, Year C)

Imaging

Imaging sessions in the Year A anatomy program were twofold. Students spent half an hour every week in imaging workshops led by tutors, where X-rays, CTs and MRI scans of different body regions were presented via an online anatomy program called An@tomedia. Occasionally, there would also be hard-copy X-ray images of real patients for students to mull over and discuss with a tutor. In addition, twice per semester, students were taught by a radiologist how to interpret imaging on the anatomy specimen days. There was a consensus among the participants that introducing imaging in Year A and learning how to take a systematic approach to interpretation was important and vital to providing students with a foundation for the later clinical years:

> I think a little bit of imaging is good. The earlier you see X-rays, CTs, even if not at an in-depth physician level, but looking at it, knowing how to take a systematic approach to it is good in Year A. So that when you are in the clinical years and you start seeing more general medicine, it allows you to recognise normal structures. (HP, Year D)

It was felt that these sessions were more beneficial when led by clinical tutors as opposed to non-clinical tutors. Three participants (two HPs and one LP) indicated a preference for more imaging sessions during Year A, with greater use of scans and X-rays of real patients as opposed to screenshots of images on An@tomedia. In contrast, one low-performing participant in the second clinical year indicated a dislike of the radiology sessions on the anatomy specimen days because the organisation of those sessions (one tutor for 20 students gathered around a small area in a large, noisy room) was not conducive to the overall learning experience.

7.1.2 Lectures

The importance of lectures emerged as another theme and an area in which improvements could be made within the Year A program. In general, there was a mixed reaction to participants' perceptions of the usefulness of lectures. Participants liked lectures when they were delivered by some individuals, but reported that they did not benefit much from lectures that were side-tracked, disorganised and/or haphazard in presentation. However, most participants attended lectures for the extra bit of clinical information they would receive from the lecturer, regardless of whether the presenter managed to deliver the entire scheduled lecture topic. In particular, lectures on the principles of anatomy were deemed to be the most useful, with one participant highlighting their significance in learning anatomy: "Principle lectures are quite good. If you know those, then without even having a really good understanding of everything in the body, you can go back to basic principles from the principle lectures. They're really good!" (HP, Year D)

7.1.3 Cadaveric Teaching

Cadaveric teaching forms an essential component of learning anatomy. All participants highlighted the importance of such a resource in the MBBS curriculum. However, similar to the arguments covered in the literature review, there was no clear response to the debate of dissection *v.* prosection, with participants noting advantages and disadvantages of both instructional pedagogies.

There were four anatomy specimen days in the Year A program during which students had exposure to cadavers. These consisted of six-hour-long days with a one-hour break. Although all participants found these sessions to be extremely useful to learning and remembering anatomy in Year A, the sessions were also considered long and overwhelming because of the sheer volume of information presented to students within a short timeframe. Nonetheless, being able to access human cadavers, appreciate the 3D anatomical structures and talk through the anatomy with visual reinforcement and with guidance from tutors and specialists was seen as a valuable opportunity and an excellent use of participants' time. Below are some excerpts from participants who highlighted the benefits of these sessions:

> Anatomy days were not useful for me in terms of learning all the facts but they were useful in getting an idea of the three-dimensional aspect of anatomy. (HP, Year B)
>
> Wet specimens make a huge difference to learning anatomy. Pictures don't really do it justice, you know. Being able to see where things go was really helpful. (LP, Year C)

> It’s all really neat and lovely in textbooks and things are exposed the way you want them to be exposed and they are colourful. But cadavers really make you think and allow you to explore. I find it really useful. (HP, Intern)

Dissection v. Prosection Debate

Participants were asked whether they had any prior dissection experience and about their thoughts regarding dissection versus prosection for learning anatomy. Although all participants knew the difference between the two forms of learning, only participants from a biomedical science background had performed cadaveric dissection during their undergraduate degree. Those from science backgrounds (e.g., zoology, pharmacy) had carried out dissection with animals (e.g., mice, rats), and the remaining participants had no dissection experience whatsoever.

The feedback from participants regarding the dissection *v*. prosection debate was mixed. Three participants wanted the opportunity to dissect and have access to prosected specimens. Four were in favour of dissection and five were in favour of prosection. The latter group felt that having a set of neatly prosected specimens and a tutor who could guide the student through each of the parts provided a better process for learning anatomy. Conversely, participants who preferred dissection as a teaching opportunity were in their second clinical year and stated that “the more you know about anatomy, the better you are at med” (LP, Year C). These participants also highlighted the difficulty associated with having such a resource made available to students and, in doing so, suggested that prosection was the next best teaching tool for learning anatomy:

> The first pre-clinical year is so heavy in content that I don’t think I’d be able to focus on dissections and really get into it. I don’t think the curriculum allows for

dissection in the first year. If we had it over 2 years, then dissection would be helpful. (LP, Year C)

Honestly, I would like to get my hands on a specimen to dissect but I think on a more pragmatic level involving the whole cohort, I think specimens would get butchered and it would be a real shame. I myself would be meticulous and careful with mine but I can't say the same for everyone. I think people would enjoy it but I think if they were to go without dissecting their own specimens, it wouldn't be a huge loss for them. I think prosection is great. Next to dissection, especially for a substantial sized cohort, prosection is more than sufficient. As a learning tool for a cohort, I think prosection is better. (HP, Year D)

The trouble is to do dissection you have to come so prepared. You have to really know what you're going to do and the reality is, no one does. And if you do a dissection when people aren't prepared, it's a waste of a cadaver. And then people don't get anything out of it…I don't think it'd be a bad thing. If it could happen, that'd be great. But my understanding is, it's a limited resource and…I don't know if there's going to be that much benefit gained by doing it. (HP, Year C)

In the first year, you need more time with the tutor using specimens [prosections]. Guided instructions from a tutor using wet specimens would be optimal. It's that discussion with the person with decades of experience—that's the important part. Because, in that, they cull out the extraneous parts that you just don't need to know. (LP, Year C)

One participant indicated that it was good to have either resource as opposed to none, but was unsure as to which would have provided a better learning experience, stating that "Prosections are good. Dissection is hard especially if you're doing it alone.

Not sure if one would be better than the other since we did not do dissection but having one option is better than having none at all" (LP, Year D).

7.1.4 Body Painting

Body painting occurred as a once-off activity during the anatomy specimen days. Given the rare occurrence of this teaching methodology, participants were asked about the usefulness of such an activity in the learning of anatomy.

During the body-painting sessions, students were tasked with working in groups of five or six to carry out different activities, which often consisted of mapping out the dermatomal patterns of innervation (i.e., painting the area of skin innervated by a particular spinal nerve). Within each group, one student had to volunteer to be painted on, one or two students were to take on the role as the 'painter' and the remaining students were to assist their group members to ensure accuracy of the tasks being carried out. Six of the 13 participants found body painting to be a fun exercise, two participants did not comment on body painting because they could not remember the activity and five found it not to be helpful in learning:

> Helped at the time with the dermatomes and painting and trying to figure out where it actually fits. But the trouble with that stuff is it's so hard to stick in your brain…the peripheral nerves and dermatomes are difficult topics to remember. At the time I did know it but at the moment I'd struggle…With body-painting, two people are doing it whereas the rest in the group are talking about what we're going to do after. (HP, Year C)

7.1.5 Teaching Resources

E-learning

Although there are many online tools for learning anatomy, such as Acland's DVD, Visible Body and Netter's images, An@tomedia was embedded within the Year

A anatomy program as a prescribed resource and made available to students at no additional cost. Therefore, it was a resource used by many, if not all, medical students.

An@tomedia is a “comprehensive, self-paced learning program that explores anatomy from four different perspectives. These perspectives teach you how the body is constructed (from regions and systems) and how you can deconstruct the body (with dissection and imaging techniques)” (An@tomedia, 9 March 2016).

All participants liked and used An@tomedia on a regular basis. It was found to be particularly useful for assisting students with the tutorial questions because all of the answers to the clinically oriented questions were contained within the program. Participants liked the illustrations and specimen pictures and the facility to obtain further information on a particular structure by clicking on various tabs within the program. One participant described his use of An@tomedia as:

> An@tomedia was very good when I was struggling to study. I would just go on and work through the modules and click on things. I liked An@tomedia because it would have little things…you click on it and ask ‘what’s this?’ and another box would open and it would explain something else in detail. So you could remind yourself about things and then go back to principles. (HP, Year C)

Textbooks

Textbooks were the main resource used to provide students—especially those without an anatomy background—with a basic framework of anatomical regions. The three most popular ones used among participants were *Clinically Oriented Anatomy* (Moore, Dalley, & Agur, 2009, 2013), *Gray’s Anatomy for Students* (Drake, Vogl, & Mitchell, 2010) and *Netter’s Clinical Anatomy* (Hansen, 2009). The first two were prescribed texts, whereas the latter was adopted for use by students. *Clinically Oriented*

Anatomy was used by half of the participants and was especially favoured over the rest because of its clinical focus. Netter's was used mainly for visual imagery.

Other resources made available to the students, such as the Anatomy Guide and Dissector manuals (created by the coordinator of the program), were not used as often in learning anatomy because the information contained in them was found to be overwhelming and simultaneously dry.

7.1.6 Assessment of Anatomy

Anatomy assessment in Year A involved students answering a set of MCQs and EMQs on five written examinations throughout the year. While participants found anatomy MCQs to be a good way of assessing knowledge, a recurrent pattern that emerged across participants' responses was that the anatomy questions should have included some sort of visual assessment, preferably along the lines of a spotter test with cadaveric specimens or a flag race to get students to learn the anatomical structure rather than just focusing on the clinical material:

> Anatomy questions were good. A good way to assess. It would be good to have a flag race type of exam. It would actually be quite a good way to assess it. It's much harder to identify. It'll be more challenging, plus you'd learn the anatomy better. (HP, Year B)
>
> Exam questions were mainly clinically relevant questions. Having progressed into the clinical years, those questions are sort of relevant as well. There's always the situation where you fall over and break your hand and it's your scaphoid bone but doctors will still sort of ask that stuff. So some of the anatomy has stuck. (LP, Year C)
>
> We just had written exams in Year A. Apart from that, you could have pins in cadavers which wouldn't be a bad thing to get you to learn that actual structure.

> It would force you to learn it rather than just learn the clinical stuff. There was a lot of anatomy in the exams. (HP, Year D)
>
> Having spotter tests where you would label a specimen or answer a question about this kind of area is the best way to assess anatomy. It would probably flesh out some people's skills a bit more than the written questions…You can get some people who are a bit more visual who are suddenly be able [sic] to do all this stuff and who would do well in a surgical or clinical situation but who might not be able to do well in written question. So it might be a useful way to examine. (HP, Intern)

In addition, one participant stated that if a written question was not worded correctly, it could alter the response of the participant to that particular question, and subsequently the purpose of the assessment: "MCQ or EMQ doesn't necessarily assess people's knowledge. It does assess recall but also, someone can get tripped up just by a play on words and not reading the question properly" (LP, Intern). It should be acknowledged that the converse could also be true—where the answer is obvious but the student does not know why it is correct.

Overall, participants found that the clinical content assessed in Year A anatomy examinations helped with their acquisition of clinical knowledge, and subsequently with the transition into the clinical years, where this material was constantly being assessed on the wards, thereby demonstrating the testing effect phenomenon (Larsen & Butler, 2013; Roediger, 2006).

7.2 Anatomy in the Clinical Years (Years B–D)

In this theme, participants' views and experiences of anatomy in the clinical setting are highlighted and presented along with their perceptions of the significance of anatomy within the different specialties.

Overall, anatomy was considered the framework that underpinned medicine in the clinical years, and participants felt that the anatomy covered in Year A—especially the clinical material from tutorials—was relevant because knowledge of such content was frequently encountered in hospitals: "More anatomy and clinical anatomy are really what you're tested on in the wards" (HP, Year C). Students acknowledged that their knowledge of anatomy from the pre-clinical year was not as strong in the clinical years. The primary reason for this decline in knowledge was the demands of the curriculum, time constraints and a lack of opportunities to formally revise anatomical knowledge.

In Year B, the main area of clinical exposure for most participants was around gastrointestinal, cardiovascular and respiratory systems, thereby requiring students to link their knowledge of anatomy with the relevant regions. Some participants encountered clinical situations in neurology, whereas others did not. During the year, students felt overwhelmed learning clinical conditions, their various presentations and how to interpret results to the point that revising or relearning anatomy in addition to this was considered too much. In fact, all participants indicated that the first clinical year (Year B), which was based primarily around medicine and surgery, involved learning about pathophysiology (i.e., diseases and management of conditions), and anatomy took a back seat within the large arena of information that students had to master, with students neglecting to revise their anatomy:

> You're looking more at disciplines in Year A [e.g., anatomy/physiology]. In Year B, the focus is more on diseases and management. That's probably why

> anatomy has been left behind. That being said, you still have to think about what's going on in a particular area and how that will affect nearby structures…So if you have pathology in the heart, if it's tamponade, what's that going to do to the surrounding structures? (HP, Year C)

In contrast, in the second clinical year (Year C), students rotated through four major disciplines: paediatrics, general practice, obstetrics and gynaecology, and psychiatry. During the year, participants stated that anatomy resurfaced primarily during general practice and obstetrics/gynaecology rotations, where knowledge of musculoskeletal and pelvic anatomy respectively were accorded much importance:

> I can't remember that we had to do much anatomy in Year B but in Year C, it came back to the pelvis with obstetrics/gynaecology and I just went back and had a look at it again. There's a lot of SDL especially for women's health because of the whole pelvic area. I remember going back to try and learn that (HP, Intern).

Little anatomy was needed during psychiatric rotations, whereas the paediatrics rotation required good knowledge of developmental anatomy, and this was seen to be lacking in the Year A anatomy curriculum. As one participant indicated, "For paediatric rotations in Year C, developmental anatomy was very important, which again was something I felt was a bit poor in terms of we didn't do it" (LP, Intern).

7.2.1 Importance of Anatomy in Medicine

Although anatomy was not specifically called to mind during most of the clinical years, as indicated by participants, it was still perceived by all participants as being important for medical practice. Participants further elaborated that medical students should have a good base of anatomical knowledge to be able to communicate appropriately with colleagues in the medical and health allied field, and to treat patients safely. As outlined below in excerpts of participants' comments in the clinical years, this view was held regardless of whether the participants were interested in surgery or radiology—two specialties that are highly dependent on excellent anatomical knowledge:

> Until you work in the Emergency Department and you see how fast they work, and you think, there's no time for stuffing around here. You've actually got to know what you're doing. So I now see the relevance and that's where your knowledge of anatomy is very relevant…Even if you're not a surgeon, you're a physician or a resident and if you are going to communicate…I need to be able to communicate to the person doing the surgery in a manner using their knowledge and using terms they understand and I know what they want to know. (LP, Year C)
>
> With any kind of emergency situation, any kind of injury or procedure, there's anatomy. In a physician setting, if you're such and such 'ologist', you probably not going to need it that much but that's so far down the track and there's so much of time where you're doing everything else and doing general jobs and being a GP or being in emergency. If you can't find a fracture, if you don't know what's endangered in a fracture, then… (HP, Year C)
>
> I think for certain specialties like surgery, anatomy is extremely important and in others it has little importance (for example, psychiatry). That being said, I think everyone still needs to have a good level of anatomy knowledge going through medical school and through the early years of internship and first couple of years of residency because everyone will be doing similar jobs…It's important,

> particularly as the intern, stuck there at night, by yourself, trying to call the surgeon about a patient…you need to be able to talk about the anatomy and to communicate and understand what might be underlying the presentation. So I think, at an early stage, everyone should be putting in a big emphasis on having at least the good basic level of anatomy. (HP, Year D)

In addition, participants indicated that the disciplines of physiology and pharmacology were equally important—particularly in the clinical setting, where interpretation of results involved possessing knowledge of these two discipline areas. "As a discipline, anatomy is more important to surgery, and physiology is more important to medicine" (HP, Year C). Some participants elaborated further on this:

> I think anatomy is very important for surgery or radiology. Some specialties really require good anatomy knowledge, but from my experience in the general medicine ward, anatomy is not really talked about. So in that case, it's physiology and pharmacology which are really important. It sort of depends where you are. (HP, Year B)

> In Year B, it's a lot of learning diseases and pathology, so physiology is getting more emphasised so there's more medicine and surgery this year. In fact, I'm revising physiology a lot more, and anatomy is not getting much coverage in my revision. (HP, Year B)

> If I was going to become a surgeon, I would think that anatomy would be the most important thing…I do think it's important that we have a basic understanding because we're treating the body but for me, something like physiology would be more important and pharmacology. That's because I'm interested in internal medicine. Anatomy is important if you're a surgeon, in

> ICU [intensive care unit], emergency. It's really important you have a basic knowledge of it. (HP, Year D)

When asked about career prospects, only three participants (two HPs and one LP) expressed an interest in the field of radiology or surgery, with the rest stating that the training, hours and lifestyle involved with the surgical and radiology specialties were deterrents. The other six high-performing participants opted for general practice or internal medicine as their first choice of specialisation because they were more interested in problem-solving, diagnoses, treatment and management of different medical issues within patients.

7.2.2 Surface Anatomy and Physical Examination

One area where all participants highlighted the use of anatomy in clinical practice was physical examination. Here, surface anatomy was regarded as paramount to performing clinical examinations because knowledge of this led to an appreciation of "what's under the surface" (HP, Year C) and an understanding of disease presentation: "If you're hearing this murmur here and if you can't think what valve it is, it doesn't really help…You need the background knowledge particularly when something's not right" (HP, Year D). Another participant referred to surface anatomy and physical examination as "bread and butter" (HP, Year D). As the participant further elaborated:

> I was used to looking at the human body in a book, all colour-coded. But to know where to palpate, it becomes really important when you're doing a lumbar puncture for example. Being able to clarify where ASIS [anterior superior iliac spine] is. How do I define this spot? How do I find it on an obese person? We need to know where it is, what it feels like and to be able to trust my assessment of where the landmark is. I think it's the most important part. (HP, Year D)

There is no doubt that surface anatomy and physical examination go hand in hand, and good knowledge of surface anatomy is extremely important in diagnosing and treating patients with confidence:

> Look at epigastric and upper abdominal pain. It's not just abdominal organs that could cause that pain. It could be vascular…could be the lungs. So if you don't have that underlying knowledge of how things are related to each other and nerve supply, and that kind of thing, then you won't think about the diagnoses that are possible. So I think it is important. (LP, Year D)
>
> A patient comes in with an undifferentiated illness and you're trying to figure out what could be going on—I think if you don't understand what's going on underneath and the relationship between organs, then you could potentially miss something. Or do unnecessary tests. (LP, Intern)

7.2.3 Anatomy and Imaging

Imaging was highlighted as being crucial in the day-to-day operation of medicine because it surfaced regularly throughout the clinical years and required very good knowledge of anatomy: "You've always got an X-ray, MRI or CT to look at and so you need to know what you're looking at" (LP, Year C).

All participants indicated that a good knowledge of anatomy was essential to interpret X-rays, CT and MRI scans, with most agreeing that imaging taught in Year A gave them a basic understanding and a systematic approach to understanding radiological scans:

> As Year B student, we're getting all the X-rays and CTs shoved in front of us and we're being asked about them. I think it's a perfect way to learn and

> reinforce and have a read. It's an easy opportunity to look at normal anatomy as well as pathology. (LP, Year B)
>
> Year A radiology was good in terms of getting basics done. How to read a chest X-ray, abdominal X-ray? How to present or systematically work through an X-ray and what are the things you're looking for? So you turn up to Year B and you don't feel like an idiot. (LP, Year C)
>
> The earlier you see X-rays, CTs, even if not at an in-depth physician level, but looking at it, knowing how to take a systematic approach to it is good in Year A. So that when you are in the clinical years and you start seeing more general medicine, it allows you to recognise normal structures. (HP, Year D)
>
> Radiology extends on anatomy. Depends on whether you had registrars or consultants who went through things with you with the scan as part of the teaching. But you have to know the basics before, otherwise you'd be lost. (LP, Intern)

Some participants indicated that the sessions could have been better organised, and more in-depth teaching on complex imaging such as CT scans that related to the clinical teaching for the week would have been more beneficial.

7.2.4 Anatomy in Surgery and Procedures

Another specialty where anatomical knowledge was listed as crucial was surgery: "Surgery reminds me a lot of the dissections. It doesn't look like it does in a textbook so you have to really think about anatomical landmarks and know where things run to get you back in perspective" (HP, Year C). Students spent a portion of their first clinical year (Year B) being exposed to surgery, and all participants indicated that this was when their anatomy knowledge was tested. Consequently, students gave anatomy much more importance during surgical rotations: “Only if I was in theatre when I’m being quizzed that I thought anatomy was important. It wasn’t too important on the wards. Looking back, it would have been useful for me and I should have done more” (HP, Year C). Some participants attempted to revise specific anatomy knowledge (dependent on the surgical procedure) ahead of time to avoid embarrassment in theatre:

> I would try to prepare before going in for surgery because you know you’d have to sit in a corner and the surgeon would ask you questions and you don’t want to look foolish. I learned that…to try and prepare. And it’s the only way you remember it—if you answer a question wrong, and you look like a fool, you’ll always remember it and if you see it, you’ll remember it as well. (HP, Year D)

In addition, the range of surgical experience that medical students had was highly varied. Across the board, students spent the most amount of time in theatre, mainly observing a range of general gastrointestinal (GI) surgeries such as hernias, colonoscopies, appendicitis and cholecystitis. Others had the opportunity to be involved with plastics procedures (e.g., hand injury, lacerations and skin repairs), orthopaedic surgeries (e.g., hip and knee replacements) and thyroid surgeries, although opportunities to go into theatre were site-dependent, with some students not as fortunate as others.

Further, many of the GI surgeries that were observed took place under laparoscopic conditions, and one participant highlighted this as a problem for students whose knowledge of anatomy had not previously been learned, let alone tested under such conditions:

> In Year B, we had a reasonable amount of general surgery. A lot of it was laparoscopic and again you’re just watching the screen and it’s just like…‘that’s the cystic artery’…and I’m like, ‘is it’? It’s really, really difficult on the screens

to pick up your anatomy. And it's the same with colonoscopies and you're not picking up anything and most people aren't engaged there. (HP, Year C)

If I didn't know an answer and I was put on the spot, I'll try and stall by talking through it to try and get the answer. This happened not uncommonly in obs and gynae when they were doing laparoscopic procedures. Everything is blown up with carbon dioxide, you're not sure what you're looking at inside, the camera is turned upside down and you don't know what's going on and they ask what's this here and there. So I'd talk through it—saying its medial to the ovary, round ligament etc. So sometimes I'd get it, and sometimes not. (LP, Year C)

7.3 Issues Surrounding Learning and Retention of Anatomical Knowledge

This section presents participants' perceptions of the challenges faced during the Year A program and in the clinical years. Some of the major subthemes emerging from the interviews concerned the structure of the pre-clinical and clinical MBBS program and its effect on students' experiences within the wards and on their retention of anatomy knowledge.

7.3.1 Learning Anatomy in a Time-constrained Curriculum

Students can employ many different approaches towards learning, such as: the surface approach, which involves rote learning and memorisation; the deep approach, which involves developing an understanding of the content to apply that information in a variety of different situations; and the strategic approach, which involves adopting a combination of the two approaches as per the goals of the student at the time (i.e., to pass an examination or to learn and remember the content for future use).

Year A Program

One of the biggest challenges faced in Year A by participants was learning anatomy within the time-constrained and condensed curriculum of the Year A program. Given that students covered all of the basic science disciplines (e.g., anatomy, physiology, pharmacology, immunology), along with law, ethics, population health, health and society, and clinical skills in 36 weeks, many found the pace of the curriculum to be extremely overwhelming. As some participants stated:

> Found the whole year quite challenging and confronting academically because it’s just a completely different learning style…So Year A as a whole was just a shock to the system in the change of learning style and having so many subjects to learn simultaneously. (LP, Year B)
>
> One of the reasons I haven’t retained as much was because anatomy in Year A was a lot and was very fast-paced. So I’ve learnt it maybe a bit superficially to be on top of the next tutorial and learning it for exams. (LP, Year C)
>
> The volume of information was overwhelming that I said it’s too much, I’ll look at it another time and that time never came… (LP, Year D)
>
> What needed to be covered and what ended up getting remembered is different. There’s a lot to learn in a year and it technically was covered but whether enough time was spent for it to sink it, I’m not sure. I think most people ended up cramming for exams or just quickly doing their homework before a class. Yes I’d done the work but it hadn’t actually sunk in. All my friends struggled in Year B when we started our pathology classes because not all of the lessons had sunk in just due to limitation of time. (HP, Intern)

When interviewing the HPs and LPs across the four cohorts, there was no distinct pattern of learning between the two groups. Most participants stated that the key to learning anatomy was to understand the content. Although students had good intentions for wanting to adopt deeper approaches to learning, the sheer volume of information and time pressures meant that the process of learning and retaining information became one that was primarily geared towards meeting assessment goals (i.e., to pass examinations). For some students, this translated to devoting more time to memorisation. As one participant stated, “I’m not good at memorising stuff. When I study, I need to understand the content otherwise I’m never going to remember it. Closer to exam time, when you’re trying to shove stuff in, I was memorising” (LP, Year C). For others, the focus shifted towards the tutorial questions, which were found to be highly assessed during examinations:

> Tutorials were very good for learning clinical anatomy. Studied for exams based on tutorials but don’t feel my grasp of anatomy is fantastic based on that. (LP, Intern)
>
> Tutorials were good, very clinical and relevant but was too quick so I started forgetting stuff I’d done in previous weeks. So much to cover that you go through it quickly and fingers crossed, you get through the exams… (LP, Year D)

Therefore, participants—especially those without a science background—became strategic in how they approached learning; that is, they primarily focused on the relevant content that was assessed during examinations. In Year A, students isolate what is assessed quite quickly following the first mid-semester examination because they identify the majority of Year A examination questions to be based on clinically oriented anatomy as presented in the tutorial questions. Consequently, the approach that most students adopt in preparation for assessments involves a combination of both surface and deep approaches: “Had to work really hard because I didn’t have a science background. Focused on clinical material given the volume of information that was there and let other things fall to the side” (HP, Year D).

Clinical Years

In the clinical years, the emphasis of the curriculum on disease processes and management within the different specialties forced students to prioritise other aspects of medicine over learning or revising discipline-specific subjects such as anatomy:

> Year B is all about diseases and you need to have a basic framework—is it common? Not common? What’s the pathophysiology? How do you treat it? And you open up so much that you just don’t have time. I know anatomy is not that useful to me right now in Year B that I’m going to forego it to get a basic clinical perspective. (HP, Year C)

Another participant stated that “Year B is more about pathophysiology. That’s by far the thing we get questioned on the most—about disease states and management for those disease states” (LP, Year B). Consequently, priorities over what areas were focused on shifted from learning about normal form and function to abnormal form and function.

To be able to retain anatomy, there should be an opportunity to learn or revise it. When asked if students had revised anatomy learned in Year A during the clinical years, most participants said they did not because Year B was overwhelming and there was so much to learn that there was not enough time to do so. Some participants described revising specific anatomy while on a specific rotation, and particularly during Year C in preparation for the VIA examination. One high-performing participant in her intern year talked about her experience during the clinical years: “For my ENT [Ear, Nose and Throat] rotation, they were doing mastoidectomies so that’s when I looked at the facial nerves and its roots but prior to that, I didn’t really care”. Similarly, another LP who was in their intern year said that he had only revised during surgical rotations, but that there was “nothing regular and formal enough”.

7.3.2 Site-dependent Opportunities for Learning and Revising Anatomy

Participants stated that there was no formal teaching of anatomy in the clinical years. Instead, the opportunity for revising anatomy usually arose during surgical rotations. Depending on the site and the tutor, some students had informal anatomy teaching; that is, anatomy was briefly covered in relation to the topic under discussion (e.g., cardiovascular case) as part of bedside or surgical tutorials:

> There’s been a bit of radiology that’s specific and there’s been surgical, more condition-based integrated anatomy, not pure anatomy. For example, there’ll be a condition and they’ll talk about appendicitis. There’ll be lots of surgical tutes. Mostly done GI. It’s not pure anatomy teaching…It’s more passive physiology with a necessary underpinning of some anatomy. (HP, Year B)

> The surgical tutes run in such a way that we present a case to the general surgeon and then he sort of picks it apart, then questions us. It’s really good but you know there might only be a couple of questions on anatomy. We might present a case on a partial thyroidectomy and there might only be one question about the nerve passing by near the thyroid and maybe a quick question on arterial supply and that might be it…That could be the only thing on anatomy we are asked for the whole week. (LP, Year B)

> In Year B, received some surgical tutes from a retired surgeon and from practicing surgeons. They would go over some anatomy with us. The tutes were

on topics like hernias or something like that. That was probably the last time I had actual teaching. No lecture theatre sort of tutes. (HP, Intern)

Further, the opportunity to observe or be involved in surgery or any surgical procedure was also highly site-dependent. Participants based in rural locations had more prospects of being involved and engaged in a variety of surgical procedures because there were fewer medical students at these sites. Conversely, students in metropolitan hospitals were often compelled to compete with their peers and with students from other universities; thus, because of the high student numbers at these sites, there were limited opportunities to participate in surgical procedures:

> GP placements in rural areas were good because I got to do things like suturing and joint aspirations, steroid injections (things metro students don’t get). That prompted me to revise a lot of anatomy as well…Even things like wedge resections which metro hospitals did in theatre under general anaesthesia, we would do in the treatment rooms with a ring block. (HP, Year D)
>
> Did anatomy in country so had a lot more clinical exposure to metro students. Metro students did two cannulas whereas we’d do countless and we’d suture in third year itself. (HP, Year D)
>
> At the site we were at, students that went through there didn’t get a rotation in every area…Because of where I was, I didn’t get into respiratory and other cardiovascular areas. (HP, Year C)
>
> Did a lot of GI, colonoscopies, laparoscopies, hernias. Some skin stuff. There wasn’t any orthopaedics…I saw one carpal tunnel release and I didn’t get thoracic surgery opportunities in the country. (LP, Year C)

One Year D participant who was in their intern year also discussed the lack of opportunities available to learn procedures in hospital: “The only procedures were in the GP office when I had the opportunity for someone to teach me corticosteroid injection, joint aspiration, sutures. But that was someone taking the time to do that with me” (HP, Intern).

As a result of the lack of formal anatomy teaching and site-dependent opportunities to learn and revise anatomy, most participants felt that their retention of anatomical knowledge in the clinical years had declined compared with when they were Year A students. Below are some of the statements from participants expressing their views on their retention of anatomy in the clinical years:

> I think it’s definitely decreased overall. That’s just because I haven’t really used a lot of it so far this year. But yeah, again I’ve learnt a few new things, but overall I think I’ve probably forgotten more than I remembered, (HP, Year B)
>
> Nowhere near as good as last year, which is quite concerning because last year it wasn’t that good. (LP, Year B)
>
> Nowhere near as good as it was. Different things I know better—the more clinical stuff you’re seeing all the time. If someone was to give me a quiz on anatomy, I don’t think I’d remember half as much. It’s mainly because you’re not using it. (HP, Year D)
>
> I think I have a better understanding but I don’t think I’ve progressed really well. I could get by but I don’t think it’s good enough. (LP, Year D)

One high-performing participant in the clinical year said his anatomy knowledge had improved because of his interest in anatomy and surgery as a specialty:

> Gotten better. Although the intricacies of upper, lower limb and pelvis, all the nitty gritty stuff might have escaped me by now, they're not out of my reach. A glance back at my notes and I'd have it in the front of my brain again. I still remember a lot of it and I've got knowledge from things that I've learnt along the way. (HP, Year D)

7.3.3 Inconsistent Delivery of Curriculum Among Teaching Staff

In relation to the clinical educators, the lack of consistency in curriculum delivery between different small-group sessions and across the different clinical sites caused frustration among students. Participants said that educators who were tasked with the responsibility of imparting knowledge to students taught and emphasised what they thought was important as opposed to what was mandated or specified by the curriculum. In addition, their expectations of students were exceedingly high given the time-constrained and condensed curriculum. This led to confusion among students regarding what knowledge they needed to learn and retain. Many stated that the outcome of the tutorials depended on the tutor:

> In Year A, found tutorials difficult. Not because of the questions but because of the ego. When students were presenting there was a lot of ego. The questions were set up around the clinical framework but then a tutor would do this PowerPoint and it would have so much extraneous detail in it and I just didn't know what was important and what was relevant from the 60-page slide. Some tutors say you need to know it all, others say focus on relevant topics only. In Year A, you have no idea what's relevant or not. I was frustrated trying to sort the important from the non-important. (LP, Year C)

> At one hospital, you get to see good things but it's at the highest level - the teaching. Sometimes we don't know what they're talking about (this was in

> Year B), whereas at another site, Year B was really good. They were more specific to exam-oriented questions. The topics they covered were specific areas that popped up on exams…Problem with clinical years and sites is that the stuff you learn depends on the doctors at the sites. They wouldn't necessarily know what should be taught or what sort of questions should be asked. Some assume you know these things so they just teach you what things are appropriate on the day. (LP, Year D)

> People at different clinical sites got different amounts of teaching. Bedside tutes were very variable depending on the site but also formal teaching on the teaching days was very variable depending on the site. (LP, Intern)

7.3.4 Attitudes of Teaching Staff Towards Students and the Effect on Learning and Retention of Knowledge

Although participants highly valued sessions with staff who were enthusiastic and passionate about teaching, it quickly became evident that tutors, clinicians and consultants both in the pre-clinical and clinical years played a significant role in influencing students' perceptions, interest in and learning of anatomy:

> If you've got someone who is an enthusiastic lecturer or teacher, you know it's going to be much more efficient use of your time and you're going to get much more out of the experience with the lecturer rather than doing it all yourself. (HP, Year B)

> Surgeon was great and inclusive. Gets you to scrub in, see thymic tissue, touch the heart, lung resections, mediastinal tumours. That was the best anatomy. That was more of a reflection of him as a person wanting to teach and get involved. (HP, Year C)

> Last year, I did oncology stuff at two hospitals and they were both very good at teaching. Lots of time, seemed sort of relaxed. So that made a lot of difference. And that was mainly based on the people I was working with. It's not because I had a particular interest. (HP, Year C)

Tutors, clinicians and consultants who taught via a process of exclusion—that is, those who barraged students with specific and detailed questions until they got one wrong—left students feeling demoralised and demotivated to learn, as highlighted by a participant in the second clinical year:

> When you're in the wards and in surgery, having someone put you down can be a de-motivational thing. Yes, you should be criticised if you don't know but some doctors put it well than others. When some people say you need to know it, it motivates you to go and look at it. But when some people say something in the way they do, it is demoralising. (LP, Year D)

In the clinical years, participants indicated that this type of teaching mostly occurred during surgical rotations. One participant stated that "surgeons do ask questions but you're never going to know everything and literally they will keep asking you questions until they get to the one you don't know" (LP, Year C). Another declared that "surgeons are strange in that they ask you questions that I would say are not relevant" (HP, Intern).

One of the high-performing participants was emphatic in describing his Year B surgical experience as one that was dreadful and that put him off learning during that year:

My first surgery rotation—'describe to me the brachial plexus and draw it for me, trace out the radial artery'. The surgeon was horrendous. He just wanted to show that he was top dog. They also want you to have it at such a level that you can call on it in an emergency. Some surgeons do that embarrassing thing to you so it cements it I think. There is a good intention behind their questions. But some surgeons would keep asking questions until I got one wrong and then went. Ha!, whereas the physicians would be like…'Do you know this?...No? Okay, I'll teach you that'. (HP, Year C)

The participant further stated that:

In Year B, the surgery there was old school with the embarrassments and those sorts of things. You get a bit defensive. So you kind of just avoid going to theatre and things like that…It's the intense level of grilling and interrogating your knowledge of it in a setting where there's heaps of other people and everyone's quiet…and surgical registrars have just had anatomy exams and then they go like…'oh really, you don't know this?'…They ask questions in very odd language. Like the other day, someone asked me: How many components is there of the rectus abdominus…and I was like…Does he mean between the tendinous intersections or does he mean the two muscles? So I think, I said ten and then they're like…'Oh my god, oh my god…Monash, Typical Monash…No…no…there's 2!' and I'm like well, if you asked it properly…And you're a bit off, not feeling too confident then…And some of them do it quite nastily…Someone would ask me to describe this fracture…and as I'm doing it…they'd go…'oh you're killing us'…And then the surgeon would just disregard me for the rest of the day…and the whole rotation, they wouldn't take me seriously after that…if people are exclusive and embarrassing you, then it

> puts you off learning. But the physicians are nice and I'm getting things right and they're more inclusive. They'll say…'Oh come and have a look at this'…and you're like, that's really interesting…I'm going to go read about that because I want to know more next time. It's the approach that people take that sometimes puts the students off. I think the surgeons - their theory is, weed the strong from the weak. Some have good intentions and want you to be strong in your anatomy, some are just insecure and want to belittle others…I don't think it's just to surgery…I think there are certain surgeons and certain people that like to do that…And it absolutely puts you off from learning. It did for me for a year. (HP, Year C)

While some of the accounts of interactions with the teaching staff were negative, some participants described having good experiences while on the wards:

> Some surgeons can be tough but it's probably coz they're busy doing what they're doing and there's time constraints. But usually if there's a bit of time in between patients and if you show a bit of interest, most people are generally nice. (HP, Year C)
>
> I don't feel like I ever got drilled in a way medical students supposedly get drilled. I would ask a registrar if I had any questions and it was more of a discussion around it. (HP, Year D)

Most participants indicated that surgeons in general always felt that students' knowledge of anatomy was lacking, although participants disagreed with this notion, stating that their knowledge, while not the best, was sufficient to get around the wards:

When compared with the undergraduate members of the cohort, I think our anatomy knowledge is more clinically orientated, so that's very beneficial. But then when we do have a surgeon asking us some anatomy questions that aren't necessarily clinically oriented…like 'can you tell me about this structure' or things like that, I would say my knowledge is probably lacking still…We have a relatively good grasp of anatomy if it's directly related to some sort of pathology but if it's more pure anatomy, we probably struggle. (LP, Year B)

You always come across a situation when people tell you you don't know enough anatomy. In surgery…ahhh…They've said…You don't know anything these days…we used to know every single branch of the external carotid artery…and it's just old blokes talking crap…It's a comparison of what they learnt *v*. what we learnt…It's more in surgery that we get these comments…But I think for the most part, all the physician stuff and that side of things, Monash students are pretty well fared I think…So their assumptions that we don't know anything is unrealistic…Most of the time you get these comments you don't know any anatomy…is when you're looking at the screen and they've got a mask on so you can't hear them half of the time and they're just like…'what's this?'…We've not studied it through a camera. (HP, Year C)

Although you don't know much at a Year B level, basic things like 'what's this nerve?' or 'how can you tell large from small bowel'—the things you learnt in Year A allow you to answer questions at a level of a third-year student quite sufficiently. (LP, Year C)

I think sometimes junior doctors in medical schools are sometimes ridiculed for their lack of anatomy knowledge or teaching. I've seen certain things in the paper and online that young doctors don't know this and that about anatomy. I think that's not really representative of at least what's being taught at Monash. (HP, Year D)

One high-performing participant in the clinical year from a non-science background acknowledged the limitations of knowledge as a medical student and noted that true learning comes with time and experience:

> I feel like I'm still learning. I don't think you really hit your stride until you're in it all day, everyday and you're actually working within the field. But definitely, if I was to see myself from Year A as I am now, I'd be very surprised, I never thought I'd get to here. I never thought I'd be able to understand all the different words. I couldn't understand Year A, why they use different terminology and now I understand it. Because you can get things done quicker. (HP, Year D)

7.3.5 Lack of Vertical Integration

Participants recognised the importance of a spiral curriculum in helping them to retain anatomical knowledge. When asked about the areas of anatomy students were lacking in and the areas where they were more confident, a pattern seemed to emerge from participants' responses. Overall, most, though not all, participants felt that their knowledge of musculoskeletal (limbs), neuroanatomy (head and neck) and pelvic anatomy was not as great as in Year A, whereas knowledge of abdomen and thoracic anatomy was much better. When probed further, they claimed that their retention of knowledge was much better in areas where they had frequent clinical exposure: "the knowledge that I've used has remained in my brain and whatever I've not used has been left behind" (LP, Year C), as this presented an opportunity to revise their anatomy and refresh their memory, as indicated below by participants in the clinical years:

> The things I've done more often over the past three years, they come to my mind easier…Spent a lot more time on Abdo and thorax in Year A and it got reinforced in clinical years doing GI and Cardio rotations. Especially in Year B. (HP, Year D)
>
> Neuroanatomy stuck pretty well but that was probably because it was such a good clinical correlation to it that you can map and think of territories and symptoms to match it and we had a lot of stroke cases last year [Year B] and really good teaching. (HP, Year C)

In contrast, participants attributed their lack of knowledge in some regional anatomy areas to not learning it properly in Year A: "Probably because it's been two years since we learnt the pelvis and I hadn't thought about it. Also I didn't really understand the pelvis in Year A" (HP, Year D). Lack of vertical integration (sufficient exposure to region-specific cases) in the clinical years was also cited as a reason for loss of retention. As one participant stated, "there's so much to know and there's no reinforcing in Year B and C. You're so busy with other stuff so you forget it. I know that I have to revise my anatomy" (LP, Year D).

Below are excerpts from participants regarding the issue of vertical integration and retention:

> I feel like I'm already forgetting a lot of it, but you don't get as much exposure. Forgotten a lot of details like all the nerves in the brachial plexus…I think I learnt it. Well, musculoskeletal was difficult to learn I think in the first place. Pelvis I know I learnt, but both of these this year, I've sort of forgotten because I haven't been exposed to them that much this year…The things I do remember

are thorax and abdomen because you get a lot of exposure to that this year [B] in medicine. (HP, Year B)

Anatomy is a use it or lose it sort of science. You don't see a lot of patients. If I was on ortho rotation for 6 months and saw lots of fractures every day, then yeah I would remember radial nerve and that it's endangered in the spiral groove. (HP, Year C)

Didn't learn it properly the first time. And it's because the Year A teaching was overwhelming and the quality of neuroanatomy was so detailed that it put me off. In reality, the only time you use anatomy is when you're looking at it. In Year B, I didn't have much experience or exposure to musculoskeletal…The thing is, it's not hard. It's just the teaching and of course I let myself get scared with the sheer volume of information. (LP, Year C)

I never learnt it properly the first time. It's hard when you have such a short amount of time. I'm much more comfortable with abdomen, head and limbs. And the pelvis, I got very comfortable during my women's rotations. Also, my big problem with neck and pelvis would have been overcome had I been able to explore the anatomy. I don't have very good spatial imagination. So when someone's telling you in a lecture, the trigone of the bladder, I can't imagine it and you can't even work it out from a 2D picture. So when you're trying to gain an understanding of a very three-dimensional structure, you struggle if those are the only tools you'd be given. Exposure facilitates the learning. (HP, Intern)

To summary, "if you don't use it, you don't remember, regardless of whether it's anatomy, pharmacology etc. You need to go over it" (HP, Year D). Therefore, according to the participants, constant reinforcement and revision of content helps with retention of knowledge.

7.4 Recommendations Offered by Students for Better Learning and Retention of Anatomy

This section presents participants' views on how anatomy teaching and learning can be improved. The students were enthusiastic about the idea of an anatomy refresher course and discussed the possibility of implementing a standardised curriculum with some form of consistent teaching during both the pre-clinical and clinical years.

7.4.1 Anatomy Refresher Course

When asked if there should be some form of anatomy revision, all participants were in favour of having an anatomy refresher course introduced at some point during the clinical years. One participant in the final clinical year stated that "I think it's a must, especially for graduate-entry students who haven't had the background in anatomy" (LP, Year D).

Although opinions differed among participants as to when the refresher course could be offered, most thought that it would be beneficial if it was integrated into the clinical years and specific to the rotation that the student was in at the time. Participants also suggested that the course be conducted online and consist of a clinical framework:

> I would have found that useful. Like when we did your quiz, I was like…Damn…there's all this stuff I've forgotten…It's kind of prompted me just to flick through and bring it back. Little prompts. That's the key with anatomy. It just prompts to study it again because the prompts you get in the clinical years is when you're caught out. (HP, Year C)

> I think it would be excellent. As for Year C, the anatomy knowledge starts sliding away and if I don't do it now, it's fading because I don't use it everyday, it's very easy to forget. (LP, Year C)
>
> Maybe we do need a bit more formal teaching as we go through the clinical years because that's when it's useful and that's when I've forgotten it. (LP, Year C)

One participant did not think an anatomy refresher course was necessary, but acknowledged that it would be beneficial for students who do not have the opportunity to revise anatomy at clinical sites:

> Perhaps…Don't feel it needs to be retaught because the opportunities are there to learn it again. It's based on what opportunities you have and what clinical environment you're at and who your supervisors are. So it's a hit and miss and some people might miss out on it. (HP, Intern)

Although it would be logistically difficult to run a face-to-face revision day, two participants in their intern year suggested that having anatomy specimen days that incorporated procedures would be extremely valuable because it would be an opportunity for them to refresh their memory of anatomical structures and to practice clinical procedures on cadavers in a supervised setting, since learning through such opportunities in the clinical environment is rare:

> Some revision on procedures…like chest tubes, would be good…I think practicing on cadavers would be great because if an opportunity arises, you can feel confident that you'll know what you want to do…And it'll be formalised

> teaching rather than your being someone who's lucky enough that someone's actually taught you in a sensible manner about the procedure. (HP, Intern)
>
> Procedural days would be useful as you don't do pleural taps or lumbar punctures unless you're really really lucky and someone's got the time to sit with you and do it. Some people graduate with having one or two of those experiences or none at all. There were plenty of opportunities for me to put in a central venous line in final year but I never did it because the patients were sick and it wasn't a good time to learn. But if I had done it before and had basic amount of confidence that someone could supervise me doing it, I would have said yes and would have been able to do it. (HP, Intern)

7.4.2 Curriculum Changes and Consistent Delivery

Participants also suggested that Year A anatomy teaching could be better improved by having fewer didactic lectures, more clinically relevant teaching, more imaging sessions using real patient scans and more exposure to anatomy wet specimens and cadavers.

One low-performing participant in the first clinical year who did not have an anatomy background stated that a peer-assisted study session could be beneficial for students who were struggling in anatomy because "it's not a great idea to teach someone anatomy in one year".

Participants also stated that there should be more stability in teaching in relation to the delivery of the curriculum, and that sessions should be structured so there is consistency among tutors in what is being delivered. This reduces confusion among students across the various groups and different clinical sites:

> In the clinical years, I don't think there was a particular curriculum that all schools had to meet. I think that's important because if you're at one school and

> they're not teaching things properly or teaching what's meant to be covered…I know at the end of Year B, everyone has to pass the same test, so you know, that's the measuring bar. I still feel like the radiology thing is a hit and miss. And it depends on…we had quite good bedside tutors who would sit down and show us what you see on this X-rays but that was not really up to the school but if you were fortunate enough to be there…So it's highly variable. (HP, Year C)
>
> It would be good to incorporate some anatomy as part of the clinical curriculum. I don't know if doctors get a template of the things that need to be taught but it would be good to have some consistency across the sites. I did find that it depends on which hospital you are, you get taught differently. (LP, Year D)

However, the onus also falls on the student to take responsibility for their learning. One participant in the second clinical year stated that:

> Any deficiencies you see with the anatomy, they weren't all curriculum based. I take responsibility for 60% of it because learning is a two-way street. Yes, you can provide all the water for the horse but you can't make the horse drink. If I was using what I use now in anatomy, developing a skeleton, a framework, I'd be good. (LP, Year C)
>
> I think students need to be made aware that it (anatomy) is more important for everyone and that everyone should be putting in a bigger effort to learn things because everyone's going to need to apply it during intern and residency years. Everyone will need to know it for everything, whether you're going to be on the medical rotation, surgical rotation, ED or GP rotation. (LP, Intern)

The qualitative findings presented in this chapter provide insights into the unanswered questions from the quantitative data analysis, and they shed light on the key issues identified at the beginning of this chapter.

- The majority of the participants were satisfied with the teaching of the Year A Anatomy program, and given the condensed nature of the curriculum, recognised that not much else could have been compressed into the anatomy curriculum.
- Tutorials were recognised as the most useful for learning given their clear clinical relevance. This aided in students' learning of anatomy and contextualisation of knowledge both within the pre-clinical and clinical years.
- Participants would have liked to have had more formal exposure to imaging teaching sessions in the pre-clinical and clinical years as this was often encountered on the wards.
- The use of cadaveric prosected specimens was considered useful for participants in helping them visualise the anatomical structures.
- Textbooks were also valued for their clinical relevance and for providing a basic framework to approach the learning of anatomy.
- The medical curriculum in the clinical years put greater emphasis on learning disease processes, their management and treatment and these detracted students from devoting specific time to learning and/or revising anatomy.
- Anatomy was considered important for being a doctor but participants stated that depending on the speciality, anatomy was more or less important. That is, detailed anatomical knowledge was more relevant to surgery and Emergency Medicine, whereas physiology and pharmacology were more relevant to internal medicine.
- Participants agreed that knowledge of anatomy was not as good as it was in the preclinical year. For some, it was better due to a vested interest in a specialty field

requiring anatomical knowledge. For others, it was worse due to lack of time in revising anatomy.

- Knowledge of anatomy was better in areas that afforded the greatest clinical exposure (gastrointestinal, cardiovascular, respiratory etc.) as compared to areas that afforded the least clinical exposure (back and neurological cases)
- In the clinical years, participants had differing amounts of exposure to anatomy with some fortunate enough to experience formal teaching sessions and others not having any exposure to certain regional anatomy. This led to participants' view that some sites had better teaching opportunities than others and the perception that there was inconsistency in the delivery of the curriculum and a lack of vertical integration of content across the four years of the MBBS.
- Most participants agreed that an anatomy refresher course offered at some point within the clinical years or prior to the start of every rotation would be beneficial to having participants revise and/or build upon their knowledge of anatomy.

The results from both phases of this research are combined and discussed in detail in the next chapter.

Chapter 8: Discussion

This chapter begins with an overview of the research questions and methodology and is followed by the presentation of the overall findings from the formative anatomy assessment, which provides the framework for the discussion that ensues. The results of the three research questions are presented and discussed as they pertain to the existing literature. The following questions are addressed using a cross-sectional approach: How does anatomy knowledge differ among students in the pre-clinical and clinical years of the MBBS course? To what extent do medical students retain anatomy knowledge? What factors may account for the loss or retention of anatomy knowledge across a student's medical degree?

The discussion continues by exploring the factors that participants believe help them learn and retain anatomy, and the factors that have affected retention—particularly in the clinical years. The significance of this study and its relevance to anatomy education and assessment is outlined, and potential limitations are acknowledged.

8.1 Introduction

8.1.1 Overview of the Research

Changes in curriculum models, teaching methodologies and time allocation over the past few decades have highlighted concerns regarding the retention of anatomy teaching. Most recent literature findings have reported students to be deficient in their knowledge of anatomy (Brunk et al., 2017; Estai & Bunt, 2016; Jurjus et al., 2014; Bergman et al, 2011; Custers et al., 2011; Cottam,1999; Feigin et al., 2002; Speilmann & Oliver, 2005). It is not clear whether anatomy is being taught inappropriately, whether sufficient time is being committed to teaching, whether students fail to learn or whether they forget what they have previously learned. In response to these concerns, this study explored anatomy learning and retention among graduate-entry medical students, as well as the strengths and weaknesses of the anatomy curriculum and the delivery model as it existed in the Monash MBBS program between 2011 and 2014, since this offered a unique snapshot of the implementation of a curriculum model across an entire cohort. In particular, this study aims to gain insights into the level of anatomy knowledge that medical students possessed during their training to become doctors.

Four cohorts of students from the pre-clinical to the clinical years of a four-year graduate-entry MBBS program were approached for voluntary participation in the study. All participants from the four cohorts were exposed to the same anatomy curriculum and teaching methods in the pre-clinical year, with no formal anatomy teaching scheduled in the subsequent years, thereby allowing for a comparison across cohorts.

To answer the research questions, a mixed-methods design was selected for the study because the combination of both quantitative and qualitative methods allowed the research team to use both post-positivist and constructivist views to develop deep insights into the phenomenon of anatomy knowledge acquisition and retention (Venkatesh et al., 2013). Through principles of triangulation, complementarity, development, initiation and expansion, data obtained through quantitative analysis provided answers to the first two research questions in terms of students' anatomical knowledge and retention, while also helping to shape the formulation of the second phase. Data from the qualitative analysis provided many insights into the third research question because they helped to illuminate the findings from the quantitative data analysis and offered possible explanations for students' retention of anatomy. Additionally, participants were asked to give their views on anatomy teaching, including their experiences of teaching in the pre-clinical year and clinical years; how adequate the anatomy teaching hours and methods were in the pre-clinical year; and what areas of the program were successful (or not) and where improvements could be made in the training of future doctors. This provided useful insights into how and why students learn anatomy, why they have difficulty retaining knowledge and how they think learning could be optimised, retained and expanded. All results obtained from the mixed-methods design will be combined and explored in this chapter.

A total of 138 students participated out of 341 total students from four cohorts. Although this response rate (41%) is reasonable, a variety of factors, such as motivation, increasing demands of the curriculum on students' time, and perhaps self-perceived competency of students (i.e., students either thinking they knew enough to not participate in an assessment, or they knew very little and did not want to partake for fear of embarrassment) could have resulted in the lower number of volunteers.

Although the sample for the study was small, the population sampled for the interviews (high and low scorers for each cohort) was selected to obtain a broad view of students' experiences in the MBBS program. At the time of the interviews, all students were in their clinical years or had graduated the MBBS program and were interns. The opinions of the clinical-year students and interns were highly valuable because, having settled into the MBBS program and acquired more experience, they were better suited to provide commentary on key components of their medical school experience. Therefore, the rich qualitative data obtained from the participants provide many insights into the wide-ranging phenomenon observed within the quantitative analysis, as well as the issues currently debated in the literature.

As stated by Lawson and Bearman (2007), who also conducted a mixed-methods study on medical students, interns, junior doctors and consultants:

> The quantitative methodology was designed to engage the consumers of medical education in a meaningful way to enable their responses, their experiences and

aspirations to be reflected in the qualitative components of the study. Importantly, the qualitative components of the methodology encouraged unanticipated outcomes of the educational process to emerge. (p. 10)

8.1.2 Findings from the Formative Anatomy Assessment

Of the 138 students who participated in the study, data from 136 participants were analysed. Using the SEM, SD and reliability score, the clear pass mark for the formative anatomy assessment administered online was 55.8%, with 52% of participants obtaining a clear pass, 41% falling in the borderline category and 7% failing the assessment (with a score below 38.9%). These results suggest that the formative assessment was challenging for students, which supports the belief that difficult examinations in anatomy are necessary after undergraduate entry to ensure that candidates have adequate anatomy knowledge before they can start practicing on patients (Raftery, 2007). The difficulty of this test suggests that it is appropriate for measuring students’ knowledge. If everyone obtained a clear pass, it could be argued that the test did not appropriately assess students’ anatomical knowledge.

The highest number of participants in the clear pass category belonged to the Year A cohort, followed by the Year B and Year D cohorts. Less than 50% of Year C students passed the assessment. The fact that two-thirds of the Year A students obtained a clear pass relative to the other cohorts, where there is no formal anatomy instruction, is not surprising. In fact, these results suggest that pre-clinical students who have recently received formal anatomy teaching and are subjected to more summative assessments on anatomy during the year are more likely to retain the knowledge because it has been recently acquired and reinforced according to test-enhanced learning principles. According to these principles, the process of remembering and retrieving information from memory can assist in the long-term retention of that knowledge

(Larsen et al., 2009, 2013, 2015). However, 30% of Year A students were in the borderline category, and 5% failed the assessment, suggesting that students are not learning anatomy thoroughly when it is formally taught. This was confirmed in the qualitative phase, where participants who had recently completed Year A stated that the sheer volume of anatomy, the fast-paced curriculum and the volume of information that had to be learned in a very time-constrained pre-clinical curriculum made it difficult for them to acquire and retain that knowledge in the long term.

8.2 Anatomy Knowledge and Retention

8.2.1 How Does Anatomy Knowledge Differ Among Students Across the Pre-clinical and Clinical Years?

Cross-sectional Findings: Mean Anatomy Score

When comparing the overall means on the anatomy assessment across all four cohorts, a gradual decline is observed in anatomy knowledge. Students in the pre-clinical years (Year A) performed better on average than those in the clinical years. Further, this difference in means was statistically significant between the Year A and Year C cohorts. This result is not surprising given that the pre-clinical (Year A) students had multiple opportunities in which to learn and revise their anatomy through lectures, tutorials, small-group workshops (osteology, surface anatomy, imaging) and cadaveric teaching. Additionally, these students are formally absorbed in a learning and testing process of their anatomical knowledge because they are assessed numerous times during the pre-clinical year—both in formative and summative contexts. Therefore, knowledge that had just been learned by the Year A students tended to remain fresh in their minds relative to the clinical-year students, whose application of anatomy is indirectly assessed through clinical EMQs, OSCEs and in formal or opportunistic workplace-based assessments. However, the low average of 60% by Year A students was unexpected, suggesting that students cannot learn and retain anatomy properly in one pre-clinical year given the time-constrained and fast-paced anatomy curriculum.

No statistical significance was found between the Year A and Year D cohort. The fact that the population represented by the Year D cohort (23%) was less than half of that represented by the Year C cohort (52%) could have been a contributing factor in relation to the difference in scores observed between the cohorts. Therefore, the observed results could be attributed to a Type II error, wherein there is a failure to reject the null hypothesis because of insufficient evidence (i.e., fewer participants in Year D).

Some studies have found that prior knowledge of anatomy has a positive effect on students' performance compared with the mode of delivery (Attardi & Rogers, 2015). In this study, students were categorised into five educational backgrounds based on prior exposure to anatomy (if any) in their undergraduate degree. These included: anatomy in a professional course, anatomy in a biomedical science course, biological science (little to no anatomy), other science (no anatomy), and no science. In comparing the mean scores on the anatomy assessment across the five groups, to determine whether the scores affected students' performance, there was no statistically significant difference between the two variables as demonstrated by the Kruskal-Wallis H test, suggesting that educational background does not necessarily play a role in how much knowledge is retained by students. However, those with prior anatomical knowledge tended to perform better, suggesting that prior knowledge helps to increase students' understanding of content that needs to be learned (Tedman, Alexander, Massa, & Moses, 2011), thereby resulting in better outcomes. However, the lack of statistical significance in this regard, and the fact that many participants from other science and non-science backgrounds also performed well on the anatomy assessment and obtained a clear pass, suggests that prior anatomy exposure is not a definite predictor of retention of anatomical knowledge. As highlighted by Mitchell et al. (2009), personal attributes, goals and cultural differences could be contributing factors that affect students' ability to achieve good knowledge of anatomy, which might ultimately translate to a useful infrastructure for clinical reasoning and management of patients in the clinical workplace. Of course, all students need a drive to succeed in medicine, but studies have shown that the lack of understanding of science by students who do not possess the prerequisite background results in this group of individuals developing a higher drive and motivation to succeed in medicine (Liddell & Davidson, 2004; Tedman et al., 2011).

Cross-sectional Findings: Regional Anatomy Score

A subsequent comparison of cohort performance across the six regional anatomy blocks indicated that across all four years, participants performed best on abdomen and pelvis, lower limb and thoracic anatomy. It should be noted that there were far more abdomen questions than pelvis questions given that the pre-clinical students were still in the process of receiving formal teaching sessions on the pelvis. Participants noted that in the clinical years, performance was better on abdominal, thoracic and lower limb anatomy compared with other regions (head and neck, pelvis, and upper limb) since these areas afforded the greatest clinical exposure. That is, frequent exposure to cases requiring the application of gastrointestinal, lower limb, cardiovascular and respiratory anatomy were regarded by participants as having a positive effect in helping them to revise, refresh and build upon existing anatomy knowledge. From the constructivist perspective, this supports the notion of workplace-based learning theory in that an environment that provides adequate support, resources and opportunities or activities for students to develop their knowledge base and skills can enhance students' learning (Billet, 2001; Eraut, 2004). These findings also support the notion of a spiral curriculum, because frequent revision and repetition of existing knowledge enhances retention of knowledge and can lead to relearning in cases where knowledge has been forgotten (Magid et al., 2009).

There was a statistically significant decline in anatomy scores between the pre-clinical Year A and clinical Year C cohorts in relation to performance on back anatomy, and between the pre-clinical and final two clinical cohorts (Year C and Year D) in relation to performance on head and neck anatomy. This poor knowledge of back and head and neck anatomy is a cause for concern because it has implications for safe medical practice as junior doctors. The statistically significant difference in head, neck and back anatomy scores suggests that the pre-clinical students, having just spent the year learning this material, were more likely to retain it, whereas in the clinical years, the amount of exposure to cases involving knowledge of back and head and neck anatomy is minimal, as noted by the participants. This was highlighted by participants as a major factor influencing their performance in anatomy during the clinical years, along with a strong emphasis on medicine (diseases, treatment and management), a lack of formal anatomy teaching, site-dependent learning opportunities and a lack of vertical integration in the clinical years. Given that learning occurs through active participation in the workplace (Billet, 2001), the opportunities afforded by the workplace (through a supportive environment with proper guidance and access to activities that help students develop their skills) are crucial to enhancing effective learning in students. As one participant said, ‘Anatomy is a use it or lose it sort of science’ (HP, Year C). Therefore, curriculum experts need to ensure that students in the clinical years obtain sufficient exposure to all regions of clinical anatomy to maintain their knowledge and optimise their learning and revision during this period.

Cross-sectional Findings: Taxonomy

The questions were categorised according to complexity (by taxonomy), and the results were analysed to identify any patterns between the level of difficulty and students' performance. Not surprisingly, questions on the lowest domain of Bloom's taxonomy—recall—revealed higher scores when compared with the questions listed in the higher domains of Bloom's taxonomy—that is, application and analysis. This is not surprising considering that the questions that require students to analyse information can be much more challenging for students than questions that require recall or regurgitation of factual knowledge. In examining the results for each of the three classifications across the four cohorts, performance was quite similar and differences were non-significant, except for recall-type questions, where a statistically significant difference was found between the Year A and Year C participants. The results suggest that knowledge on the lower classification scale of Bloom's taxonomy, which often requires low-level understanding and more memorisation, was best recalled by the pre-clinical-year students, whose exposure to formal anatomy teaching assisted them to recall the information. Given that students in the pre-clinical curriculum are more likely to adopt surface approaches to learning as a way of coping with large amounts of information (Smith et al., 2014), this finding was expected. In contrast, questions that require not only recollection, but also the application and analysis of that information, were poorly answered by all cohorts when compared with the recall-based questions. This could be because the pre-clinical students are yet to master the skill of employing a deep approach to learning, which occurs when students make connections between anatomical structures and their clinical significance. Without this, it is difficult to obtain conceptual coherence (Woods, 2007); that is, students struggle to create a mental map wherein basic anatomical facts can be organised and applied in the context of clinical cases, which ultimately forms the foundation for developing clinical reasoning (Kulasegaram et al., 2015). Although a fair amount of superficial learning must occur in anatomy given the numerous anatomical terms and structures (Pandey & Zimitat, 2007), unless a deep approach to learning is also used and a connection is made between the anatomical structure and its clinical significance, retention of knowledge remains a challenge. Therefore, perhaps the clinical students have difficulty remembering the factual knowledge that is necessary to make the clinical application or analysis. Unfortunately, this issue was not explored as part of the qualitative analysis; hence, one can only speculate as to the findings in this regard. Other studies have also been unable to find a direct link between taxonomic classification and performance levels (Cunnington et al.,1996; Kibble and Johnson, 2011).

8.2.2 To What Extent Do Medical Students Retain Anatomy?

Findings from comparison of VIA with anatomy assessment scores

So far in the literature, reported retention averages of anatomy knowledge range from 75% to 93% for retention intervals of approximately 18–30 months (Blunt & Blizard, 1975; Custers, 2010; Kennedy et al., 1981). A study that examined knowledge of abdominal and pelvic anatomy among third-year medical students at the start of two rotations—general surgery and obstetrics/gynaecology—found that retention of anatomy was poor (approximately 50%), especially when matched with test items from the first year (Jurjus et al., 2014). However, this study only examined students over one year of an entire MBBS program and measured knowledge of two anatomical regions.

To explore retention of anatomical knowledge formally taught in Year A, the formative anatomy scores of participants from the three clinical years were compared with their summative anatomy score from Year A. While the formative assessment was constructed in such a way that the type of questions and level of difficulty would be similar to that of the VIA, there are limitations to the inferences made from this analysis because the same assessment tool was not utilised in obtaining the VIA scores for each cohort although there were similarities with the assessment tools utilised. Additionally, stronger anatomy students self-selected to participate in this study and hence this can be viewed as a bias.

Nonetheless, the descriptive findings of these results indicate that the final-year students (Year D) showed lower levels of anatomy knowledge of almost 20% from the pre-clinical year VIA. This was followed by the second clinical cohort (Year C) showing lower levels of knowledge by 11% and finally the first clinical cohort (Year B), which showed a slightly higher increase in anatomy knowledge of 2%. These findings support those of Feigin et al. (2007), who found that recall of specific anatomy was superior in students at the time and immediately following the delivery of teaching (i.e., Year B), but it was poor when examined two years later (i.e., Year C and Year D).

Although all participants in this study indicated that anatomy was not prioritised in Year B because of the emphasis on pathophysiology, there was a positive and statistically significant moderate correlation between scores on the formative assessment and that on the VIA, perhaps indicating that some form of tacit learning may have occurred (Eraut, 2000). Perhaps the clinical experience afforded by rotations in surgery and medicine in Year B can be partly credited with the preservation of anatomical knowledge among this group of students.

The results from the final two clinical cohorts were statistically significant, suggesting and supporting the fact that retention is regarded as a “negatively accelerated logarithmic forgetting curve” (Meyer et al., 2015; p. 133). Further, more time spent away from formal anatomy teaching and fewer opportunities for vertical integration in the clinical years will result in a higher likelihood of knowledge being forgotten (Feigin et al., 2007). Although these students had acquired more training and experience in the clinical years compared with the first-year clinical students, their results demonstrate poor retention of anatomical knowledge compared with Year A. Participants indicated that the blocked nature of the clinical rotations in Year C, which were based around paediatrics, general practice, obstetrics and gynaecology, and psychiatry, called for less anatomy revision; thus, the focus on clinical medicine resulted in a shift away from anatomy. For students in their final clinical year (Year D), there was no formal assessment of anatomy during the year, although they had to undergo a clinical knowledge test and hurdle modules for each rotation, suggesting that they are less likely to consider anatomical revision until there is internal motivation to do so.

The findings from this study is suggestive of those of other studies in that knowledge declines over time, especially if it is not revisited. The results of the quantitative data analysis were further supported by students' perceptions from the interviews, with most stating that their retention of anatomical knowledge was nowhere near what it used to be when they were in the pre-clinical year. They cited a lack of formal anatomy teaching and curricular demands in the clinical years as reasons for this decline. Participants also stated that knowledge not used was forgotten, which is similar to the concept "out of sight, out of mind" (Sugand et al., 2010, p. 84). A study that examined chest radiographic anatomy at two different points in the medical curriculum showed that content learned initially is forgotten if it is not used. This particularly applies to content that involves surface rather than deep learning (Magid et al., 2009). Given that memorisation is an essential component in framing the fundamentals of a discipline such as anatomy, such information can remain as superficial knowledge when efforts of retrieval practice and understanding the significance of content are not made to transfer the information to long-term memory (Brame & Biel, 2015).

The statistically significant and strong Pearson correlations obtained between the summative and formative assessment scores from the three clinical cohorts also suggests that students who performed well in the Year A summative examination were more likely to perform well on the formative anatomy assessment in the clinical year, and students who know how to learn effectively retain this knowledge more effectively than their peers. This was evident in the findings from the handful of participants in the final two clinical years, who performed quite well on the VIA in Year A, but who also recorded slightly better results on the formative assessment. One of these participants, who was interviewed, acknowledged the result and suggested personal goals (i.e., interest in anatomy and surgery as a future career) as motivating factors to keep up to date with anatomy knowledge. However, some of the high-performing participants from the pre-clinical year who were still high-performing in the clinical year believed that their anatomy was not as good as it had been in Year A. This perception of declining knowledge could be a “discrepancy in what students think they know and what they think they need to know” (Older, 2004, p. 87).

Nonetheless, given that preclinical learning of anatomy (which occurs through didactic and integrated means) accounts for the majority of students’ knowledge base in the area, and provides the framework upon which further knowledge and clinical knowledge is built, our results highlight the importance of two concepts—a spiral curriculum and frequent assessment and remediation—in helping students retain their knowledge. If students struggle with acquiring the necessary knowledge during this period, they are more likely to encounter problems with consolidation and clinical reasoning in the clinical years, given that the foundational knowledge upon which clinical information is built remains weak (Kulasegaram et al., 2015). Although the re-contextualisation of knowledge obtained within workplace based settings can assist with this consolidation (Evans et al., 2010), our results show that not all students are afforded this opportunity. Therefore, early intervention and careful monitoring of learning is just as important as early introduction to content (Madig et al., 2009). Material that is introduced in the pre-clinical year must be reintroduced again formally within the clinical years to allow all students access to the same curriculum and to foster long-term retention of knowledge, because there is a certain level of unreliability associated with opportunistic presentations requiring anatomy knowledge in the clinical rotations, which might not necessarily revisit the relevant anatomy. The belief or assumption that students are absorbing information or learning from clinical exposure is not as reliable as one might hope (Magid et al., 2009). As such, intervention strategies must be put in place to assist students in need of further support.

Validity of the Formative Assessment

When designing and administering the assessment tool for this study, an important issue that had to be accounted for was that of validity. Does the test measure what it intends to measure? In this study, a set of new MCQs and EMQs that approximated real-world situations (Van der Vleuten, 1996) was drafted according to Year A anatomy objectives (see Appendix E), thereby ensuring content validity. If the same test questions that students had been exposed to in the pre-clinical summative VIA examination (the results of which were used as the pre-test score for the Year B–D cohorts) were used in the online formative anatomy assessment (to obtain the post-test scores), then one could argue that students' (particularly those in the pre-clinical and first clinical year) response times to the questions could have been altered because of recognition of context within the questions. Research has shown that if students are exposed to the same question over a brief period, they are most likely to use recall rather than using the higher-order thought processes expected for the cognitive level of that question (McGuire, 1963; Miller, 1990). For the later clinical-year students, there would have been a time lapse of 1–3 years from when they had seen the pre-clinical Year A anatomy questions. However, the results obtained from the formative anatomy assessment can be said to be an objective measurement of a student's anatomy knowledge because administering the formative assessment so close to the Year A and Year C summative VIA examination (the two cohorts that produced the most statistically significant differences in performance) indicates that students most likely used the tool as a means of checking and assessing their own knowledge of anatomy rather than as a means for learning anatomy (McNulty et al., 2015). Further, the significant increase in performance on the summative VIA by the Year A students (15.2%) highlights the effect of test-enhanced learning and positive outcomes of repeated retrieval in promoting learning (Brame & Biel, 2015). Additionally, the benefit of participating in formative assessments gives students an indication of their knowledge, and perhaps motivates them to revisit the content and consolidate their knowledge further.

8.3 Anatomy-learning Survey

8.3.1 Student Approaches Towards Learning of Anatomy

As medical educators, one of our goals is to create an optimal environment for students to learn anatomy. Thus, it is imperative to understand how students approach learning anatomy and why they perform poorly or fail to understand anatomy. In 1976, Marton and Saljo (1976) introduced the term 'approach to learning' to characterise the different ways in which students tackled the learning of a concept or skill. The literature has identified three major approaches to learning in the literature—*surface approach* (memorisation), *deep approach* (understanding) and *strategic approach* (combination of both)—all of which relate to different learning outcomes (Biggs, 2003; Louw et al., 2009; Newbie & Entwistle, 1986; Ramsden, 2003). According to Ramsden (2003), the learning approach that is adopted influences the outcomes.

The strategic approach was highlighted during the interviews as a learning approach frequently used by students. Although participants indicated their intentions to adopt deep approaches to learning anatomy, with an emphasis on understanding content, they admitted that closer to assessment time, a strategic approach was instead employed, with some participants focusing on memorisation of facts and others focusing heavily on tutorial questions that they had deduced from previous examinations to be highly assessed during examinations. This supports Smith's (2007) assumption that students consciously and subconsciously mould their strategies for learning based on content and format of examinations.

In this study, there was no clear pattern of learning evident among the HPs and LPs with the student groups. Majority of students reported that they adopted a combination of deep and surface approaches, with half of the participants placing more emphasis on the search for meaning prior to memorisation. Only a handful of participants (13%) employed a deep approach, and 15% employed a surface approach in isolation. In a discipline such as anatomy, there is much surface learning that must occur, especially in the initial stages of exposure to the subject. Without surface learning, deep learning cannot take place (Smith et al., 2014). When the learning approach adopted was compared across the HPs and LPs, there was no relationship or statistical significance between the two, which suggests and supports the findings in the literature that other factors may influence students' learning and retention of anatomy. These include the context in which learning takes place, past learning experiences, intentions and preferences for learning, personal attributes, goals and cultural differences (Mitchell et al., 2009; Ramsden, 2003; Smith & Mathias, 2007; Smith et al., 2014). The study did not delve into details of the abovementioned factors; hence, no conclusive statement can be made regarding student approaches to learning and their effect on assessment. However, it brought to light some additional issues, such as time pressure, teaching methods and curriculum structure, that may affect performance.

8.3.2 Student Attitudes Towards the Learning and Use of Anatomy

Many factors can influence students' attitudes towards learning. These include learning styles adopted, teaching methodologies, student motivation for learning, past experiences and perceptions (Gogolin & Swartz, 1992; Tedman et al., 2011). In our study, most participants felt satisfied with the teaching of anatomy in the pre-clinical year, especially when it came to content, stating that not much more could have been incorporated into such a packed program. More than 80% of participants indicated that the anatomy covered in Year A, which was highly clinically oriented, was considered necessary for clinical practice, suggesting that students recognise the importance of the discipline in the field of medicine. Moreover, this way of teaching anatomy paved the way for participants to appreciate its significance, with almost all students stating that it was the framework that underpinned medicine in the clinical years, and that it was an important part of being a doctor—a finding that has been echoed in other studies (Fitzgerald et al., 2008; Moxham & Plaisant, 2007; Prince et al., 2003). Participants also highlighted that regardless of what specialty they would choose down the road, it was important for all medical students to have a good knowledge of anatomy because this would not only assist in communication with other healthcare professionals, but it would essentially be needed and called upon during rotations in general practice, on the wards and particularly in emergency rooms, where time is crucial and a doctor's knowledge of anatomy could mean the difference between life and death for a patient. Such knowledge is also required following graduation, when students are interns and are potentially placed in a hospital doing the night shift alone—especially in regional, rural and remote sites.

More than half of the participants indicated that anatomy was used frequently during clinical skill sessions. This is not surprising given that many patient physical examinations require sound knowledge of surface anatomy (Standring, 2009) and the underlying structures. Participants generally felt confident about their surface anatomy knowledge because this was covered extensively in the Year A anatomy sessions. This was further supported by the fact that students' confidence in anatomy helped them to use their knowledge during clinical skills, especially when performing a physical examination. A weak negative association was found between students' use of anatomy in clinical skills and their confidence when using anatomy, suggesting that students are less likely to apply their anatomy knowledge in clinical skills if they lack confidence in their knowledge. This provides a good indication of insights and reflections by student of their skills and knowledge. However, perhaps the lack of confidence that participants had in their anatomical knowledge could be partly attributed to their inability to assess their own anatomical competence. As stated by Lazarus et al. (2012), the transfer of anatomical knowledge from the classroom to the clinic can be a challenging task for students.

Slightly more than half of the participants disagreed or were unsure if anatomy was an important subject in their medical career. This faulty perception could be attributed to the fact that students, being novices in the field and yet to be immersed in their profession, are oblivious to the level of knowledge that is required of them in the clinical setting. On the path to becoming an expert in a particular field, students begin as novice learners who, with the guidance of instructors, develop their skill set and gradually transition to be expert learners. For some, this process can take longer than others (Horii, 2007). There was also a moderately negative but statistically significant association between students' perception of anatomy being important for becoming a doctor, but not as an important subject for their medical career. It could be that students view basic anatomy as an important part of medical practice, but that the specific anatomy required for specialisation in a discipline would only be important when the student branches out into that specialist field. This was confirmed during the interview phase, where participants placed varying degrees of importance on anatomy relative to the different specialities that students could embark upon as a career choice. Students perceived that anatomy was most important in emergency rooms and in surgical and radiological specialties. In contrast, the disciplines of physiology and pharmacology were considered most important to the fields of internal medicine and paediatrics. Similar findings have been reported by Lawson and Bearman (2007), wherein junior doctors and interns were more likely to understand the importance of anatomy in clinical practice, and were hence more concerned about their lack of knowledge in the area and its relation to surgery, whereas medical students were more concerned about their lack of knowledge in pharmacology and physiology and "the integral application of this skill in medication prescribing" (p. 28). In another study, medical students highly valued the importance of physiology as they did anatomy, noting that students appreciate the clinical significance of the basic biomedical sciences during pre-clinical training (Olowo-Ofayoku & Moxham, 2014). This reason could be because, in the clinical years, a strong emphasis is placed on disease processes, treatment and management, which all require a great deal of knowledge in physiology, pathology and pharmacology, in addition to anatomy, which provides the structural framework for the other two disciplines.

8.3.3 Use of Teaching Resources in Learning Anatomy

Aside from tutorials, the most-utilised resources for learning anatomy were textbooks and An@tomedia. Similarly, after tutorials, which were rated the highest, textbooks, cadaveric exposure and An@tomedia were also extremely valued for being useful in helping students learn anatomy. The difference in responses between which resource was most used and which was most useful was explored further during the interviews, where participants indicated that while students preferred textbooks and tutorials when initially learning anatomy, the most useful resource for remembering anatomical knowledge was tutorials, because they emphasised the clinical relevance of anatomical structures. In effect, participants were describing the concept of contextualisation as helping them to learn anatomy. This concept is an essential component of integration at the course level, and its importance is based on its capacity to demonstrate the applicability of principles of basic science to clinical settings (Kulasegaram et al., 2013). In addition, most textbooks contain clinically relevant sections, and this component is frequently deemed by students to be the most useful resource. Further, the specimen days involving cadaveric exposure allowed students to transfer the 2D knowledge obtained from textbooks into a 3D understanding, thereby consolidating their learning and transferring concepts into long-term memory.

Lectures

Lectures were regarded as one of the least useful resources for learning anatomy. Again, during the qualitative phase, participants emphasised that lectures that were delivered in didactic form were only considered beneficial when all of the content for the session was covered during the scheduled lecture (i.e., when the lecturer did not get side-tracked) and the lecture contained clinical information that signified the importance of anatomical structures. This supports findings from the literature that dry lecture content fails to engage students, with lectures being far superior when basic science information is integrated in a casual manner (Kulasegaram et al., 2013; Stuart & Rutherford, 1978). Additionally, students found that the principles of anatomy lectures—those that provided a guiding framework for the organisation of the body—were the most useful for learning anatomy. During the interviews, a few participants highlighted the importance of the principle lectures in anatomy, in allowing students to work through anatomical problems. This is important because students often encounter the problem of knowledge transfer—failure to apply what has been learned in one context (e.g., classroom) to a different context (e.g., clinic) (Spencer & Weisberg, 1986). According to Norman (2009), this transfer only occurs about 10%–30% of the time. By possessing knowledge of the principles of anatomy—for example, how pain referral works with respect to superficial pain, deep pain and pain from paired and unpaired organs—students are better able to understand and apply those principles to different situations (e.g., patient presenting with abdominal pain *v*. pain in lower leg *v*. chest pain).

Much has been said in the literature about the didactic approach to teaching. The behaviourist approach to learning, which views the teacher as the sage on the stage, has been associated with memorisation of fragmented facts, leading to superficial learning (Collins, 2009). Thus, to enhance learning, we need to actively engage students (Magid et al., 2009). If lectures continue to be adopted in the modern curriculum, there should be modifications to how this didactic mode of instruction is delivered to increase students' engagement and allow students to achieve the learning outcomes. That is, the process of delivery of instruction needs to move towards the cognitive model, which views the learner as central to the process of learning (Collins, 2009).

Surface Anatomy

While the surface anatomy classes were reported to be very useful for examining and palpating surface landmarks, a common criticism highlighted by participants was the lack of student volunteers during these sessions. Most often, it was the same group of students offering to be palpated, drawn upon or examined, and this was seen to be associated with a different learning experience for these students compared with their peers. These findings are similar to those reported by Aggarwal et al. (2006), with gender segregation highlighted as a barrier to effective learning of surface anatomy, and with males comprising the majority of volunteers.

Through personal experience of teaching surface anatomy and body painting, various factors such as issues of confidence, body image, the notion of feeling disadvantaged in learning the material as a volunteer, and the underlying cultural sensitivities associated with some students play a major role in whether a student agrees to participate as a volunteer during practical classes. In fact, what commonly happens is that each week, the same students volunteer for the examination. If the same individual is forced to volunteer each time because no one else wants to, that equates to passive learning for that volunteer because they are unable to actively be involved in examining the body for its surface anatomical projections and landmarks.

In a profession that is based on patient care regardless of gender, shape and size, body image issues must be addressed early in medical school to develop a sense of confidence in students' ability to examine their peers and, subsequently, patients (Finn & McLachlan, 2009; Sugand et al., 2010). It is therefore the responsibility of tutors and academic staff to monitor and gently break these barriers by encouraging other participants in the group to take turns volunteering for the examination.

Thus, while surface anatomy is essential for providing students with a strong foundation in the clinical years, students benefit the most from these sessions when they are led by clinical teaching staff, and when all students participate and take turns to volunteer as the examinee for the sessions. After all, there is no substitute for learning surface anatomy.

Osteology and Body Painting

Osteology and body painting were learning resources that participants felt were useful to a certain extent. Given that all bones share a number of similar features, most felt that numerous sessions of osteology were not required, and more time could have been spent on medical imaging instead. Similarly, body painting, which occurred once a year after an anatomy specimen day, was viewed by participants as a fun activity that helped with learning some of the surface anatomy at the time. However, most did not find it helpful to their learning process, contradicting the study by McMenamin et al. (2008), which emphasised the usefulness of body painting in prompting retention and recall of knowledge. There are limitations to the inferences made here given that participants in our study had a “one-off” experience with the body-painting activity. However, the participants’ opinions do reinforce Standring’s (2012) view that body-painting activities “can appear to engage students in the process of knowledge acquisition but do not necessarily aid the subsequent implementation of that knowledge in the clinic” (p. 814).

An@atomedia

An@tomedia online, the comprehensive online anatomy package used by Monash University students, allowed them to explore anatomy from both systemic and regional perspectives, while also allowing for examination of the body through dissection and medical imaging. All participants accessed the online tool—in particular, before tutorials—because the clinical references to anatomical structures embedded within the site were regarded as very useful for students' preparation for tutorials, their learning and their alignment with assessment tasks.

8.4 Factors Surrounding Retention of Anatomical Knowledge

Overall, students acknowledged that factors that assisted their learning of anatomy included active and collaborative learning achieved through small-group teaching in Year A, contextualisation of concepts achieved through medical imaging and clinical applications of anatomical knowledge, and experiential learning acquired through exposure to cadaveric specimens. However, there was room for improvement within these arenas.

The main factors negatively influencing retention of anatomical knowledge stemmed from cognitive overload resulting from a heavy workload in a packed curriculum, a lack of vertical integration, few workplace-based opportunities for learning stemming from a lack of anatomy exposure during clinical placement (i.e., site-dependent opportunities), negative attitudes of clinicians and educators to supporting learning, and assessments that had very little focus on anatomy in the clinical years.

8.4.1 Factors Assisting Students in Learning Anatomy

Active and Collaborative Learning

Small-group teaching involving a small number (8–10) of students and a tutor serving as the facilitator has been shown to increase students' engagement and motivation, provided that the session allows students to actively participate in their learning (Moscova et al., 2015) and collaborate with others. In the modern curriculum, small-group teaching occurs in different settings through different modes of delivery: PBL, TBL and tutorial-based sessions.

Participants in this study rated tutorials, which occurred as part of small-group teaching, as the most useful resource for learning anatomy. During the interviews, they explained that tutorials in the pre-clinical year were perceived as being mostly valued for their clinical content because this provided students with the framework for why anatomy is important, where it was used and how it could be applied in the clinical context, thereby reinforcing the importance of contextualisation as helping students to learn and retain such clinically relevant knowledge (Kulasegaram et al., 2013). In medical education, contextualisation can be achieved in many ways—either through integration of basic science and clinical concepts in the context of a patient or through the integration of basic science information during clinical sessions and vice versa.

Participants also indicated that the small-group learning and clinical application questions that comprised the tutorials helped create an appropriate environment for students to take an active part in their learning by engaging in discussion. Similar findings were reported by the Australian Medical Education Study (Lawson & Bearman, 2007), wherein students highly valued teaching methods associated with small-group learning, teaching in the presence of the patient, clinical skills and simulation experiences. This supports the notion that students are more motivated to learn anatomy when they can perceive the importance and relevance of the material, and this motivation is linked to students adopting deep-learning approaches and subsequently increased retention (Dahle et al., 2002; Meyer et al., 2015).

The concept of small-group teaching and PBL follows the principles of adult learning—that is, by calling on learners to draw upon past experiences and by fostering internal motivation through a focus on clinical relevance of concepts, which aim to foster students’ SDL. SDL is an important skill, particularly because its usefulness in promoting lifelong learning practices manifests in the clinical years, where there is a clear need to develop and maintain SDL in a dynamic field like medicine. However, this approach has critics who argue that students are limited in their capacity to self-assess their strengths and weaknesses (Norman, 1999). Thus, while they may learn a skill through the process of SDL, it does not necessarily manifest into possessing competence in that skill in the short or long term. However, given a structured approach to the organisation of SDL, a student's self-assessment of their strengths and weaknesses can be quite good. In a study by Lawson and Bearman (2007), students rated PBL to be both the best and worst features of medical education. It is easy to understand this notion when considering the prior learning experiences of students. Many students enter medical school having had a didactic approach to teaching and learning from their previous degree/school. This leads students to expect a similar style of teaching to ensue in medical school (Moscova et al., 2015). However, when faced with the reality, most struggle with the novelty of SDL and integrated curricula to the point that there is an adjustment period where students must come to terms with a new form of curriculum and teaching and develop ways that can help them adapt to the learning styles that are expected of them. Given that the medical curriculum in the graduate-entry program is PBL-based, participants expressed similar issues regarding SDL and how they had to adapt to this new style of learning. This adjustment period can be rapid for some, but much longer for others, making the transition time from novice to a trained professional variable for each person (Horii, 2007).

Thus, there is a difference between small-group sessions that foster active participation and learning and those that promote SDL. As demonstrated by Whelan et al. (2016), if small-group teaching is designed in such a way that there is more emphasis on SDL and less support from the tutor, students feel frustrated and disadvantaged in their learning because of a lack of direction and feedback from facilitators. This leads to incomplete progression through learning objectives and poor scores on an anatomy examination. This is particularly prominent in learners who lack good SDL skills. In contrast, when small-group teaching fosters active learning and is accompanied by tutor demonstrations, guidance, discussion and engagement, students can progress through the learning objectives for the session and subsequently achieve higher scores on an anatomy examination than the comparison group—especially when dealing with questions that involve application of knowledge. Given that a firm foundation of basic principles is necessary to enhance students' SDL (Davis et al., 2014), these findings are not surprising.

Therefore, the clinical context and experience afforded in a properly designed anatomy curriculum that embodies small-group teaching and fosters active and collaborative learning can help to increase students' buy-in and engagement, deepen and strengthen their anatomy knowledge and give students a rationale for learning anatomy.

Experiential Learning

Cadaveric exposure achieved through the anatomy specimen days, wherein students could observe prosected cadavers and be guided by a tutor demonstration, was viewed as a useful methodological tool for learning anatomy. This is similar to studies wherein students perceived small-group demonstrations around prosections to be the most beneficial tool in learning anatomy (Chapman et al., 2013; Murphy et al., 2015). It could be that the hands-on experiential learning approach offered through cadaveric exposure and tutor guidance (Kolb, 1984; Mathiowetz, Yu, & Quake-Rapp, 2016) affects students' perceptions of the effectiveness of such teaching days.

In this study, the use of cadavers was highly valued by participants because it allowed them to appreciate the visual and spatial representation of anatomical structures. Knowledge of anatomy and its spatial relationships becomes important in routine clinical practice—especially during a physical examination—because both students and doctors rely heavily on such knowledge to understand the internal structures that lie beneath the body's surface (Smith & Mathias, 2011; Vorstenbosch et al., 2016).

However, the quantitative analysis also showed that the specimen days were not the most-used resource, with only 2% of participants selecting this option. The reasons for this could be twofold. First, students had limited opportunity to engage with cadaveric specimens in the pre-clinical year because there were only four anatomy specimen days scheduled throughout the year, which, combined with an overloaded curriculum, can affect students' perceptions of the usability of this resource (Dissabandara, Nirthanan, Khoo, & Tedman, 2015). Second, as each cadaveric session occurs after a big block (musculoskeletal, neuroanatomy, thorax, and abdomen and pelvis), students would have had limited time in which to consolidate their theoretical knowledge with exposure to the cadaver. Given that most of the pre-clinical students did not have prior exposure to cadavers from their undergraduate degree, these sessions, while offering great value, could be construed as being taxing, because students had to absorb a lot of information in a very short period (i.e., six hours) (Dissabandara, et al., 2015). This would be even more challenging for beginner students who came into the program with little to no knowledge of anatomy (non-science students) because they would first need to comprehend the anatomical terminology before attempting to identify all of the important structures within a cadaver, and to understand their context, complexity and clinical significance (Dissabandara et al., 2015). Studies have shown that when students from non-science backgrounds are first confronted with science-related material, they are more anxious and stressed than the science students, although this anxiety can reduce over time with good-quality exposure to the material (Ellaway et al., 2014; Gogolin & Swartz, 1992). Therefore, while cadaveric exposure was considered a valuable tool in learning anatomy, participants indicated that they had to possess a framework of basic knowledge and require constant exposure to anatomical specimens before the usefulness of these specimens could be fully appreciated and used in the learning of anatomy. As stated by Dissabandara et al. (2015), adequate preparation is necessary (e.g., through lectures, prosections, models) to prepare students for the active learning that occurs during the dissection process. Seeing as learning anatomy through cadaveric specimens also engages students in an active process, because students are required to explore the cadaver to identify and understand the significance of anatomical structures, the same could be argued for prosected specimens.

In the literature, the time-intensive teaching tool of dissection has been extensively debated, with predictions that this pedagogical approach to learning anatomy will be gradually erased and replaced by modern approaches such as prosected specimens, computer-assisted learning, 3D anatomy software and plastinated specimens (Craig et al., 2010; Eizenberg et al., 2000; Latoree et al., 2007). Currently, with the decline of anatomy hours over the past few decades, the teaching modality that has suffered the most in terms of decreased hours is that of dissection. Although this decline has reached a plateau, one could question that any further reductions in anatomy course hours is likely to be at the expense of the students' learning experience (Drake et al., 2009) and is even more likely to result in further dissatisfaction among the wider medical community. However, a survey by Bouwer et al. (2016) provides evidence that dissection is still an important part of medical education in Australia and New Zealand, with 17 out of 21 medical schools in the region using this resource. The literature has also shown that many medical students regard dissection-based learning to be central to their understanding of anatomy (Kerby et al., 2011; Snelling et al., 2003) and to achieving the learning outcomes of an anatomy undergraduate course (Chapman et al., 2013). Students in the graduate-entry MBBS course at Monash University had no opportunities for dissection given the nature of the MBBS curriculum. However, some participants had prior dissection experience (from their undergraduate degree) with cadavers and animals. Therefore, participants were asked whether they would have liked to have had some dissection during the year. Similar to the dissection versus prosection debate observed in the literature (Azer & Eizenberg, 2007; Davis et al., 2014; Johnson, 2002; Kerby et al., 2011; McLachlan & Patten, 2006; Pabst, 2009; Rizzolo & Stewart, 2006; Smith & Mathias, 2007), the students in our study recounted mixed feelings about the preference for one over the other. While there was some predilection for wanting to dissect, all participants agreed that having some form of cadaveric exposure was better than none. Studies have shown that there is little to no significant difference in educational outcomes between students that undertake dissection versus prosection (Dinsmore et al., 1999; Nnodim et al., 1996), and that prosection is more efficient at achieving course outcomes (McLachlen & Patten, 2006). In addition, all participants stated that learning anatomy using cadaveric specimens was an essential and important resource that institutions should retain through whatever means possible, whether it be through dissection or prosection. While participants acknowledged the packed curriculum in Year A, stating that there would have been no time or space to include dissection in the pre-clinical year, some liked the idea of having dissection incorporated in the later clinical years. Perhaps having accumulated some years of experience in the clinical setting, they felt that dissection would have been helpful to learning anatomy as this would make them better doctors.

In schools where dissection is introduced as an elective in the later clinical years (Ramsey-Stewart et al., 2010), participants' experience of it is rated positively, with some stating that the course should be made available to all medical students. Having an optional dissection course is one way of ensuring that students who have a genuine interest in advancing their knowledge of anatomy can experience exposure to a cadaver and acquire key professional and technical skills, as well as reinforce and extend their anatomy learning. Most schools that are unable to offer the opportunity for dissection have limited resources, finances and/or lack the infrastructure necessary to house a dissection-based facility (Korf et al., 2008; Older, 2004). As such, most turn to prosection-based, plastinated specimens and computer-assisted software to help students learn anatomy (Latoree et al., 2007; Leung et al., 2006; Sugand et al., 2010). Given that we are teaching a generation that embraces technology, there is no shortage of choices for students to learn anatomy through computer simulation technology, especially with the development of numerous anatomy software packages such as Netter's 3D Anatomy and Visible Body. However, one study has reported that students in a computer-based laboratory are at a disadvantage when asked to identify anatomical structures on a cadaver because they have not had the opportunity to transfer their learning from one context to another (Saltarelli et al., 2014). Therefore, in the absence of dissection opportunities, institutions must retain some form of cadaveric exposure using human specimens so that students can develop a deep approach to learning anatomy (Smith & Mathias, 2010). The usefulness of cadaveric specimens is further supported by surgeons who underwent extensive training two to three decades ago. According to their views, cadaveric exposure and prosections represent the best modalities through which anatomy can be taught (Sheikh et al., 2016). This finding is also corroborated by another study, where students felt that their prosection-based learning experience was sufficient for them to learn anatomy (Whelan et al., 2016).

Therefore, although dissection was not an option for participants in the Monash graduate-entry medical curriculum, students valued the 3D anatomical knowledge acquired through their limited exposure to prosected cadavers, and studies have shown that students learning anatomy in a prosection-based curriculum result in similar (Cuddy et al., 2013) or improved (Nnodim, 1990) examination scores compared with those in a dissection-based curriculum; thus, performance is not hindered using this methodology.

Contextualisation Through Medical Imaging

All participants viewed the discipline of anatomy as important to medicine, but what students particularly highlighted was the role that anatomy played in interpreting medical imaging. This notion supports what has already been reported in the literature in that anatomical knowledge is heavily relied on in areas of physical examination, medical imaging, diagnostics and patient diagnosis (Lazarus et al., 2012; Leveritt et al., 2016; Orbson et al., 2014). Similar findings have been reported by consultants, junior doctors and medical students in the UK (Leveritt et al., 2016), who state that medical imaging is a field in which all medical students should be adept—especially prior to entering clinical placements or specialties—because of its frequent use in clinical placements.

Participants appreciated the introduction of medical imaging in Year A anatomy and the systematic approach to interpretation, particularly when they were led by medical tutors as opposed to non-medically qualified tutors. However, they also suggested that medical imaging needed to be incorporated in more depth in the pre-clinical curriculum (i.e., more time allocated to learning how to approach CT scans and MRIs) to prepare them better for the clinical years because living anatomy has become one of the primary means through which patients are evaluated and examined. As a group of surgeons indicated, exposure to imaging—especially integrating CT scans with anatomy—is essential in today's medical world (Sheikh, Barry, Gutierrez, Cryan, & O'Keeffe, 2016). Therefore, medical schools should consider integrating anatomy with radiology because these are positively associated with helping students to learn, as well as applying anatomical knowledge and interpreting images from different medical imaging tools (Murphy et al., 2015).

Given the increasing shift towards minimally invasive surgical procedures, it is important for medical students to be sufficiently equipped with the skills to interpret anatomical structures as depicted through the lens of a camera. A number of participants highlighted their lack of knowledge in anatomy when asked questions during laparoscopic surgery. The fact that medical students today struggle with the interpretation of medical images (Moscova et al., 2015) warrants its introduction into basic science teaching because it forms a critical component for developing the skills of medical students and future doctors. Therefore, designing a course that incorporates medical imaging techniques such as radiology, endoscopy, and ultrasound, together with the teaching of anatomy, will help to generate interest among students and increase students' engagement, subsequently improving their learning experience (Moscova et al., 2015). Equally important when considering the incorporation of radiology and anatomy is the mode of delivery. Given that students learn best when engaged in an active process of thinking and reasoning, imaging classes must be designed with a stronger practical component that is supplemented through imaging lectures, because students rate the former much higher than the latter since it increases spatial awareness and understanding of anatomy (Machado et al., 2013; Moscova et al., 2015).

8.4.2 Factors Affecting Students' Learning and Retention of Anatomy

Curricular Design and Cognitive Overload

Two major factors that were highlighted consistently during the qualitative phase as issues affecting students' learning and retention of anatomy were that of a condensed curriculum eventually leading to cognitive overload. Jurjus et al. (2014) claims that knowledge of basic sciences including anatomy does not depend on the type of curriculum during the pre-clinical years. This is contrary to another study, which claims that any deficiencies in anatomical knowledge that are present are related to structural issues surrounding the curriculum and not associated with student intent and motivation regarding learning anatomy (Olowo-Ofayoku & Moxham, 2014). Whether a curriculum is PBL-based or traditionally-based, it has been argued that schools can teach anatomy effectively if it is taught in a clinically relevant manner (Older, 2004). However, what students are taught and what is learned and retained is ultimately dependent on the cognitive activity of the learner. To achieve cognitive integration, learners must be able to explicitly view and develop an understanding of the causal relationships between basic science mechanisms and clinical features (Kulasegaram et al., 2015; Lisk et al., 2016). In medicine, the field of pathology is used as a bridge between the basic sciences like anatomy and clinical presentations of injury, illness and disease.

The results of our study, as made clear by the students' performance on the formative anatomy assessment and their scores on the summative VIA, provide evidence supporting both viewpoints—that is, that both curriculum design and student intent/motivation plays a role in how students learn and retain knowledge, although these are not the only contributing factors. Some retention studies (Custers et al., 2011; Feigin et al., 2002, 2007) have supported the notion that students immersed in the learning process of a particular task are more likely to perform better on assessments administered at the same time. Therefore, when comparing the anatomy assessment scores across all four cohorts, it was expected that the mean Year A scores would be significantly higher than all the clinical cohorts. However, the overall mean for Year A participants was only 4% higher than Year B suggesting that anatomy is not being learned effectively by the Year A students, even though it is formally taught in a clinically relevant way. When probed further about this issue during the interviews, cognitive overload emerged as one of the major issues facing students in today's pre-clinical curriculum. In fact, students are continuously faced with challenges of how to absorb not just all of the different sciences, but also the social, ethical, legal and epidemiological aspects of health within a time-constrained and condensed curriculum that spans one pre-clinical year in this case. This finding and frustration was echoed in both phases of the study, as most participants agreed that the volume of anatomy in Year A was daunting and that the amount of anatomy students needed to learn in such a time-constrained curriculum was the biggest hurdle for them in Year A. Given that anatomy occupies a large part of the MBBS graduate-entry curriculum, with all body regions covered within a period of 36 weeks in the pre-clinical year, these findings are not surprising. Further, almost half of the participants stated that their immediate motivation for learning anatomy was to pass examinations, indicating that a prime motivator for learning anatomy in Year A is to successfully pass the assessment components. It has been established that if the demands of the curriculum are high, the drive for learning becomes strategic and students learn not with passion or interest, but mainly to meet assessment goals, thereby adopting more of a surface approach to learning (Pandey & Zimitat, 2007), which results in students possessing superficial knowledge about a topic. Although participants recognised the importance of anatomy in medicine and valued the clinical relevance associated with anatomy teaching, they stated that the fast-paced curriculum and the amount of information they had to learn, alongside all the other disciplines, was so overwhelming that, closer to assessment time, participants directed their learning of anatomy primarily towards meeting assessment goals.

When students are expected to learn a large volume of information in a short amount of time, their cognitive capacity is overloaded, thereby hindering the learning process. Consequently, the student becomes unable to process information, let alone transfer it to long-term memory (Moscova et al., 2015; Mousavi et al., 1995), and this ultimately results in students adopting surface approaches to learning or not learning a concept at all. This lack of knowledge then transfers over into the clinical years, when there is greater demand on students to learn about various disease forms with little or no time for revision or relearning of anatomy. The lack of workplace-based learning opportunities for anatomy in the clinical years, combined with a shortage of formal teaching at most clinical sites, results in a vicious cycle, with students who began with a perfunctory knowledge of anatomy in the pre-clinical year never having the opportunity to develop this further. This was evidenced by the moderate to high positive correlation between students' scores in the pre-clinical summative assessment (VIA) and scores on the formative assessment in the clinical years. However, these correlation scores also suggest that if high-performing students from the pre-clinical year can maintain high levels of anatomical knowledge in the clinical years, when there is not much formal anatomy teaching, then it can be argued that there are other factors such as intrinsic motivation, cultural differences such as learning styles and approaches and attitudes towards learning that affect students' knowledge; hence, the onus on revising anatomy does not solely depend on curriculum content and vertical integration, but also on the student who should evaluate their own knowledge and accordingly fill in the gaps through SDL.

Comprehensive Coverage

Anatomy is a fact-based discipline filled with volumes of anatomical terms and structures that comprise the human form. Traditional anatomy is built on the pedagogical principle of comprehensive coverage (Rizzolo et al., 2006), with traditionalists insisting that students must learn every single term, structure and branch of every vessel because this is crucial to making them a good doctor. In contrast, modern anatomy follows a different approach, with modernists stating that anatomy serves the foundation upon which clinical knowledge is built. To accommodate the growing body of knowledge in the field of medicine, gross anatomy teaching has been substantially reduced and undergone a downward spiral, having declined by 55% over the past six decades, with the biggest decline occurring between the years 1955 and 1973 (Drake et al., 2009; Pabst, 2009). Subsequently, in the modern curriculum, a large proportion of anatomy courses are part of an integrated curriculum because of the assumption that integration of basic science, clinical and social aspects "provides contextual learning, thereby increasing deep understanding" (Wilkerson et al., 2009, p. 816).

Although some authors state that anatomy is in such a state of decline that it may soon disappear from the medical curriculum (Raftery, 2007), this can be considered an over-exaggeration. Over the past few years, anatomy teaching hours in the US have plateaued, reducing only slightly and reaching a stable level in 2014, with an average of 147 hours (Drake et al., 2014). Nonetheless, this reduction is viewed as detrimental to learning and retention because students are expected to master a large volume of anatomical information in a much shorter period compared with their predecessors. Within this shortened curriculum is the expectation that students should retain all of their pre-clinical knowledge in the clinical years—a notion that is unrealistic given the design of today's medical curriculum. Participants in our study recognised that their anatomy knowledge from the pre-clinical years was not as strong as it used to be, primarily because of the curricular demands placed upon them to learn medicine in the clinical years. The lack of formal anatomy teaching, combined with an intensive focus on mastering different diseases, their treatment, and formulating management plans and other medically-related issues, were factors that students highlighted as negatively affecting their ability to retain or extend their knowledge of anatomy past the pre-clinical year.

Clinicians complain about students' lack of anatomical knowledge and their inability to recall knowledge learned in the pre-clinical years on the wards. However, with a condensed pre-clinical curriculum and a segregated clinical curriculum, how can students be expected to retain knowledge that has been taught in one or two years of an MBBS program without providing them with the opportunity to revisit and consolidate this knowledge through vertical integration and application of content in the clinical years?

In a time-intensive curriculum, we must equip students during the pre-clinical years not only with sufficient knowledge, but also with the necessary skills required of a junior doctor. When it comes to the discipline of anatomy, the components that have clinical significance, and that will be used frequently in clinical practice, are regarded as most important. Any knowledge that is recognised as a prerequisite for a specialty can then be further developed during postgraduate training and residency programs (Brooks et al., 2015; Craig et al., 2010; Heylings, 2002; McKeown et al., 2003; Older, 2004).

To understand the specific knowledge required within the different specialties, the importance and use of anatomy within these areas must be examined. While literature findings (Arraéz-Aybar et al., 2010; Cottam, 1999; Orbson et al., 2014) and this study (as indicated by participants) have supported the notion that anatomy remains one of the most important basic sciences in the study of medicine, a hierarchical system of importance is accorded to the different anatomical topics within different specialties (Anaesthesiology, Medicine, Neurology, Ob/Gyn, Pathology, Paediatrics, Radiology and Surgery). Achieving consensus among the clinicians within varying specialties on the ranking order of the anatomical topics (embryology, function, innervation, lymph, medical imaging, structure and vasculature) that is important for medical students to know can be a challenging task, although all agreed that medical imaging was an essential requirement in every specialty as this was and is the primary mode through which anatomical knowledge is used in clinical practice (Orbson et al., 2014). This finding is similar to that reported by Leveritt, McKnight, Edwards, Pratten and Merrick (2016), wherein medical students, junior doctors and consultants stated that medical students must be sufficiently adept at interpreting the different imaging modalities prior to entering a clinical placement or a clinical specialty. Students in this study have also reiterated the importance of medical imaging in the clinical years and have expressed a greater need to incorporate more medical imaging within the pre-clinical years. Topics relating to lymph and embryology received the lowest rating in terms of importance (Orbson et al., 2014).

In terms of physician opinions regarding the perceived importance of anatomy topics by course module (abdomen, head and neck, thorax, upper limb, lower limb, pelvis), no particular region was deemed more important than any others. Once again, the importance of a module depended on the specialty, with those that have the most obvious anatomical specialisation understandably ranking the importance of that particular region higher relative to others. For example, specialists within obstetrics and gynaecology ranked pelvis and abdomen higher relative to other regions, neurologists ranked head and neck, upper limb and lower limb higher than others, and surgeons gave the most importance to abdomen, possibly because of the numerous responses from general surgeons in the survey (Orbson et al., 2014). These findings are consistent with the experiences of our participants in that frequent exposure to clinical cases requiring specific knowledge of abdomen, thorax and lower limb allowed students to better retain that knowledge.

Given these findings, the question that arises is: What constitutes core anatomical knowledge that would be important for a junior doctor? Currently, there is no ‘one-size-fits-all’ answer to the development of a core anatomy curriculum. In Australia, there is no national curriculum, although some have called for it primarily because of the major differences in anatomy teaching hours that exist among the universities in Australia (Craig et al., 2010; Herle & Saxena, 2011), possibly resulting in questions of what content is taught and emphasised in these institutions. Although the American Association of Clinical Anatomists (Leonard et al., 1996) and the British Anatomical Society (McHanwell et al., 2007) have proposed a core syllabus for anatomy through consultations with physicians of a particular specialty and/or group of expert anatomists (Fasel et al., 1998, 1999), it can be argued that a non-medically trained anatomist would have differing views as to what constitutes core curriculum compared with a clinically trained physician. These differences can be observed in the guidelines proposed by the two organisations, with the former emphasising detailed anatomical knowledge and the latter emphasising competence-based objectives (e.g., able to describe, predict functional effects of damage) linked with clinical relevance

(Vorstenbosch et al., 2016). Even with the development of an anatomy curriculum, the teaching of anatomy should involve placing the relevance and significance of anatomical structures into a clinical context. Teaching should be relevant to the profession (Leveritt et al., 2016), and any specific anatomical knowledge (e.g., muscle attachments) pertaining to a specialty (orthopaedics or plastics) should be dealt with in advanced anatomy courses specialised for that field. Thus, medical educators must be directed as to what to teach to maintain consistency across all groups, both in the pre-clinical and clinical years.

Variability in Teaching

A recurring theme across participant interviews was that of inconsistent delivery of curriculum and the role that medical educators played in this. Although active learning enhances the student's learning experience, it is highly dependent on the teaching style of the tutor (Whelan et al., 2016). Not all participants in this study perceived tutorials in the pre-clinical year to be the most useful way for learning anatomy stating that the success of a tutorial was seen to be highly dependent on the teaching staff. There were many inconsistencies reported between the various tutorial groups, and participants stated that tutors who used a more teacher-centred rather than student-centred approach limited student engagement. Our findings highlighted a teacher-focused approach, wherein the tutor is fixated on transmitting information to students rather than allowing students to construct their knowledge (Trigwell et al., 2009). Many participants in this study expressed dissatisfaction with teaching in the clinical years as well, citing their frustration with the inconsistent curriculum delivery across rural and metropolitan clinical sites, leaving some feeling disadvantaged in their learning. Some participants stated that some tutors and educators had extremely high expectations of students. Students were often confused as to what was expected of them and how much knowledge they needed to acquire, not just at clinical placements, but also for assessment purposes, which goes against the principles of constructive alignment (Biggs & Tang, 2011). This disconnect between the different tutors and the different clinical sites, defined as “a lack of coordination and communication, particularly from the central administration to the clinical environment”, was also reported by students and doctors in the Australian Medical Education Study conducted by Lawson and Bearman (2007, p. 30).

The role of an educator, whose passion and interest lies in medical education, is viewed as enhancing students’ learning experience (Lawson & Bearman, 2007). Clinical educators occupy a pivotal role in medical education, acting not only as educators, but also as mentors, supervisors and role models for students. However, many are hired from different departments, making it difficult to have all educators on the same page. Some are full-time academics devoted to teaching and research, while others are practicing physicians, surgeons and specialists whose part-time and potentially primary focus is their patients and their practice, and others are retired and expected to volunteer their time. Further, many are perceived by students to be insufficiently trained for their role as clinical educators or supervisors (Lawson & Bearman, 2007). Even if a training session was to be organised, studies have reported that some educators are uncomfortable with the idea of continuing to educate for free. Others worry that clinicians and consultants who are busy juggling their own practice (competing priorities) and their teaching demands are limited in their time and hence would probably not attend training sessions on how to teach. These are some of the limitations associated with employing clinical educators, and that pose challenges when attempting to ensure that all educators are on board to understand the curriculum they have been charged to teach.

However, if clinicians and teaching staff are not made familiar with the curriculum and what is expected from them in their role as clinical educators, what results is high variability in teaching quality, with very little control for how teaching is delivered and, more importantly, what content is delivered. Consequently, these factors become barriers to effective teaching, with students the unfortunate recipients. To allow students to progress efficiently in their learning, the principles of constructive alignment should be utilised and implemented (Biggs, 2014; Biggs & Tang, 2008). That is, the learning outcomes should be explicit to all parties involved in teaching and learning (i.e., educators and students respectively) and students must be aware of the expectations required from them to accomplish these learning goals (Billett, 2016). In addition, such outcomes should be focused rather than broad-based (Billet, 2016) because this can lead to variability in what needs to be covered or learned, as encountered by our participants. This stance is further complemented by Eraut (2004), who states that the level at which knowledge is pitched should be appropriate for students to grasp. If novice students are taught at an expert level when they have yet to attain that status, the knowledge facing them appears daunting and, subsequently, they are more likely to develop ineffective learning strategies and coping mechanisms, which will ultimately lead to decreased knowledge and confidence in the workplace (Eraut, 2004, 2007). Students must also be given assurances that no matter which clinical site at which they are based, they will have “equivalent educational experiences and learning outcomes to those in central program” (Solarsh et al., 2012, p. 809). More importantly, a clearly standardised clinical curriculum needs to be developed in the clinical years to ensure that no student is disadvantaged in their learning experience.

Assessment of Anatomy

The purpose of assessment is to ensure competence—that is, to validate our belief that, upon completion of a medical degree, good-quality doctors have been produced (Vorstenbosh et al., 2014). To that effect, competence-based medical education is generalised to indicate a specific set of curriculum outcomes that must be met for a student to graduate and practice medicine (Frank et al., 2010). The term 'anatomical competence', which Schoeman and Chandratilake (2012) define as possessing appropriate anatomical knowledge along with the practical and clinical applications of that knowledge, is regarded as not being "properly operationalized nor incorporated into a published evidence base" (Vorstenbosch, Kooloos, Bolhuis, & Laan, 2016, p. 9).

In today's pre-clinical curriculum, anatomy is usually assessed through larger integrated examinations incorporating numerous other disciplines. In the graduate-entry MBBS program at Monash University, anatomy is assessed five times throughout the pre-clinical year as part of integrated written examinations. As Wilkerson et al. (2009) state, "application of knowledge requires both mastery of facts and deep understanding acquired through deliberate practice and the use of multi-modal learning methods" (p. 813). Therefore, anatomy questions are framed as a series of MCQs and EMQs, linked to clinical scenarios and categorised according to the three levels of Bloom's taxonomy—know, apply and analyse—thereby testing students on these facets of anatomical knowledge. By assessing students not just on factual recall of information, but also on how such information relates to and can be applied to clinical practice, the faculty can determine whether students have developed a sophisticated understanding of content. In addition, this mode of assessment conveys to students the importance and value of integration within the curriculum (Kulasegaram et al., 2013).

When probed about the examination process in Year A, participants viewed the assessment of anatomical knowledge in the pre-clinical years quite positively indicating that such clinically relevant knowledge was frequently tested on the wards and hence, the Year A anatomy examinations helped prepare them for the transition to the clinical years and to be ward ready. However, some participants suggested that there should have been an opportunity to assess topographical anatomy through cadaveric specimens, particularly as students found the visualisation of structures they encountered during the anatomy specimen days to be quite challenging. This is not surprising given that students are immersed in a curriculum where they have limited access and exposure to wet specimens and cadavers, with only four specimen days allocated throughout the year. There were no spotter tests associated with anatomy examinations in the pre-clinical graduate-entry MBBS program. This can be viewed as detrimental to students' retention of anatomy knowledge because students have different learning styles and doctors—particularly new graduates—frequently use spatial knowledge of anatomical structures to assist them in their recall of anatomical knowledge during clinical practice (Vorstenbosch et al., 2016). Therefore, the ability to retain sufficient knowledge of 3D anatomy is important for developing anatomical competence; hence, testing visual representations of anatomy should form an essential part of its various assessments. Further, it has been shown that students create and manipulate mental images to arrive at answers to questions that provide no visual cues (Vorstenbosch et al., 2014). Given that this falls into most questions assessed in anatomy, it provides a greater reason to implement a spotter examination that seeks to assess students' visualisation skills and knowledge of 3D anatomical structures. This would enhance students' repository of visual imagery and subsequently assist them in later clinical years and in clinical practice as they seek to generate mental images of anatomical structures when faced with patients (Vorstenbosch, 2016).

In the past, practical anatomical (spotter) tests as well as MCQs—the most favoured and highly used tool of assessment in medical education—were criticised for being based largely on pattern recognition (Herle & Saxena, 2011), and for testing low levels of knowledge or rather, testing recall of isolated facts (Wood, 2003). However, Smith and McManus (2015) suggest that with the right design—that is, questions that assess students' higher cognitive thinking, this problem can be overcome. Therefore, by asking questions that not only require fact-based recall but also integration and application of factual knowledge, deep learning can be fostered—an approach that is very beneficial to the learner in the long term. Similarly, many studies have indicated that if MCQs are well constructed, they can allow for the assessment of students' higher-order cognitive (thinking) skills (Clifton & Schriner, 2010; Epstein, 2007; Palmer & Devitt, 2007). Thus, it is important for question developers to be skilled in constructing effective test items so as "to ensure that the materials used to evaluate learners are valid assessments of a learner's knowledge" (Collins, 2006, p. 551). The National Board of Medical Examiners (NBME) has developed an item-writing manual resource (Case & Swanson, 2001) entitled 'Constructing Written Test Questions for the Basic and Clinical Sciences'. This manual is used extensively in the pre-clinical graduate-entry assessment and is aimed at providing test writers with best-practice guidelines for constructing good and effective MCQs and EMQs.

Following the pre-clinical year, there is no formal teaching nor assessment of anatomy in the clinical years, except for a small anatomical component in the second clinical year (Year C) VIA examination. The combination of integrated examinations in the pre-clinical year and a lack of anatomy assessments in the clinical years is a significant flaw in the medical curriculum and poses two problems. First, students' perception of the reduced weight given to anatomy assessment within integrated examinations, and the lack of assessment in anatomy during medical training reinforces the notion that anatomy is not deemed important to pass pre-clinical and clinical-year examinations (Whelan et al., 2016). This sends the wrong message to students that they need not invest too much time in studying anatomy because a poor performance in this area can still result in the student passing the overall integrated examination (Craig et al., 2010). Second, how does one determine, let alone measure, anatomical competence in the clinical years given that it is an attribute that an individual must possess (Vorstenbosch et al., 2016)? As stated by Pabst (2009), "transferring a teaching concept without also transferring the assessment in detail might result in a major disappointment" (p. 545). Further, the term competency is not static—that is, a recent graduate who is certified to practice after having met the necessary milestones required for mastering a particular competency will not maintain competence indefinitely because the opportunities afforded by the workplace setting are an important component for maintaining those skills. For example, "a physician may find that some aspects of her abilities atrophy during the course of her career, while others develop to the mastery level" (Frank et al., 2010, p. 641). Therefore, given that competencies can develop or recede over time, it should be regarded as a dynamic ever-changing concept—one that is "grounded in the environment of practice or learning" (Frank et al., 2010, p. 641). Additionally, the concept of competency currently operates on "time-based credentialing" (Frank et al., 2010, p. 642)—the point at which a physician is capable of performing as a medical practitioner independently. Frank et al. (2010) suggest that "the term 'competent' be used instead with modifiers that specify which domains of ability, which context, and what stage of medical education or practice it refers to" (Frank et al., 2010, p. 642). For example, at end of the pre-clinical year, the student, having obtained the necessary requirements for progression, can be deemed ‘ward ready’—that is, competent to enter a supervised clinical rotation in a teaching hospital. This same student would then have to meet a different set of requirements to be considered competent to progress to the next clinical year, and so on. Therefore, to demonstrate competency in anatomy, it not only needs to be revised in the clinical years, but also examined especially when integrated into the clinical setting (Sugand et al., 2010).

While it may seem that “medical school basic curricula ultimately succeed or fail at the bedside when students need to draw upon their entire fund of knowledge as they learn to form nuanced clinical decisions” (Wilkerson, Stevens, & Krasne, 2009, p. 812), one needs to identify how students call upon their knowledge in a clinical setting. As demonstrated by Vorstenbosch et al. (2016), using the think-aloud process, junior doctors are more explicit in their use of anatomy, frequently using spatial knowledge of anatomical structures to assist their recall of anatomical facts during clinical practice as compared with more experienced doctors whose use of basic science knowledge (anatomy, physiology, biochemistry) becomes encapsulated and more implicit (Boshuizen & Schmidt, 1992; Schmidt & Rikers, 2007). This encapsulation theory is what separates the novices from the experts who, through experience, have enfolded basic science knowledge into clinical knowledge. Therefore, although junior doctors do not verbalise their thought process during a clinical consultation with a patient, they rely heavily on anatomical information stored in memory and often use basic science knowledge when solving clinical problems (Lisk et al., 2016), with the clinical reasoning that takes place being strongly associated with the use of anatomical terms (Vorstenbosch et al., 2016). Although most participants in this study indicated that they did not use their anatomical knowledge in the clinical setting, it can be argued that is a case of failure to acknowledge that the application of learning is implicit (Eraut, 2004). Students in training, unaccustomed to talking about ways in which they learn may not be able to consciously report what has been learned unless it has occurred in a formal setting, thereby represent deliberative learning. Hence, anatomical competence in this regard is difficult to measure, and whether students are learning, revisiting or building upon their existing knowledge base is a metacognitive issue.

Until curricular reform can take place again and more summative assessments can be incorporated into the medical curriculum, formative assessments are one way of assessing anatomical competence because they offer students insights into their own level of mastery of the discipline and provide the faculty with a necessary tool for effective remediation. As studies have shown, participation in formative assessments on a voluntary basis is associated with a better performance on summative assessments (Hattie, 2009; Kibble, 2011; McNulty et al., 2015) in comparison to non-participants. This theory is supported by our findings from the pre-clinical year cohort. When scores from the 2014 Year A participants' formative anatomy assessment were compared with the 2014 summative VIA anatomy scores which (in this group only) occurred a month following and was of a similar difficulty to that of the formative test, the results yielded statistically significant increased scores of 15% on average, supporting test-enhanced learning theory. Although the same tests were not used to obtain these scores, the strong positive and significant correlation between the two variables support the view that the testing effect may have played a role (Larsen & Butler, 2013; Larsen et al., 2009). Further, the participants who undertook the formative assessment performed much better on average than those who did not by (non-participants). Therefore, students' participation in the formative assessment helped them to better prepare for the summative examination (Brame & Biel, 2015; Larsen et al., 2009, 2013). One could argue that the self-selection bias of participants cannot be excluded; hence, the interpretation of this result should be approached cautiously. However, other studies support the notion that formative assessments provide learners with appropriate resources to assist them in their learning and to help monitor their progress (McNulty et al., 2015). Our results also support the importance of the testing effect in that active retrieval opportunities and written testing can enhance retention in learners (Carpenter & Kelly, 2012; Larsen et al., 2009, 2013; Toppino & Cohen, 2009; Wissman, Rawson, & Pyc, 2011). Of course, the positive effects of this on student learning are only applicable when formative assessments are well designed in that they provide an appropriate environment and authentic context for learning through the development of clinically relevant scenarios while offering students the opportunity to integrate their basic science knowledge with the clinical sciences (Velan et al., 2008).

In our study, a web-based online assessment was used as the mode of delivery. This had clear advantages because it provided students with a safe environment in which they could participate, while giving them the flexibility of time and place where they could undertake the assessment. The online delivery mode also limited the need for gathering many students in one place at a specific time to undertake a paper-based formative assessment (Velan, Kumar, Dziegielewski, & Wakefield, 2002), all of which could have further limited participation and hence resulted in decreased number of participants. A comparative study of both online and paper-based assessments has found that the former provides more opportunity for practice and learning outside of the classroom and is thus more beneficial than the latter (DeSouza & Fleming, 2003). Similar findings were reported by Coulby, Hennessey, Davies and Fuller (2009) in that students undertaking a competency-based assessment through personal digital assistants resulted in immediate feedback and positive learning outcomes for students during clinical placements.

While participants in our study did not emphasise that anatomy be assessed in the clinical years, they did indicate a preference for revising anatomical knowledge during this period through whatever means possible (e.g., online refresher courses, quizzes, face-to-face teaching, cadaveric exposure). Studies have shown that online self-assessment tools are well-favoured by students and the best predictors of performance (Hattie, 2009; Rizzolo et al., 2002). Therefore, it would be useful for students to have ample opportunities to assess their strengths and weaknesses in anatomy in the clinical years using online assessments. Formative assessment that is planned and deliberate allows students the opportunity to revisit, revise, consolidate and retain knowledge (Bahrick & Hall, 2005) while also providing them with immediate and regular feedback.

Attitudes of Clinicians and Surgeons Towards Students' Knowledge of Anatomy

There were two perspectives to the attitudes of clinical teaching staff towards students' learning and retention of knowledge. On one hand, students would look to clinicians and surgeons to help them assimilate and build upon their medical knowledge. This finding is supported by studies that show medical students look favourably upon teaching staff and value the support they offer in learning anatomy (Johnson et al., 2013; Mathiowetz et al., 2016). Experiential learning (hands-on experience—i.e., learning by 'doing') can be affected not only by the learner's motivation, confidence and commitment to learn but also by the learning environment itself (Eraut, 2004). Participants in our study felt that learning in the clinical years was most useful when the clinical staff took the time to teach and create a supportive environment from which they could learn. This is similar to findings from the

Australian Medical Education Study (Lawson & Bearman, 2007), where students found an active clinical environment that incorporated appropriate learning opportunities for students, with a certain degree of responsibility, as well as some degree of supervision, was highly conducive to enhancing the students' learning experience. Such results reinforce learning in the workplace theories which state that a supportive environment which provides proactive learners with plenty of opportunities to seek out and meet new challenges, while providing feedback help to develop a learner's confidence in the workplace and their motivation to learn (Billet, 2001; Eraut, 2007, 2008).

In contrast, when the workplace environment is unfavourable towards learning, and is accompanied by poor working relationships, lack of encouragement and trust among colleagues, students become demotivated, less confident and less likely to seek out opportunities to enhance their learning (Billet, 2016; Eraut, 2007). This was evident during the interview with participants who claimed to be discouraged from learning anatomy when faced with teaching staff who demeaned and embarrassed students by barraging and intimidating them with questions until one was not answered correctly. One participant, reporting on experiences from both pre-clinical and clinical years, felt completely demoralised and demotivated to learn. Once again, similar findings were echoed by Lawson and Bearman's (2007) study, wherein students and junior doctors found intimidation, humiliation and ridicule of students by clinicians and senior staff to be the least appropriate and efficient way of teaching and learning.

The anatomy curriculum of today is far different and much less intensive as compared with that of the student's predecessors so perhaps a surgeon's criticism of students' knowledge of anatomy may reflect their predilection to being hard taskmasters (Herle & Saxena, 2011). If a surgeon compares their training in anatomy to that of the current student, they would probably feel that the knowledge medical students possess today is far less than what is required for a surgeon and hence there are bound to be negative perceptions and attitudes towards students. However, not all medical students move on to specialise in surgery. For the majority, their main exposure to surgery will be when they encounter it as part of their clinical rotations. When students encounter negative experiences during their surgical rotation, it most likely puts them off specialising in such a field—something that surgeons should consider before they move to detract from the appeal of this specialty for students.

As voiced by one participant, knowledge accumulates over time and with experience. If clinicians, surgeons and consultants at clinical sites were to acknowledge this, it would make the learning experience of medical students much more fruitful and enjoyable on the wards. Studies (Lisk, Agur, & Woods, 2016; Woods, Brooks, & Norman, 2005; Woods et al., 2006) have shown that when students are exposed to the causal relationships between basic science and disease processes during teaching of clinical medicine, retention of knowledge and diagnosis of clinical presentations is improved. This is where anatomy revision becomes important in the clinical years as "basic science instruction allows students to develop a coherent framework for the understanding of clinical knowledge, which, in turn, prepares students for future learning" (Mylopoulos & Woods, 2014, p. 671) and this is where both students and surgeons can help one another. If students can refresh their knowledge prior to surgical rotations (through revision and formative assessment), then surgeons might feel more motivated to teach and present the relationships between anatomical structures and their implications for clinical procedures.

Much of the literature findings reported clinicians' and surgeons' views of medical students' anatomical knowledge to be negative with many stating that they had insufficient knowledge necessary to practice medicine safely (Staskiewicz et al., 2007;

Warner & Rizzolo, 2006; Waterson & Stewart, 2005). The results of our assessment clearly show a decrease in knowledge from the pre-clinical years. However, the majority of our participants from the interviews perceived the anatomy covered in the pre-clinical year did prepare them for the clinical years and the knowledge they had, while not the best, was sufficient to get around the wards, a finding similar to other studies which show that medical students in the clinical years and the majority of junior doctors in the UK rated their anatomy course as sufficiently preparing them for clinical placement (Lawson & Bearman, 2007; Leveritt et al., 2016). As some authors have suggested, the negative perceptions of students' anatomical knowledge are perhaps a manifestation of the unrealistic expectations of their predecessors (Chuang, Canny, & McMenamin, 2011).

Integration of Knowledge

Integration of basic science knowledge with clinical skills has been a major challenge in medical education especially since the Flexner Report of 1910 included basic science as a major component of medical education (Kulasegaram et al., 2013).

Many studies (Bhangu et al., 2010; Feigin et al., 2007; Jurjus et al., 2014; Waterston & Stewart, 2005) have called for the incorporation of vertical integration in the curriculum, viewing its principles of repetition and reinforcement in the clinical years as a necessity to help students retain knowledge well into clinical training. The whole concept of integration is associated with the cognitive activity that occurs in the mind of the learner when learning takes place. That is, the focus of integration should be learner-centred, focusing on changes that occur as students explore the basic and clinical sciences together. It is important to note that simply creating curricula that are integrated may not necessarily lead to cognitive integration (Kulasegaram et al., 2013). For integration to be successful, it must be intentional—that is, it must be teacher-led and driven by a need for both basic scientists and clinicians to demonstrate the importance and effect of science and medicine working together. Therefore, the content, not the delivery method is important when considering the design and implementation of integrated curricula.

The findings from our study that knowledge declines significantly over time supports this notion of integration and provides evidence that knowledge must be revisited during the clinical years to be retained. During the interviews, students identified the lack of vertical integration in the Monash medical curriculum and site-dependent opportunities as some of the reasons for their downfall in retaining anatomical knowledge. Although participants felt that the anatomy taught during the pre-clinical years was of a sufficient level to provide them with a foundation to enter clinical placement and participate in the day-to-day activities expected from a medical student, studies have shown that learning can only be consolidated when it is revisited and relearned over time (Feigin et al., 2002, 2007; Magid et al., 2009). And the medical curriculum in which these students are immersed, appeared to fail to integrate anatomy through all four years. Subsequently, students are left to their own devices to self-direct their learning which amid learning clinical medicine and building upon clinical knowledge was considered a fraught task. If there was a specific need for anatomy on a clinical rotation, participants would consider undertaking some sort of revision pertinent to that rotation. Although some participants had opportunities at their clinical placements for revision and informal teaching that occurred through bedside teaching, not all were fortunate in this regard. Students who were placed in rural hospitals valued the experiences gathered through working in those environments as there was less competition for clinical experience because of smaller numbers of students at these sites when compared with metropolitan hospitals. Consequently, students at rural placements were afforded more opportunities to learn and practice their skills, subsequently taking on greater responsibilities. This is similar to a study by Lawson and Bearman (2007), students rated rural rotations as the best in terms of the experiences offered by such placements. This further supports the notion that on-the-job learning is an essential component of the learning experience (Eraut, 2007) and that learning and active participation in the workplace go hand in hand in terms of enhancing the student's learning experience (Billet, 2001). Therefore, the type of activities that we offer students in the clinical environment can affect how much knowledge they build upon and retain.

The consensus from participants in our study was to integrate some sort of anatomy revision through the clinical years to reinforce and build upon their anatomical knowledge, a finding similar to other studies wherein 73% of junior doctors called for vertical integration in the clinical years (Leveritt et al., 2016) and medical students called for anatomy revision sessions, especially during surgical placements (Insull et al., 2006). Students are more likely to request formal teaching in the clinical years as this leads to deliberative learning and it is here that students recognise that the activities with which they have been formally engaged have contributed to their learning (Eraut, 2000). However, acquisition of knowledge obtained through simple exposure to clinical anatomy in the clinical settings (example – time spent in operating room) is not sufficient to increase recall or maintain knowledge (Jurjus et al., 2016). What facilitates better retention and deeper understanding is the application of content to a variety of different settings and contexts (Pandey & Zimitat, 2007).

Thus, although studies have shown that the design of a curriculum is essential to providing students with appropriate learning environments in which they can assimilate and build upon knowledge (Sugand et al., 2010), what curriculum experts need to bear in mind is how to prepare medical students to meet the basic demands of a variety of different specialties in medicine, all of which require a foundational knowledge of anatomy. This can only be achieved by creating space within the curriculum for horizontal and vertical integration to occur. In providing students with foundational anatomy knowledge that is clinically relevant in the pre-clinical year, in allowing them the opportunity to revise basic knowledge in the clinical years and in ensuring that content is revisited in different settings pertinent to their clinical rotations, medical educators become engaged in acts that not only foster integrated teaching but also encourage integrated learning (Kulasegaram et al., 2013).

Therefore, to produce such a change within the curriculum and incorporate vertical integration, multiple factors must align. These include willingness by staff to integrate knowledge; acceptance that students cannot learn every single detail and therefore, careful selection of what should be taught must be decided and agreed upon by the various curriculum experts; collaboration between basic scientists and clinicians to develop learning sessions that emphasise the importance and value of the topic under discussion; collaboration between academic teaching staff and curriculum experts to incorporate vertical integration into the existing framework; sufficient resources allocated to staff to allow for development and implementation of key learning activities, and finally; design of appropriate assessments to ensure competence.

Of course, in ensuring that we have integration within our curricula, we must ascertain that “the science is not diluted to the point where there is a lack of understanding of the scientific process and a lack of integration within each biomedical discipline that reduces anatomy and physiology to mere instruments of present day clinical thinking” (Olowo-Ofayoku & Moxham, 2014, p. 986). This issue was raised by a high-performing participant who stated that while tutorials were clinically relevant and good for making connections between the anatomical structures and their clinical implications and significance, the focused nature of the clinical questions acted as a hindrance because students quickly went in search of the ‘right answer’ rather than exploring the anatomy around the region and building their knowledge to incorporate more than just the clinical facts.

To help bridge the gap in students’ knowledge of anatomy in the later clinical years and reduce the significant number of students who feel they have lost out on their anatomy knowledge, institutions could provide additional electives (Brooks et al., 2015). These additional and optional courses are viewed quite positively by students (Ramsey-Stewart et al., 2010) and would provide them with an opportunity to revisit their anatomy should they want to pursue a specialty that requires a much more detailed knowledge of anatomy (e.g., surgery, radiology, or emergency medicine). Thereafter, advanced anatomy courses can be developed and offered that are specific to the practical needs of each specialty to help students meet the demands of residency and specialist training (Orbson et al., 2014).

It is impracticable to expect students to remember content that has been taught in one or two pre-clinical years, but that has not been formally institutionalised in the clinical curriculum. However, what is also important to remember is that while content initially learned is forgotten when not used, the fact of having learned it once before leads to rapid relearning the next time that it is introduced and much better scores when assessed (Magid et al., 2009). Therefore, curriculum experts, medical educators and clinicians must be reminded that long-term learning and retention requires constant revisitation, repetition and assessment to allow integration of old facts with new material. Only then does it lead to long-term consolidation and intellectual maturation of the student (Gagne, 2004; Magid et al., 2009).

8.5 Research Limitations

There are a number of limitations associated with this study. First, students were given notice of the formative assessment and therefore could have prepared for the test, resulting in a possible bias of results. However, the difficulty of the assessment and low scores from participants makes this unlikely as the results suggest that participants engaged in this assessment task to measure their own base level of knowledge.

Given that approximately 50% of the cohort population offered their time for this study (which is to be expected when using volunteers in a study), the issue of selection bias must be considered. It can be argued that it is usually the better students who participate in a study. Therefore, these results may not be applicable to the general population of medical students. To assess this, the summative VIA scores of participants were compared with those of non-participants. As expected, the mean performance of the participant group on the VIA was higher than the non-participants by approximately 4% in the Year B and Year C clinical cohorts and by approximately 8% in the Year D cohort. Lack of access to non-participant data meant that statistical analysis could not be conducted. However, if our results show that knowledge declines in a group of students who appear to be the better participants from their cohort, one could perhaps argue that that performance from the non-participants would be similar or lower?

The anatomy questions chosen for assessment were limited and not fully representative of all topics covered in curriculum. Additionally, only one assessment method was utilised in the testing process (i.e., MCQs/EMQs) with the questions consisting of the theoretical aspects of anatomical knowledge and not the practical component (e.g., there were no image-based questions or practical test). Therefore, while students may have performed at a low level in this area, it cannot be concluded that their knowledge in other aspects of anatomy is poor because students have different learning styles and consequently some students do better with some forms of assessment than others. However, the assessment tool utilised in this study emulated that of the anatomy component on the VIA and consisted of MCQs and EMQs framed around real-world problems. Therefore, it can be argued that the results are “adequately reliable and valid with respect to the cognitive processes” (Vorstenbosch et al., 2014, p. 114) required in using anatomical knowledge.

While the formative assessment may be regarded as a crude measure of students’ knowledge, it can be considered an objective test that reveals level of knowledge of individuals at different levels of training, similar to a study conducted by Spielmann and Oliver (2005), who examined only carpal bone anatomy. Further, a larger number of questions on the assessment would have called for a higher demand on students for their time and consequently, could have possibly dissuaded students from participation. Therefore, because of time constraints and gaining student participation, a limited range of questions was used. Nonetheless, efforts were made to select high-yield clinically oriented anatomy questions and experienced assessors contributed to their development and standardisation.

There is also the issue of unequal representation of cohorts in our sample which may have skewed overall results in favour of those who were better represented. However, the Year A (pre-clinical) and Year C (second clinical year) cohorts were two groups of participants where there was approximately 50% recruitment and the results from these two cohorts on the anatomy assessment also revealed the most statistically significant differences, thereby indicating that some loss of anatomy knowledge occurs in the clinical years.

Further, the timed response of this assessment task (i.e. the timer counting down on screen) required that participants think critically and quickly similar to the setting of a medical practice, particularly emergency rooms, and surgery where decision-making must occur rapidly and where there is little room for error. However, this exact feature could have also limited students' performance by shifting their focus on the ticking time clock rather than the question itself, hindering students from reading the question properly and answering it correctly (Attardi et al., 2016). Perhaps in allowing students more time to answer questions, it would have yielded different outcomes. Ideally administering a face-to-face quiz would be better, but constraints of time, location, travelling and commitment by students to all attend a quiz at a given time and location reduces the likelihood of participation and as shown, majority of students prefer online quizzes as opposed to face-to face delivery (Attardi et al., 2016).

Finally, our findings were based on data collected from one site and revealed anatomy knowledge among a group of graduate-entry students, who came from varying educational backgrounds and had one year in which to learn anatomy. As far as the literature has highlighted, the standard curriculum format in all other institutions within Australia consists of a two-year pre-clinical and a two-year clinical curriculum. Therefore, there might be limited generalizability to the population because of the unique curriculum and also the differences in student populations. However, one of the strengths of this assessment was that all four cohorts were subjected to the same entry requirements and experienced the same anatomy curriculum and teaching methods, thereby allowing for a comparison across cohorts. The results therefore provide evidence that the medical curriculum plays a key role in how students learn anatomy and this can be generalised to other institutions. Although knowledge does decline over time and this concept of decreased anatomical retention can be applied in other contexts

(Jurjus et al., 2014), our results also show that in a condensed fast-paced curriculum that is the medical curriculum of today, knowledge acquisition in the pre-clinical years is perhaps the beginning point for what transpires to a loss of retention in the clinical years.

Chapter 9: Conclusion

Anatomy, which is the language of medicine (Gogalniceanu et al., 2010), forms the cornerstone of clinical practice. The discipline of anatomy has been central to the education of medical and healthcare professions around the world (Abu-Hijleh, 2010; Raftery, 2006; Sugand et al., 2010). Thus, such training—particularly in medical schools—is seen to provide the foundation upon which specialty training can be developed (Lawson & Bearman, 2007).

A review of the history of anatomy education shows that the amount of time devoted to the teaching of anatomy has declined considerably over the past century, and the anatomy curriculum has subsequently undergone a range of curriculum and delivery changes (Craig et al., 2010; Drake et al., 2002, 2009, 2014; Leung et al., 2006). Even in modern medicine, teaching hours have declined since the medical education reform in the 1980s. These changes have been attributed to three main factors. The first is *pedagogical*, in which integrated, PBL and systems-based curricula have replaced the traditional curriculum in most schools (Drake et al., 2014; Klement et al., 2011; Louw et al., 2009; Muller et al., 2008). The second is *economic/financial*, whereby dissection facilities are scarce among institutions worldwide because they require a good source of cadavers. Body donation programs are required, which necessitate time, money and resources that institutions are unable to provide (Leung et al., 2006; Older, 2004; Sugand et al., 2010). The third is *temporal*, because the addition of other course content to the curriculum has resulted in a condensed anatomy curriculum. Further, there is pressure to reduce pre-clinical curricular time to free up more time for the teaching of clinical medicine (Drake et al., 2014; Wilkerson et al., 2009). As Cottam (2012) states, ‘the educational landscape has changed. The students, the integrated and clinical nature of the curriculum, the changing role of the educator, the skills that are assessed, and the sources of anatomical information and emphasis needed have dramatically changed' (p. 679). There has also been an emphasis on competency-based programs, which have contributed to a reduction in time and a focus on outcomes in education (Frank et al., 2010).

As a result of these changes, clinicians and surgeons have stated that the de-emphasis of anatomical knowledge in the curriculum has resulted in medical students and graduates possessing poor knowledge of anatomy such that it is unsafe for them to practice medicine (Cottam,1999; Standring, 2009; Waterson & Stewart, 2005). Further, reduced teaching hours combined with modern approaches to teaching leave medical students and graduates feeling less confident in their anatomy knowledge (Fitzgerald et al., 2008; Lawson & Bearman, 2007; Prince et al., 2003). Given these concerns, and knowing that anatomy forms part of the pre-clinical curriculum in any medical school, the question of identifying the true nature of anatomy knowledge was essential to understanding the phenomenon being observed by the larger medical community. If all students are failing to retain knowledge that has been taught during the pre-clinical years, then the modern medical curriculum is failing to prepare graduates to practice medicine safely. Different medical schools operate under different curricula; therefore, it is difficult to achieve educational equivalence across the medical curriculum. While institutions try their best to achieve this through consultations with curriculum experts and clinicians, the experiences of students need to be heard to better understand the problems being encountered in the pre-clinical and clinical years. Given that the students of today are the doctors of tomorrow, it is important to identify and understand the gaps in knowledge acquisition and retention so that intervention strategies can be developed. This has significance not just for students, but also for patients and the larger medical community. The question of whether students lose key knowledge of anatomy in the clinical years and whether they are poorly prepared for clinical training, as indicated in the literature, or whether they are not learning anatomy properly the first time around had to be investigated, along with what regions of anatomical knowledge were most easily retained or lost and why. Therefore, this study set out to explore anatomy learning and retention in one Australian graduate-entry medical school. This is the first study of its kind in Australia and New Zealand. Although all students entered the graduate-entry program from a variety of prior educational backgrounds, and hence had varying degrees of anatomy knowledge before starting medical school, they were instructed in the pre-clinical year according to the same anatomy curriculum and used similar teaching and assessment methods, thereby allowing for a comparison across cohorts.

Students in this study had received one pre-clinical year of formal anatomy teaching, after which time their exposure to anatomy and formal teaching of anatomy in the clinical years was highly varied and dependent upon clinical sites. Therefore, the topic of learning and retention was explored through both quantitative and qualitative means using the theoretical frameworks of post-positivism and constructivism to answer the three research questions:

- How does anatomy knowledge differ among students in the pre-clinical and clinical years of the MBBS course?
- To what extent do medical students retain anatomy knowledge?
- What factors may account for the loss or retention of anatomy knowledge across a student’s medical degree?

The hypothesis for this study was similar to that of past retention studies (Feigin et al., 2002, 2007) in that students’ knowledge of anatomy would decline over time as they progressed from the pre-clinical year (where anatomy was formally taught and assessed) to the clinical years, where such activities were highly varied. However, this study is unique because it explored knowledge of all seven anatomical regions and did not focus on only one topic, as many other studies have done (Feigin et al., 2002, 2007; Meyer et al., 2015; Speilmann & Oliver, 2005). Further, the factors accounting for the retention or loss of anatomy knowledge were also explored through qualitative mechanisms (a feature not addressed in other studies), with the potential hypothesised contributors to such loss of knowledge being lack of formal teaching and anatomy assessments in the clinical years, lack of opportunities for vertical integration of learning and subsequent lack of student motivation to specifically study and/or revise anatomy. Hypothesised contributors to the retention of anatomical knowledge were learning styles, with deeper understanding facilitating better retention, interest in anatomy and perhaps motivation through future career aspirations such as surgery, which would require extensive knowledge of anatomy.

To summarise the findings of this study, participants in the pre-clinical years performed better on the formative anatomy assessment task than participants in the clinical years, with the most statistically significant difference in knowledge evident between that of the pre-clinical students and Year C students (i.e., clinical students in the second-last year of the MBBS program). Additionally, one of the strengths of the study was that it not only measured factual knowledge, but it also provided insights into learners' capacity to apply anatomical concepts to clinical problems (Kulasegaram et al., 2013). We could not assess clinical reasoning directly because students could have arrived at the answer by choice; however, our findings indicate that overall, all students were better at recall but poorer on application and analytical-type questions:

> Given this evidence, integration of curricula should focus on efficiently and effectively promoting the cognitive meshing of content knowledge from basic

> and clinical science. This linking is likely achieved most effectively at the level at which students make direct contact with the content of the formal curriculum: the teaching sessions. (Kulasegaram et al., 2013, p. 1581)

When comparing retention of anatomy from when participants were in the pre-clinical year, those in the final two clinical years (Year C and Year D) demonstrated a statistically significant lower level of knowledge. Although the limitations of the study, in particular the use of the VIA scores as a non-equivalent baseline, has been acknowledged in in the thesis, the similarities of the assessment tools for the VIA and the anatomy assessment, followed by the similarity of difficulty of both assessments (as indicated by the borderline) suggests that there is some loss of knowledge from the pre-clinical to clinical years. Further, the findings of this study, obtained through a mixed-methods approach suggests that this decline of knowledge over time occurs particularly when students are not exposed to the content on a regular basis either via formal instruction of anatomy in the clinical years or frequent clinical exposure to different anatomical regions. Across all cohorts, knowledge of anatomical regions (thorax, abdomen and lower limb) that was either most recently covered in pre-clinical teaching or was most often encountered during training in the clinical years (through cardiovascular respiratory, gastrointestinal and lower limb cases) was better retained than their counterparts. These findings support those of other retention studies (Custers et al., 2011; Feigin et al., 2002, 2007), which found that knowledge of anatomy is much better at the time when content is delivered and assessed (as it is in the pre-clinical year), and it is most likely forgotten and subsequently declines over time when it has not been relearned or revisited (which occurs during the clinical years). However, the results of this study highlight a significant problem that has not been discussed much in the literature before—that is, the problem of anatomy knowledge acquisition. A mean performance of only 60% among pre-clinical participants, students who had received frequent formal teaching in anatomy during the year and multiple summative assessments suggests that students are not learning anatomy to a high standard the first time around. In fact, performance in the pre-clinical years was mainly affected by a condensed medical curriculum and fast-paced anatomy curriculum, resulting in a cognitive overload (Kirsh, 2000). Participants said that this resulted in them using predominantly surface or strategic approaches to learn anatomy (Eizenberg, 1988).

For effective learning to take place:

> the design of courses needs to be underpinned, either explicitly or implicitly, both by theories of student learning but also by the more practical theories of instructional learning and course design that seek to give practical guidance to the designing of courses. (Smith et al., 2014, p. 270)

Perhaps what then needs to occur is a modification of the existing curriculum to match Flexner's philosophy of education. Curriculum experts need to examine the different disciplines that are compressed into the pre-clinical teaching years and examine the necessity and timing of each. To allow students the opportunity to learn and develop their critical thinking skills, a balance must be struck between the extraneous and intrinsic loads (Moscova et al., 2015). The effectiveness of a curriculum that is primarily constructed around the basic sciences while also incorporating social sciences and clinical skills was evident in a study by Wilkerson et al. (2009), whereby the authors implemented the principles of cognition and learning to deliver a curriculum using the AIDERS mnemonic (attention, interpretation, deep understanding, exposition, reinforcement/restructuring and social construction). This led to a PBL curriculum consisting of system-based blocks with disciplines of anatomy/pathophysiology, genetics, pharmacology, clinical skills and clinical reasoning integrated within each block. This is supplemented by traditional lectures, active and collaborative learning (i.e., small-group work) and experiential learning (i.e., hands-on laboratory sessions), and it concludes with a formative assessment at the end of each week. This block system was effective because it allowed students to direct their focus and attention towards a smaller set of topics, thereby creating a manageable cognitive load. Having less class time for students and limiting the number of other courses they needed to focus on enhanced students' self-directed study, gave them time to process content learned during the week and enabled the integration of different disciplines within the system.

In the clinical environment, workplace-based environments that were not supportive of participants' learning (such as clinical educators who were unaware of what needed to be taught, who taught to an extremely high level or who barraged students about their knowledge) affected participants' ability to use the opportunities and experiences available to learn, with some stating that it even demotivated them (Billet, 2001; Eraut, 2007). Further, the lack of opportunities for anatomy revision, which mainly occurred informally through bedside tutorials and was site-specific, combined with increased pressures to learn about diseases, diagnosis, treatment and management in the clinical years, meant that participants had limited time in which to review previous anatomy knowledge. This was compounded by the lack of formal teaching of anatomy via vertical integration and a lack of formal assessments of anatomy in the clinical years (although anatomy was indirectly assessed during clinical written examinations and OSCEs).

This study shows that the integration of basic science and clinical knowledge is highly valued and used, especially in the teaching of anatomy during the pre-clinical years. However, vertical integration of basic science and clinical medicine is not formally institutionalised in the later clinical years, and students ultimately suffer a loss of anatomical knowledge, particularly in regions where this knowledge has not been applied or relearned. This was evident in the results, with students scoring low on regions of anatomy that they had the least exposure to on the ward (i.e., head and neck, back, upper limb). Facilitating knowledge transfer from one context to another necessitates the integration of basic science and clinical concepts early in the pre-clinical years, along with the use of difference clinical problems to identify commonalities within each of these (Norman, 2009). This will assist with retention of anatomical knowledge in the later clinical years, which can be further facilitated through integration and revisiting content learned in the pre-clinical years (Custers, 2010; Drake, 2007). As studies have shown, schools that devote more time to anatomy teaching and that integrate anatomy with clinical aspects of the course and revisit anatomy later in the curriculum record higher anatomy scores than other schools (Bergman et al., 2008; Prince et al., 2003).

In terms of whether anatomy teaching was sufficient in Year A, participants felt that the content covered in the pre-clinical year was adequate to prepare them for the clinical years. Although overall means on the formative anatomy assessment decreased as cohorts moved further into clinical training, not all participants demonstrated decreased knowledge. Participants who performed well on anatomy in the clinical years were high achievers in the pre-clinical year. They indicated a preference for developing their knowledge base in anatomy, as well as having opportunities for informal anatomy teaching during their clinical placements. Therefore, claims from the larger medical community that anatomical knowledge of medical graduates is declining has some merit, but it does not hold true for all students. As a clinician reports, students' knowledge in the wards varies; some students are excellent and some are not as good

(Leveritt et al., 2016). To understand the reports from clinicians and surgeons on students' poor anatomy knowledge in the wards, one must consider clinicians' expectations of students' knowledge. From their perspective, the training that clinicians received decades ago must be considered because it varies substantially from the anatomical training that medical students receive in the modern curriculum. With advancements in medicine and technology, modern clinicians have different expectations of medical students and graduates. They must understand the body from a clinical and disease-based perspective, and they must be able to use medical imaging tools to interpret and diagnose illnesses—all in a shorter period than their predecessors would have had. Additionally, they must possess sufficient knowledge of anatomy and continue to enhance that knowledge throughout their career (Rizollo et al., 2006). Consequently, the basic knowledge that a graduate of today is expected to possess differs from and outweighs that of a medical graduate 20 or 30 years ago. Given these expectations, the literature findings are not surprising, although one can question whether they are warranted. However, this study reveals that, in addition to condensed curricular time, lack of integration of knowledge and fewer assessments on anatomy in the clinical years, factors such as career aspirations/motivation, interest in anatomy, and approach and attitude towards teaching and learning also influence knowledge retention.

Currently, there is an international debate on the different modalities of instruction and which one offers the best solution to increasing anatomical knowledge (Pabst, 2009). However, to date, there is no definitive answer. With globalisation, institutions comprise students and educators from different educational and cultural backgrounds, and as research has shown, there are obvious learning differences among different cultures (Mitchell et al., 2009). Therefore, to assist students in this regard, a multimodal approach to teaching anatomy should continue to be employed, and adequate guidance must be provided to students within each of the teaching modalities, because SDL can falter without proper guidance. Overall, participants in this study were positive in their learning experiences when these involved small-group teaching that actively engaged them in their learning, and when content was clinically related. However, given that anatomy teaching and its resources have dwindled over the past few decades, the question to ask relates to how to maximise the teaching of content in this discipline without compromising quality. This can best be achieved through vertical integration—that is, subsequent revisitation of pre-clinical anatomy in the clinical years, but with progressively more clinical content to showcase the clinical relevance of the topic (Smith et al., 2014).

The shift in pedagogical instruction of anatomy from the traditional discipline-based curriculum to an integrated and interdisciplinary curriculum has been gradually increasing over the past two decades. While many reasons have been cited for this phenomenon, one of the most important reasons is that clinicians must integrate basic science knowledge and clinical knowledge when treating a patient. Therefore, it is imperative to frame the curriculum in a similar manner (Brooks et al., 2015) while training students to become doctors. However, the constant call for integration within the literature and the urge to view this as a priority in medical education suggests that "integration is not a solved problem" (Kulasegaram et al., 2013, p. 1578). Through the reintroduction of content and clinical association, students will be able to increase their understanding and subsequent retention of that knowledge (Mann, 2002). According to adult learning theories, when students use prior learning experiences, their application of newly acquired knowledge is enhanced (Lazarus et al., 2014; Phillips, 1995); thus, our curricula must seek to improve this outcome.

Our findings also reveal that medical educators play a big role in influencing how students approach the learning of anatomy. The Monash medical curriculum has undergone significant modifications, from a six-year curriculum in its inception in 1961 to a five-year curriculum adopted post-2000, to the addition of a four-year graduate-entry medicine program that commenced in 2008 (Solarsh et al., 2012). This graduate program is unique in that it consists of a 1:3 split across pre-clinical to clinical experience, as opposed to a 50:50 split between pre-clinical and clinical training offered by other graduate-entry programs in the country. While the curriculum is based around four longitudinal themes that “vertically integrate the basic biological, population and social sciences with clinical practice” (Solarsh et al., 2012, p. 807) across the four years of study, this study has shown that this is far from what occurs. The difficulties in communication and monitoring across a distributed program have resulted in wide-ranging experiences for students. While this is not necessarily a bad thing, and one cannot maintain absolute consistency in clinical environments, it should be reasonable to assure students across all sites that their experience in the clinical setting will evolve around clearly prescribed and common curriculum content. Yet, excerpts from participants reveal that many clinicians on site are oblivious to what needs to be taught and to what level of detail. This is contrary to the usual procedures outlined by institutions, which state that courses are delivered with the same content and in the same way across sites. Often, students do not acquire learning experiences that their peers at other sites have obtained (Solarsh et al., 2012). This study’s results not only emphasise the continued need for constructive alignment (Biggs & Tang, 2008) and for experts to design a curriculum that is context-appropriate and specific to the profession, but also to develop tutor training programs that highlight the pedagogical aspects of teaching and the roles that medical educators play in today’s medical curriculum (Trigwell et al., 1999). Although compliance from educators is an issue, this could be achieved by incorporating students' evaluations of the tutors, which would allow tutors to attain meaningful feedback on their performance and identify areas for further improvement (Whelan et al., 2016). Participants highly valued tutors who demonstrated a passion for teaching while keeping content clinically relevant compared with those who were unaware of the curriculum or who wanted to showcase their knowledge. As Pawlina (2010, p. 1) states, "great teachers are valuable commodities now more than ever". In the face of increasing pressure on academic institutions to generate economic growth and the subsequent increase in recruiting research-based academics and clinicians, there is an increasing need to introduce innovation in education. Therefore, non-medically qualified or teaching-focused individuals are now being recognised for their high-quality teaching, and many institutions are working towards retaining and advancing the careers of such individuals by promoting teaching and learning (Pawlina, 2010).

Given the importance of anatomy in clinical practice (Berman, 2014; Cottam, 1999; Davis, et al., 2014; Herle & Saxena, 2011; Kerby et al., 2011; Standring, 2012; Sugand et al., 2010), there has been an outcry at the declining knowledge perceived to be present among medical students and new graduates (Cottam, 1999; Craig et al., 2010; Gogalniceanu et al., 2010; Herle and Saxena, 2011; Singh et al., 2015; Waterston & Stewart, 2005), and the fact that assessments drive students' behaviour towards learning (Newble & Jaeger, 1983). Therefore, institutions need to revise their curricula to reduce cognitive overload, introduce active forms of teaching and learning to achieve better knowledge of anatomy, incorporate more assessments into anatomy and design effective tools to test anatomical knowledge and administer them frequently—especially during clinical training. Only then can we be confident that medical students are attaining anatomical competence. The findings of this study show that students do not lose all anatomical knowledge, and knowledge that is retained is related to frequent clinical exposure to those anatomical regions on the wards, thereby emphasising the value of the workplace environment and workplace-based learning (Billett, 2001, 2004; Eraut, 2004, 2007, 2008). Therefore, our results support the conclusion that no matter what the curriculum model, students' knowledge of anatomy is affected by the amount of time spent learning anatomy, the clinical context associated with anatomy teaching, and the revision and integration of clinical anatomy knowledge in medical training (Bergman et al., 2008). Students are more likely to thrive when there is consistency in delivery, more exposure to anatomy in clinical sites, and more time to learn, assimilate and test their knowledge. These factors can all be generalised to the larger population of medical programs globally.

9.1 Recommendations

This study set out to explore anatomy learning and retention among medical students in a graduate-entry MBBS program. The findings presented in this study have highlighted issues surrounding the medical curriculum in one graduate-entry institution, and they have provided insights into gaps in knowledge among students and why these gaps occur. This section outlines how we can address these gaps.

The literature views the threat to anatomy in the modern curriculum as being manifold, including increased workloads and pressure on students and clinical services, a lack of qualified teachers, a lack of opportunities for learning anatomy in the clinical environment, and increased pressure to research in academic departments (Raftery, 2007). The findings in this study suggest that there are areas for optimisation within the MBBS program and areas where we can facilitate improvement going forward.

Recommendation 1: The pre-clinical curriculum needs to be reviewed and revised in the first instance to reduce cognitive overload, because overcrowding and the amount of information that students are expected to learn can be overwhelming.

Given that basic science knowledge is viewed as the "cognitive framework for anchoring clinical knowledge" (Kulasegaram et al., 2013, p.1581), medical education experts need to ensure that their curriculum allows students to achieve cognitive integration. In a compressed curriculum, students are overloaded with so much information that the learning process is hindered and they are unable to process knowledge in a deep manner. Both horizontal and vertical integration need to be thoughtfully designed and implemented in the curriculum. Of course, "simply presenting basic science in close proximity to clinical knowledge may not guarantee the putative benefits of integration" (Kulasegaram et al., 2015, p. s67). That is, scheduling a basic science lecture and clinical lecture on the same day might not necessarily lead to integration. There must be faculty buy-in from all interested parties (Kulasegaram et al., 2015). To facilitate better learning and the subsequent retention of learned knowledge, the teaching of basic sciences must be embedded and contextualised so that learners can appreciate the true significance of content and its relation to the clinical sciences and medicine. Subsequently, this leads to conceptual coherence and better diagnostic abilities and patient management (Kulasegaram et al., 2013; Woods, 2007). Such integration can be achieved not only through PBL and small-group teaching sessions in the pre-clinical years, but also through back-to-base science days during clinical rotations and shared teaching models that seek to engage students in a truly meaningful learning session.

Recommendation 2: The opportunities afforded by the workplace should be widespread in that they should provide students with a variety of experiences to advance their learning. Further, the core curriculum should be communicated clearly and simply to clinical educators so that the communities of practice come together to support students appropriately.

The findings in this study suggest that although there is a decline in students' anatomical knowledge, all is not lost; knowledge of regional areas that have the most clinical exposure and those that are relevant to current learning are retained; thus, efforts must be made by curriculum experts and clinicians in the workplace environment to increase exposure to all regions of anatomy in the clinical years to optimise learning during this period. This can be achieved by establishing core competencies for anatomy. Developing a core national curriculum for anatomy that is similar to what exists in the UK would be the first step towards resolving the anatomy debate on a national scale. However, on a smaller scale, it would be useful for each institution to have its own set of core anatomical competencies that are made explicit to all parties and that must be followed by all sites in the clinical years. This would ensure that students receive similar learning experiences regardless of where they are placed during clinical training. Specifying the curriculum in this way allows instruction to occur in a formal setting as opposed to a setting in which the student may or may not be fortunate enough to have someone teach a particular concept.

Recommendation 3: Enhance both horizontal and vertical integration (Bhangu et al., 2010; Fitzgerald et al., 2008; Waterston & Stewart, 2005) to link relevant teaching of anatomy, pathology and clinical exposure to key conditions in the clinical years.

Although participants valued the importance of anatomy in medicine, this realisation tended to occur during the clinical years, when the lack of formal anatomy teaching placed additional pressure on students to undertake more SDL. This requires a significant effort on the part of students to schedule revision time for anatomy in an already-condensed curriculum. In light of student concerns over their anatomical knowledge (Ahmed et al., 2010; Mitchell & Batty, 2009; Smith & Mathias, 2011), an anatomy refresher course, could be introduced to help students revise their knowledge in the clinical years, as suggested by participants. As demonstrated by Jurjus et al. (2016), an anatomy refresher course that is incorporated during the clinical years as a sort of a flipped classroom approach can assist in addressing students' deficit in anatomy knowledge while subsequently improving clinically relevant knowledge of medical students on a clinical placement. Therefore, in designing an anatomy curriculum and creating pathways for vertical integration, significant cross-links must be made between anatomy and medicine with ties to clinical applications to facilitate better knowledge transfer (contextualisation) and recall in the wards and thereafter.

Recommendation 4: Students' performance and progress in anatomy knowledge should be monitored with the aim of providing remediation.

As stated by Larsen et al. (2009), retrieval practice is essential to boosting long-term retention. Therefore, to increase retention, there must be repetition of content in a variety of different forms and, to offer remediation to students in need, any knowledge gaps that exist need to be identified. Only then can appropriate tools of remediation be developed. To ensure equity of access, a standardised formative assessment tool for competence could be implemented via e-modules at the beginning and/or end of a refresher course to allow students to gauge whether their knowledge is at an acceptable level (Jurjus et al., 2014). This could consist of a pre-test, interactive learning activity and post-test structure that is further supplemented with hands-on learning experience (Ramsey-Stewart et al., 2010) perhaps offered through cadaveric or virtual exposure in the first instance and opportunities for practicing procedures later in the clinical years.

The results of students' performance on formative tasks associated with the refresher modules could be used by faculty as a guiding tool to offer further support and remediation for students who appear to be struggling with the discipline. Of course, care must be taken when deciding how often to administer/offer formative assessments because participation and compliance declines if these are administered too often (McNulty et al., 2015). However, the useful predictive validity of the Year A VIA might also allow us to identify students who need further teaching, revision and monitoring within the spiral curriculum.

Recommendation 5: Prior to graduation and during residency, all students should undertake a licensing examination that assesses various components of their anatomical knowledge, similar to step 1, 2 and 3 of the licensing examination (USMLE) that medical students and graduates undertake in the US.

If a national examination existed, it would ensure some form of quality control because all medical graduates in Australia and New Zealand would be required to sit the assessment, regardless of the curriculum, teaching hours, mode of delivery and internal assessment they were exposed to during their medical program. In essence, it would "act as a de facto core curriculum, encouraging universities to prepare their students in the stated competencies of the examination" (Schiller et al., 2011, p. 10).

According to Korf et al. (2008), knowledge resides not only in books, but also in the mind. It survives through both production and reproduction, and it remains useless if it is not applied and practiced. Therefore, a standardised assessment would ensure that all students and graduates meet the necessary requirements for medical practice; consequently, this would assure the larger medical community that graduates are competent to practice medicine safely.

9.2 Implications for Future Research

Leveritt et al. (2016) find that graduate medical students are more confident in their anatomy knowledge at the beginning of a placement compared with the undergraduate cohort. Given that the direct-entry medical curriculum at Monash University consists of two pre-clinical years and three clinical years, and medical students have two years in which to learn anatomy, it would be interesting to examine the anatomy performance of students in the undergraduate medical program and compare it with students in the graduate-entry program. This could then be expanded to investigate students in other medical schools across different states and countries.

Assessing a student's knowledge can be a difficult task because the type of assessment modality used is MCQs, which relies on a combination of recall, recognition and analysis. As Jurjuis et al. (2016) states, "there is not a single agreed-upon measure of knowledge retention, and the length of time between knowledge acquisition and measuring recall or recognition to determine retention is fraught with ambiguity" (p. 342). Further, assessment scores provide little information regarding how knowledge is applied at the bedside and on the wards. If the goal of integration is to observe how cognitive changes occur within the minds of learners, then future research will need to focus not just on retention of basic science knowledge, but also on how that knowledge is applied in the clinical setting. Examining students' use of anatomical knowledge during clinical reasoning or in the performance of a clinical skill would provide valuable evidence of the effectiveness of integration.

This study did not explore visualisations and cross-sectional radiological anatomy in the formative assessment. Thus, while retention may have been lost over time, areas that are frequently encountered in clinical practice might have been retained. Further research is needed in this area to identify gaps in students' knowledge.

A final perspective that should be considered is that of medical educators. This could be explored in tandem with medical students to provide insights into the challenges faced by educators in academic institutions and in the workplace.

Overall, the results of this study show that in a compressed curriculum, students are forced to make decisions about their learning and how they approach it, perhaps not by choice but by the need to keep pace with the delivery of the curriculum which is relentless and to progress through each year of their medical degree. With the design of such a curriculum, the goal of medical education, which is to produce medical graduates who are capable and confident in their capacity to practice medicine safely, remains unaccomplished. By training students with a mindset to pass examinations, medical institutions are doing a disservice to themselves and the community. We need to instil confidence in our students and graduates, as well as in society and communities, that the doctors produced in medical schools are of the highest calibre. This can be achieved by reassessing and modifying the existing curriculum to reduce cognitive overload, creating frequent opportunities to formatively assess students' anatomical knowledge and subsequently making more room for students to learn efficiently. After all:

> a pre-clerkship medical curriculum succeeds to the extent that its students arrive on the wards with an organized approach for analysing their patient's problems and an ability to selectively draw on, interpret and apply information from the vast reservoir of material covered in the pre-clerkship years. (Wilkerson et al., 2009, p. 820)

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Appendices

APPENDIX A

Participant Information Form

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

INFORMATION TO PARTICIPANTS INVOLVED IN RESEARCH

You are invited to participate

You are invited to participate in a research project entitled "Anatomy retention among medical students in a graduate-entry MBBS course: A mixed-methods cross-sectional study"

This project is being conducted by a student researcher Michelle Machado as part of a Ph.D at Victoria University under the supervision of Dr. Marg Malloch with support from Dr. Cathy Haigh at Monash University.

Project explanation

Given that Anatomy forms the basis of clinical examination and is thus an important part of today's medical curriculum, the purpose of this study is to obtain a snapshot of anatomy knowledge among students currently enrolled in the pre-clinical (Year A) and clinical (Years B-D) years of the Monash Bachelor of Medicine, Bachelor of Surgery (MBBS) graduate-entry degree. In doing so, the aim is to examine the extent of a student's anatomical knowledge and to determine whether students receiving formal anatomy teaching (in Year A) retain more anatomy than those who are in the clinical years and whose source of revising and learning anatomy is more informal and unstructured. Ultimately, this may have an impact on the way the anatomy curriculum is delivered across an MBBS degree.

What will I be asked to do?

The project will be conducted in two phases. Phase One involves the provision of basic information and then an anatomical assessment task. If you consent to participate in this study, your name, e-mail address and student ID number will be recorded for future reference and you will be assigned a participant number. A week prior to the commencement of Phase One (to take place in late 2014), you will be emailed a link to an online site which can only be accessed on the specified date along with log-in details to access the site. The username will be listed as your participant number and a randomly generated password will be allocated to you.

On the date specified for Phase One, you will be able to access the online site containing some questions pertaining to your previous background and learning approaches to anatomy. Following completion of this, you will be directed to commence the anatomy assessment task. This will consist of 60 anatomical questions relevant to clinical practice and will incorporate questions from all regions of the body (head and neck, back, upper limb, lower limb, thorax, abdomen and pelvis). You will be allowed a total time of 1 minute per question with a maximum total time of 60 minutes to complete the assessment. The assessment task can only be attempted once and within the time period specified.

Once the assessment is completed, you will be provided with an immediate overall score on your performance as well as a breakdown of your score in each of the anatomical regions. The overall score of this assessment will be compared to your anatomy score in the Year A VIA, as this will provide more information to help develop the second phase. Upon completion of data analysis for Phase One, you may be requested to participate in Phase Two of the research (to take place in early 2015). This will be conducted through an interview of approximately 60-90 minutes and will allow the research team to gain further insight on the findings obtained in Phase One. During the interview, which will be audio recorded for later transcription, you will be identified as a participant number and your personal information will not be used or mentioned.

All personal information provided by the participant will be coded (assigned a number) and remain strictly confidential. The purpose of providing these details is solely to assist us in contacting you and in identifying you during the later stage of the research, so as to compare the data to your Year A data (VIA anatomy score) and to invite you to participate in Phase Two.

What will I gain from participating?

By participating in this research, you will gain an extra opportunity to test your knowledge and understanding of anatomy as it currently stands. This will allow you to determine where your strengths lie within the field of anatomy and to identify potential areas for improvement. It will also help you to prepare for the Year A and Year C VIA exams (when your turn comes). You will receive immediate feedback on your performance following completion of the assessment.

In addition, the research contributes to new knowledge and hence, your participation will be of great benefit to the medical community comprising students such as yourselves, universities and teaching hospitals as it would lead to a deeper understanding of the extent of a medical student's anatomical knowledge across an MBBS degree. The results could help to shape the anatomy curriculum within an MBBS degree with a potential benefit to the future cohorts and to you as mentors to future students.

How will the information I give be used?

The results acquired through the anatomy assessment task and through interviews will be analysed and used in the completion of a doctoral thesis for Michelle Machado. These results will be presented at conferences and will also be published in reports or relevant professional journals. This data will not be used for any other project or disclosed to external organisations. It is important to note that in the collection, analysis, storage and presentation of data, all identifiers (i.e. name, address, student ID) will be removed and replaced by a code and hence your identity will not be disclosed. However, it will be possible for the research team to re-identify you. This will be required so as to compare your data to your Year A mark and to invite you for an interview.

On the completion of this research, a summary of the findings will be made available to all participants. If you would like to receive a copy of the summary findings, please ensure that you contact a member of the research team after January 2016 and we will be more than happy to forward you a copy.

What are the potential risks of participating in this project?

There are no risks to your academic progress regardless of your decision to participate in this research. Detailed feedback on your performance on this anatomy assessment will be made available to you immediately following completion of the anatomy assessment task and can be used to gauge your own progress within the MBBS course.

If you should become concerned about your performance in the anatomy assessment or distressed following an interview, you are provided with an option to contact a member of the research team. You are also able to contact Dr. Carolyn Deans – Psychologist at the College of Arts, Victoria University at 03 9919 2334 or at Carolyn.Deans@vu.edu.au

More importantly, you have the right to withdraw from the data collection stage at any point during and up to one week following your participation in Phase One and up to four weeks following your participation in Phase Two (if applicable). You must contact any member of the research team within this time via telephone or e-mail to indicate your withdrawal of consent. You also have the opportunity to request that any and all data acquired from your participation not be used in the research provided that you give a written indication of your intention to withdraw consent within the specified timeframes. You must note however, that removal of any and all data from the research will not be possible if consent is withdrawn after the specified time.

How will this project be conducted?

As referred to above, the research will be conducted in two phases: a quantitative data collection phase comprising an initial questionnaire on previous background and learning approaches to anatomy followed by an online anatomy assessment task. This will be followed by a request to 'x' participants for the qualitative data collection phase comprising of a 60-90 minute interview.

Who is conducting the study?

Dr. Margaret Malloch **Chief Investigator** Director of Research Training College of Education Victoria University Ph.+61399194175 Email:marg.malloch@vu.edu.au	**Michelle Machado** **Student Researcher** Ph.D Student College of Education Victoria University Email:michelle.machado@live.vu.edu.au Tel: +613 5122 7106	**Dr. Catherine Haigh** **Co-supervisor** Year 4C Academic Coordinator Deputy Director Monash University School of Rural Health – Latrobe Valley and West Gippsland Tel: +61 3 5122 7238 Email: cathy.haigh@monash.edu

Any queries about your participation in this project may be directed to the Chief Investigator listed above.
If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

APPENDIX B

Consent Form

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

CONSENT FORM FOR PARTICIPANTS INVOLVED IN RESEARCH

INFORMATION TO PARTICIPANTS:

We would like to invite you to be a part of a study into 'Anatomy retention among medical students in a graduate-entry MBBS course: A mixed-methods cross-sectional study'.

The purpose of this research is to obtain a snapshot of anatomy knowledge among students currently enrolled in the pre-clinical (Year A) and clinical (Years B-D) years of the Monash Bachelor of Medicine, Bachelor of Surgery (MBBS) graduate-entry degree. In doing so, the aim is to examine the extent of a student's anatomical knowledge and to determine whether students receiving formal anatomy teaching (in Year A) retain more anatomy than those who are in the clinical years and whose source of learning and revising anatomy is more informal and unstructured. Ultimately, this may have an impact on the way the anatomy curriculum is delivered across an MBBS degree.

The project will be conducted in two phases. Phase One involves the provision of basic information and then an anatomical assessment task. If you consent to participate in this research, your name, e-mail address and student ID number will be recorded for future reference and you will be assigned a participant number. A week prior to the commencement of Phase One (to take place in late 2014), you will be emailed a link to an online site which can only be accessed on the specified date along with log-in details to access the site. The username will be listed as your participant number and a randomly generated password will be allocated to you.

On the date specified for Phase One, you will be able to access the online site containing some questions pertaining to your previous background and learning approaches to anatomy. Following completion of this, you will be directed to commence the anatomy assessment task. This will consist of 60 anatomical questions relevant to clinical practice and will incorporate questions from all regions of the body (head and neck, back, upper limb, lower limb, thorax, abdomen and pelvis). You will be allowed a total time of 1 minute per question with a maximum total time of 60 minutes to complete the assessment. The assessment task can only be attempted once and within the time period specified. Following this phase, the data will be analysed and results will be compared with your anatomy grade in the Year A VIA. Upon completion of analysis of the Phase One data, you may be requested to participate in Phase Two, which involves a 60-90 minute interview. The purpose of this phase is to gain an in-depth understanding of the pattern of results obtained in Phase One.

All personal data provided by the participants will be coded, and are required solely for the purpose of making comparisons to the participant's Year A data (anatomy scores) as well as to invite participants for an interview. Confidentiality will be maintained.

There are absolutely no risks to your academic progress regardless of your decision to participate in this research. Detailed feedback of your performance on this anatomy assessment will be made available to you immediately following completion of the assessment task and can be used to gauge your retention of anatomical knowledge within the MBBS course. Participants will also be provided with an option to contact a member of the research team if concerned about the performance on this assessment.

You also have the right to withdraw from the data collection stage at any point during and up to one week following your participation in Phase One and up to four weeks following your participation in Phase Two (if applicable). You must contact any member of the research team within this time via telephone or e-mail to indicate your withdrawal of consent. You also have the opportunity to request that any and all data acquired from your participation not be used in the research provided that you give a written indication of your intention to withdraw consent within the specified timeframes. You must note however, that, removal of any and all data from the research will not be possible if consent is withdrawn after the specified time.

VICTORIA UNIVERSITY
MELBOURNE AUSTRALIA

All of the research data obtained from participants and all results presented at conferences or published in journals will be de-identified (i,e, all identifying information will be removed and you will be assigned a number but the means to re-identify you is restricted to the research team).

CERTIFICATION BY SUBJECT

I, "[Click here & type participant's name]" of "[Click here & type participant's suburb]"

certify that I am at least 18 years old* and that I am voluntarily giving my consent to participate in the study:
"'Anatomy retention among medical students in a graduate-entry MBBS course: A mixed-methods cross-sectional study"
being conducted at Victoria University by: "Dr. Marg Malloch"

I certify that the objectives of the study, together with any risks and safeguards associated with the procedures listed hereunder to be carried out in the research, have been fully explained to me by:

"Michelle Machado"

and that I freely consent to my participation in this research and particularly to:

- being contacted during the research at the e-mail address provided for any information pertaining to the research
- participation in the initial questionnaire and the online anatomy assessment task
- the researcher accessing my anatomy grade in the Year A VIA.
- participation in an interview (if requested)
- the researcher utilising and publishing the de-identified data collected from both the anatomy assessment and interview process (if applicable)

I certify that I have had the opportunity to have any questions answered and that I understand that I can withdraw from this study at any point during and up to one week following participation in Phase One and up to four weeks following participation in Phase Two (if applicab
le) and that this withdrawal will not jeopardise me in any way.

I have been informed that the information I provide will be kept confidential.

Signed:

Date:

Any queries about your participation in this project may be directed to the researcher
Dr. Margaret Malloch
61 (3) 9919 4175

If you have any queries or complaints about the way you have been treated, you may contact the Ethics Secretary, Victoria University Human Research Ethics Committee, Office for Research, Victoria University, PO Box 14428, Melbourne, VIC, 8001, email Researchethics@vu.edu.au or phone (03) 9919 4781 or 4461.

[*please note: Where the participant/s are aged under 18, separate parental consent is required; where the participant/s are unable to answer for themselves due to mental illness or disability, parental or guardian consent may be required.]

V.1/2013 2 of 2

APPENDIX C

Research Ethics Approval

Quest Ethics Notification - Application Process Finalised - Application Approved

quest.noreply@vu.edu.au

Thu 7/10/2014 10:31 AM

To:Marg.Malloch@vu.edu.au <Marg.Malloch@vu.edu.au>;

Cc:michelle.machado@live.vu.edu.au <michelle.machado@live.vu.edu.au>; cathy.haigh@monash.edu <cathy.haigh@monash.edu>;

Dear DR MARGARET MALLOCH,

Your ethics application has been formally reviewed and finalised.

» Application ID: HRE14-139
» Chief Investigator: DR MARGARET MALLOCH
» Other Investigators: MS Michelle Machado, DR Catherine Haigh
» Application Title: Anatomy retention among medical students in a Graduate-Entry MBBS course: A mixed-methods cross-sectional study (Please note this title is slightly different to the one presented at confirmation. An application to amend the title will be made later in the year).
» Form Version: 13-07

The application has been accepted and deemed to meet the requirements of the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007)' by the Victoria University Human Research Ethics Committee. Approval has been granted for two (2) years from the approval date; 10/07/2014.

Continued approval of this research project by the Victoria University Human Research Ethics Committee (VUHREC) is conditional upon the provision of a report within 12 months of the above approval date or upon the completion of the project (if earlier). A report proforma may be downloaded from the Office for Research website at: http://research.vu.edu.au/hrec.php.

Please note that the Human Research Ethics Committee must be informed of the following: any changes to the approved research protocol, project timelines, any serious events or adverse and/or unforeseen events that may affect continued ethical acceptability of the project. In these unlikely events, researchers must immediately cease all data collection until the Committee has approved the changes. Researchers are also reminded of the need to notify the approving HREC of changes to personnel in research projects via a request for a minor amendment. It should also be noted that it is the Chief Investigators' responsibility to ensure the research project is conducted in line with the recommendations outlined in the National Health and Medical Research Council (NHMRC) 'National Statement on Ethical Conduct in Human Research (2007).'

On behalf of the Committee, I wish you all the best for the conduct of the project.

Secretary, Human Research Ethics Committee
Phone: 9919 4781 or 9919 4461
Email: researchethics@vu.edu.au

This is an automated email from an unattended email address. Do not reply to this address.

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

This is to certify that the project below was considered by the Chair of the Monash University Human Research Ethics Committee. The Chair was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number:	CF14/2163 - 2014001138	
Project Title:	Anatomy retention among medical students in a Graduate-entry MBBS course: A mixed-methods cross-sectional study	
Chief Investigator:	Dr Catherine Haigh	
Approved:	**From:** 11 August 2014	**To:** 11 August 2019

Terms of approval - ***Failure to comply with the terms below is in breach of your approval and the Australian Code for the Responsible Conduct of Research.***

1. Approval is only valid whilst you hold a position at Monash University and approval at the primary HREC is current.
2. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
3. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
4. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

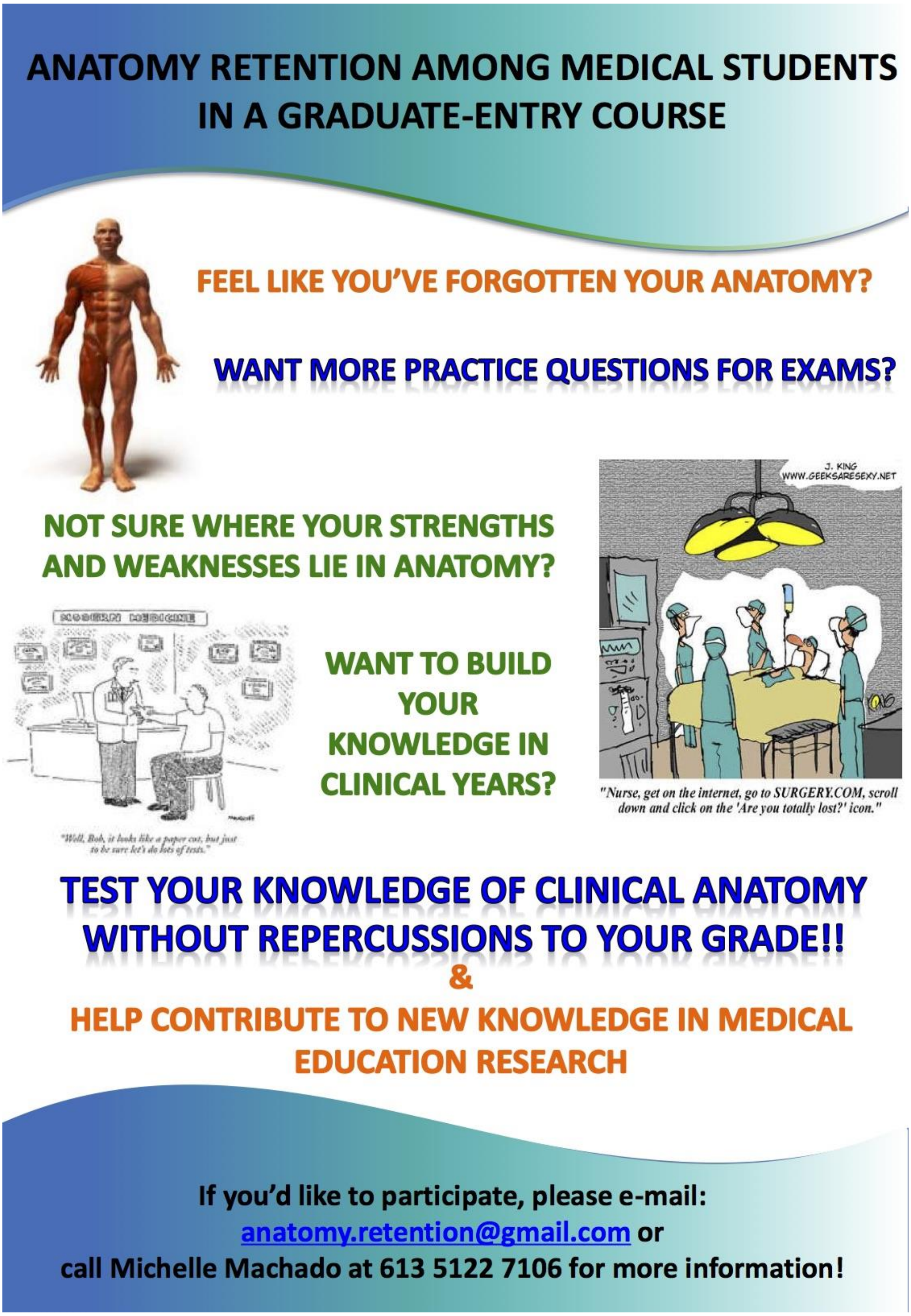
Professor Nip Thomson
Chair, MUHREC

cc: Mrs Michelle Machado, Dr Margaret Malloch

Postal – Monash University, Vic 3800, Australia
Building 3E, Room 111, Clayton Campus, Wellington Road, Clayton
Telephone +61 3 9905 5490 Facsimile +61 3 9905 3831
Email muhrec@monash.edu http://www.monash.edu.au/researchoffice/human/
ABN 12 377 614 012 CRICOS Provider #00008C

APPENDIX D

Research Flyer to Students


ANATOMY RETENTION AMONG MEDICAL STUDENTS
IN A GRADUATE-ENTRY COURSE
FEEL LIKE YOU'VE FORGOTTEN YOUR ANATOMY?
WANT MORE PRACTICE QUESTIONS FOR EXAMS?
NOT SURE WHERE YOUR STRENGTHS AND WEAKNESSES LIE IN ANATOMY?
MODERN MEDICINE
"Well, Bob, it looks like a paper cut, but just to be sure let's do lots of tests."
WANT TO BUILD YOUR KNOWLEDGE IN CLINICAL YEARS?
J. KING
WWW.GEEKSARESEXY.NET
"Nurse, get on the internet, go to SURGERY.COM, scroll down and click on the 'Are you totally lost?' icon."
TEST YOUR KNOWLEDGE OF CLINICAL ANATOMY WITHOUT REPERCUSSIONS TO YOUR GRADE!!
&
HELP CONTRIBUTE TO NEW KNOWLEDGE IN MEDICAL EDUCATION RESEARCH
If you'd like to participate, please e-mail:
anatomy.retention@gmail.com or
call Michelle Machado at 613 5122 7106 for more information!

APPENDIX E

List of Anatomy objectives covered in Year A

Regional topic areas of clinically relevant anatomy examined

Abdomen & Pelvis

1. Organs affected by ischaemia from occlusion of foregut, midgut & hindgut arteries.
2. Significance and diagnosis of a perforated peptic ulcer and the resulting haematemesis and/or malena resulting from damaged vessels.
3. Endangerment of spleen from lower left rib fractures.
4. Potential hernia sites, noting difference between indirect and direct inguinal hernia.
5. Site of pain referral associated with hernias.
6. Site of pancreatic cancer and its association with obstructive jaundice.
7. Significance of gallstones and where they are most likely to lodge.
8. Lowest parts of peritoneal cavity in supine male and female, noting significance of pus or blood potentially accumulating at these sites.
9. Visceral sources of pain for epigastric pain, umbilical pain, suprapubic pain, perineal pain and loin pain.
10. Lymph drainage in tumour spread from abdominal organ
11. Site of pain referral from pelvic structures *via* obturator nerve
12. Significance of tumour spread from prostate cancer to spine *via* internal vertebral venous plexus
13. Relationship and significance of ureters to cervix and to uterine arteries
14. Importance of pelvic floor in maintaining faecal continence.

Thorax

1. Distribution of coronary artery and significance of dominance in coronary artery occlusion
2. Ideal site for intercostal catheterisation *via* anterior and lateral approach, noting sites where thoracic wall nerves and vessels are endangered.
3. Effect of severed thoracic duct with ligated thoracic duct
4. Sites of pain referral over thorax, noting specifically how cardiac pain and oesophageal pain may mimic each other.
5. Significance of inhaled material to pass into right main bronchus.
6. Significance of cardiac tamponade and acceptable site for pericardial tap.
7. Significance of deviation of trachea.
8. Significance of lymph drainage of lungs, noting significance of widening of carina on bronchoscopy.
9. Surface projections of fissures and lobes of lungs in diagnosis of lung disease.
10. Lymph drainage of breast noting implications for tumour spread
11. Significance of venous drainage of breast and venous spread of tumours and infection
12. Arterial supply and anastomoses of breast

Back

1. Indicate particular spinal nerve which emerges from each intervertebral foramen (noting that there are 8 cervical spinal nerves, yet only 7 cervical vertebrae).
2. Sites, mechanism, degrees and effects of lumbar disc herniation, noting where discs are least supported.
3. Meninges & associated spaces, level of termination of spinal cord and ideal site for lumbar puncture, noting required posture of patient and bony surface landmarks to detect most appropriate level.
4. Structures potentially affected in back injuries and anatomical basis for reflex muscle spasm.

Head & Neck
1. Potential complications of thyroid surgery, noting endangerment of arterial and nerve supplies. 2. Ideal sites for cricothyroidotomy. 3. Lymph node biopsies in posterior triangle of neck noting endangerment of accessory nerve and subsequent effects. 4. Lesions of cranial nerves IX, X, XI and subsequent effects 5. Motor effects of strokes involving main blood vessels of brain 6. Cranial nerves supplying extra ocular muscles of eye and how these are tested. 7. Sites of emissary veins, noting significance as potential avenues of intracranial spread for face and scalp lacerations. 8. Contents of floor of mouth and relation of vessels to submandibular gland 9. Branches of facial nerve and sites where motor nerves are endangered with facial lacerations and incisions 10. Nerve endangered with depressed fracture of zygomatic bone.

Upper Limb
1. Role of dorsal digital expansion in finger movements and significance of injury to it. 2. Motor and sensory impairments from lesions to median nerve at wrist and in carpal tunnel 3. Motor and sensory impairments from lesions to ulnar nerve at wrist and entrapment in cubital tunnel. 4. Rotator cuff muscles noting sites and structures involved in painful arc syndrome 5. Note key neurovascular contents in axilla region and effects of damage to structures. 6. Motor and sensory impairments of damage to posterior cord 7. Mechanism, components torn and effects of dislocated acromioclavicular joint, noting structures endangered. 8. Key neurovascular contents in palm and dorsum of hand and importance of it for cannulation. 9. Mechanism, effect and structures endangered in fractured mid-shaft of humerus.

Lower Limb
1. Sites where major lower limb nerves are endangered by laceration (where arteries are palpable and across large superficial veins). 2. Acceptable site for central venous catheterisation, comprehending boundaries of femoral triangle. 3. Mechanism and effects of fractured neck of femur, noting supply to its head. 4. Factors resulting in positive Trendelenburg sign. 5. Sites where nerves are endangered by entrapment, particularly under inguinal ligament and in tarsal tunnel. 6. Motor and sensory impairments from lesions to tibial nerve entrapped in tarsal tunnel; common fibular nerve in popliteal fossa and behind head of fibula via laceration or compression. 7. Surface markings of dorsalis pedis artery. 8. Diagnosis and potential consequences of compartment syndrome in leg (particularly anterior compartment). 9. Mechanism and effects of damage to cruciate ligaments and how to test integrity of these ligaments.

APPENDIX F

Anatomy Learning Survey & Anatomy Test Questions

ANATOMY LEARNING QUESTIONNAIRE

1. **My previous educational background was**
   A. Anatomy in a professional course (Physiotherapy/Occupational therapy)
   B. Anatomy in a biomedical science course
   C. Biological Science
   D. Other science
   E. No science

2. **The resource I use/used the most for learning anatomy is/was**
   A. Textbooks
   B. An@tomedia
   C. Anatomy days at Clayton
   D. Tutorials
   E. Lectures
   F. Study groups
   G. Other (please specify)

3. **The resource I find the most useful for learning anatomy is**
   A. Textbooks
   B. Anatomedia
   C. Anatomy days at Clayton
   D. Tutorials
   E. Lectures
   F. Study groups
   G. Other (please specify)

4. **The volume of anatomy knowledge that I needed to learn in Year A was daunting**
   A. Strongly agree
   B. Agree
   C. Unsure
   D. Disagree
   E. Strongly disagree

5. **The volume of anatomy knowledge that I needed to learn in Year A was necessary**
   A. Strongly agree
   B. Agree
   C. Unsure
   D. Disagree
   E. Strongly disagree

6. **The main motivation for learning anatomy is to pass exams**
   A. Strongly agree
   B. Agree
   C. Unsure
   D. Disagree
   E. Strongly disagree

7. **The approach I mainly use to learn anatomy is**
   A. Search for meaning in the content
   B. Memorise the content
   C. Memorise and then search for meaning
   D. Search for meaning and then memorise
   E. Other (please specify)

8. **I don't see anatomy as the most important subject in my medical career**
   A. Strongly agree
   B. Agree
   C. Unsure
   D. Disagree
   E. Strongly disagree

9. **I find it difficult to use my anatomy knowledge as I am not confident in my knowledge base**
   A. Strongly agree
   B. Agree
   C. Unsure
   D. Disagree
   E. Strongly disagree

10. I frequently use my anatomy knowledge during clinical skills sessions

A. Strongly agree
B. Agree
C. Unsure
D. Disagree
E. Strongly disagree

11. I see anatomy as an important part of becoming a doctor

A. Strongly agree
B. Agree
C. Unsure
D. Disagree
E. Strongly disagree

12. The challenges I perceive in learning anatomy are

A. The amount of material that needs to be learned
B. Application of anatomical knowledge to clinical cases
C. Visualisation of anatomical structures
D. Location of anatomical structures
E. Other (please specify)

13. Prior to commencing Year A, I had a solid foundation in anatomy (or particular systems e.g., the musculoskeletal system – if the latter, please specify)

A. Strongly agree
B. Agree
C. Unsure
D. Disagree
E. Strongly disagree

ABDOMEN/PELVIS

1. Leah, a 27-year old female bodybuilder presents to her GP with pain in her left lower abdominal area following a session of heavy weight lifting at the gym. On examination, the GP finds a small protrusion in the groin area located right above and lateral to the mid-point of the inguinal ligament. Which of the following hernias is Leah MOST LIKELY to be diagnosed with?

   A. Diaphragmatic hernia
   B. Direct inguinal hernia
   C. Femoral hernia
   D. Incisional hernia
   E. Indirect inguinal hernia

Objective	Define the term ‘hernia’ (noting mechanism, diagnosis & effects). List potential hernial sites from the abdomen through orifices normally present & through areas of weakness. Contrast an ‘indirect’ with a ‘direct’ inguinal hernia.
Taxonomy	Application
Borderline	0.5

2. Leah is admitted for a hernia procedure. During the surgery, which of the following structures would be found passing through the deep inguinal ring and traversing the inguinal canal?

   A. Femoral branch of genitofemoral nerve
   B. Iliohypogastric nerve
   C. Ilioinguinal nerve
   D. Ovarian artery
   E. Round ligament of uterus

Objective	Outline surface markings of the superficial inguinal ring & of the deep inguinal ring. Comprehend the walls of inguinal canal & structures transmitted
Taxonomy	Recall
Borderline	0.3

3. Following a laparoscopic inguinal hernia repair, a 47-year old man complains to his doctor about pain in the scrotum. Examination reveals pain and paresthesia in the anterolateral surface of the scrotum. Which of the following nerves was MOST LIKELY injured during this hernia repair?

   A. Anterior femoral cutaneous nerve
   B. Femoral branch of genitofemoral nerve
   C. Iliohypogastric nerve
   D. Ilioinguinal nerve
   E. Subcostal nerve

Objective	Indicate the site of pain referral (noting it is often not at the source which may obscure diagnosis, hence hernial sites should be examined in abdominal pain)
Taxonomy	Application
Borderline	0.3

4. A 55-year old male is admitted to hospital following complaints of severe abdominal pain. Radiological examination reveals the obstruction to be at one of the branches of the inferior mesenteric artery. Which of the following organs is MOST LIKELY to have been affected by the ischaemia?

   A. Ileum
   B. Ascending colon
   C. Caecum
   D. Descending colon
   E. Transverse colon

Objective	Comprehend the arteries of foregut, midgut & hindgut (& their distribution)
Taxonomy	Recall
Borderline	0.7

5. Emma presents to the Emergency room with hematemesis (vomiting blood). Endoscopy reveals an ulcer that has perforated the posterior wall of the first part of the duodenum. Which of the following arteries is MOST LIKELY to be damaged as a result of this?

   A. Gastroduodenal artery
   B. Gastro-omental artery
   C. Left gastric artery
   D. Short gastric artery
   E. Splenic artery

Objective	Explain the significance and diagnosis of a perforated peptic ulcer. Explain how a massive haematemesis &/or malena can result from a peptic ulcer (indicating the artery directly behind the stomach and the artery directly behind the first part of the duodenum)
Taxonomy	Recall
Borderline	0.4

6. During an AFL game, one of the players, Matthew, is injured when his opponent smashes into him. The physician on site discovers that Matthew has sustained rib fractures on the left side and is rushed to hospital. Radiological examination reveals a fractured 9th and 10th rib on the left side near the angle of the rib. Which of the following organs is MOST LIKELY the first to be injured?

   A. Liver
   B. Pancreas
   C. Left Kidney
   D. Spleen
   E. Stomach

Objective	Explain how the spleen is endangered in fractures of the lower left ribs.
Taxonomy	Application
Borderline	0.7

Questions 7 and 8 relate to the following options. Each option may be used once, twice or not at all.

A. Body of pancreas
B. Common bile duct
C. Cystic duct
D. Head of pancreas
E. Hepatopancreatic ampulla (Ampulla of Vater)
F. Neck of pancreas
G. Pancreatic duct
H. Right hepatic duct
I. Tail of pancreas
J. Uncinate process

7. Jim, a 62-year-old man develops severe jaundice and is taken to the hospital by his son. On history taking and ordering further tests and radiological examination, the doctor makes a diagnosis of pancreatic cancer. At which of the following pancreatic sites is the tumour MOST LIKELY to be found?

   Answer - D

Objective	Explain why obstructive jaundice tends to occur with cancer of the head of the pancreas (noting the structure intimately related to it)
Taxonomy	Application
Borderline	0.4

8. A 26-year-old woman is diagnosed with acute pancreatitis resulting from obstruction of a gallstone. At which of the following sites is the gallstone MOST LIKELY to lodge?

Answer - E

Objective	Explain the significance of gall stones (noting where they are most likely to lodge).
Taxonomy	Borderline
Recall	0.6

9. A 42-year old female is diagnosed with peritonitis - inflammation of the peritoneum. Based on your anatomical knowledge, which of the following is the lowest point at which peritoneal fluid would gravitate to?

A. Rectovesical pouch
B. Rectouterine pouch
C. Vesicouterine pouch
D. Rectovaginal pouch
E. Subphrenic space

Objective	Indicate the lowest parts of the peritoneal cavity in a supine male and in a supine female (noting that pus or blood can accumulate in these sites).
Taxonomy	Application
Borderline	0.6

10. A 60-year old woman presents to the Emergency room with severe pain in the hypogastric (suprapubic) region. Based on your knowledge of referred pain, which of the following organs is MOST LIKELY to be the source of the pain?

A. Appendix
B. Kidney
C. Ureter
D. Sigmoid colon
E. Vagina

Objective	Indicate visceral sources (noting afferent nerve paths & associated spinal cord segments) for: - retrosternal chest pain - epigastric pain - umbilical pain - suprapubic pain - perineal pain - loin pain (right/left)
Taxonomy	Analysis
Borderline	0.5

11. Which of the following would be the first palpable lymph node in a patient with stomach cancer?

    A. Superficial inguinal lymph node
    B. Axillary lymph node
    C. Right supraclavicular lymph node
    D. Left supraclavicular lymph node
    E. Deep inguinal lymph node

Objective	Trace the path of lymph drainage (noting significance in tumour spread): - from stomach - from testis. Explain why the first palpable lymph node tends to be the left supraclavicular node (noting it is a late sign although often the first sign of cancer in these organs)
Taxonomy	Application
Borderline	0.7

12. Jim, a 77-year old has been diagnosed with prostate cancer and is undergoing a pelvic lymph node dissection in order to determine if the cancer has spread to the lymph nodes. A day following the surgery, Jim is unable to feel sensation around the medial aspect of his thigh. Which of the following nerves has MOST LIKELY been injured during the surgery?

    A. Femoral nerve
    B. Saphenous nerve
    C. Obturator nerve
    D. Pudendal nerve
    E. Genitofemoral nerve

Objective	Comprehend the boundaries of femoral triangle, gluteal region, popliteal fossa & tarsal tunnel and the key neurovascular contents in each of the above major regions
Taxonomy	Recall
Borderline	0.5

13. Which of the following arteries provides the main supply for midgut structures?

    A. Celiac trunk
    B. Splenic artery
    C. Inferior mesenteric artery
    D. Superior mesenteric artery
    E. Ileocolic artery

Objective	Comprehend the arteries of foregut, midgut & hindgut (& their distribution)
Taxonomy	Recall
Borderline	0.7

14. Anna, a 45-year-old woman presents to the Emergency Department with severe pain in the left lumbar and iliac fossa region. On history taking, Anna tells the doctor that she has been voiding (urinating) quite frequently and that the colour of her urine is slightly brown in color. Radiological imaging reveals the presence of cancer in an organ directly related to the termination of the left ureter. In which of the following structures is the cancer MOST LIKELY to be found?

A. Apex of bladder
B. Fundus of uterus
C. Cervix of uterus
D. Recto-sigmoid junction
E. Ovary

Objective	Indicate the relationship of the ureters to the cervix and to the uterine arteries. Explain the significance of each.
Taxonomy	Application
Borderline	0.5

15. Following delivery of her first born child, Melinda, complains problems with defecation. On history taking, the doctor suspects damage to the pelvic floor muscles during delivery resulting in a diagnoses of faecal incontinence. Which of the following muscles is MOST LIKELY to contribute to faecal continence and hence has been damaged?

A. Pubococcygeus
B. Puborectalis
C. Iliococcygeus
D. Internal anal sphincter
E. Obturator internus

Objective	Explain **role of the pelvic floor** (particularly puborectalis) **for faecal continence** (noting why pelvic viscera normally do not prolapse during a Valsalva manoeuvre).
Taxonomy	Recall
Borderline	0.5

THORAX

1. George, a 45-year old man presents to the Emergency Room with angina, and hypotension. A coronary angiogram reveals that George's coronary circulation is right-dominant and there is ischemia around the apex of the heart. Which of the following arteries is the MOST LIKELY cause of this ischemia?

   A. Anterior interventricular (descending)
   B. Circumflex
   C. Left marginal
   D. Posterior interventricular (descending)
   E. Right marginal

Objective	Outline the area of distribution of each coronary artery (noting the components of the conducting system supplied). Indicate which coronary artery is typically dominant.
Taxonomy	Recall
Borderline	0.6

2. A 53-year old woman in a car accident develops a hemopneumothorax on the left side. An intercostal catheter (chest tube) is inserted in order to remove air and drain the pleural fluid. Which of the following sites is the MOST APPROPRIATE insertion point for this procedure?

   A. Superior to the 5^{th} left rib in the mid-clavicular line
   B. Inferior to the 5^{th} left rib in the mid-axillary line
   C. Superior to the 6^{th} left rib in the mid-axillary line
   D. Inferior to the 6^{th} left rib in the mid-axillary line
   E. Superior to the 11^{th} left rib in the scapular line

Objective	Indicate the sites where thoracic wall vessels & nerves are endangered by a penetrating injury. Indicate the ideal site for intercostal catheterisation via an anterior approach and via a lateral approach.
Taxonomy	Application
Borderline	0.5

3. A 60-year old man wakes up at night with retrosternal pain. He is rushed to the hospital where the physician performs a cardiovascular assessment and is unable to find any abnormalities. Which of the following structures is the next MOST LIKELY source of his pain?

   A. Parietal layer of serous pericardium
   B. Mediastinal pleura
   C. Oesophagus
   D. Diaphragmatic pleura
   E. Fibrous pericardium

Objective	Indicate potential sources of referred pain to dermatomes over thorax (noting why cardiac pain and oesophageal pain may mimic each other) and from thoracic structures (particularly myocardium, pericardium & pleura) to dermatomes over other sites.
Taxonomy	Analysis
Borderline	0.3

4. As a medical student, you are about to observe a doctor perform pericardiocentesis on a patient suspected of having cardiac tamponade. As the doctor prepares to drain excess blood from the pericardial cavity, he asks you to indicate the site at which the needle should be inserted. The MOST APPROPRIATE site to do so would be

   A. Right 4^{th} intercostal space, sternal margin
   B. Left 4^{th} intercostal space, sternal margin
   C. Right xiphisternal junction
   D. Left xiphisternal junction
   E. Left 5^{th} intercostal space, midclavicular line

Objective	Indicate the effects of accumulation of fluid in the pericardial cavity (noting the significance of 'cardiac tamponade', particularly from a sudden bleed into it). Indicate an acceptable site for a pericardial tap.
Taxonomy	Application
Borderline	0.4

5. A 44-year old man was stabbed in the right side of his neck, approximately 3 cm superior to the middle of the clavicle. He develops a pneumothorax as a result of the injury and is rushed to hospital. Which of the following signs would be MOST APPARENT during a physical exam?

   A. Decreased breath sounds on both sides of thorax
   B. Deviation of trachea and apex beat to right side
   C. Deviation of trachea and apex beat to left side
   D. Increased breath sounds on right side of thorax
   E. Decreased breath sounds on left side of thorax.

Objective	Explain the significance of deviation of the trachea.
Taxonomy	Analysis
Borderline	0.4

6. During a surgical procedure in the posterior mediastinum, the structure between the descending aorta and azygos vein is inadvertently lacerated. Which of the following is the MOST LIKELY structure to be injured?

   A. Left recurrent laryngeal nerve
   B. Hemiazygos vein
   C. Pulmonary artery
   D. Right recurrent laryngeal nerve
   E. Thoracic duct

Objective	Contrast the effect of a severed thoracic duct with that of a ligated thoracic duct
Taxonomy	Recall
Borderline	0.5

7. A 41-year old man who presents with fever and shortness of breath is diagnosed with lobar pneumonia. Examination reveals bronchial breathing confined to the right axillary region. Which of the following lobes is MOST LIKELY affected?

   A. Hilum
   B. Inferior lobe
   C. Lingula
   D. Middle lobe
   E. Superior lobe

Objective	Map the surface projections of the fissures and lobes of the lungs
Taxonomy	Analysis
Borderline	0.4

8. A 35-year woman patient is diagnosed with cancer of the right breast. Which of the following lymphatic structures would majority of the cancer cells first spread to?

   A. Axillary lymph nodes
   B. Parasternal lymph nodes
   C. Left supraclavicular lymph nodes
   D. Right lymphatic duct
   E. Thoracic duct

Objective	Outline the lymph drainage of the breast contrasting lateral with medial quadrants (noting the significance of overlap across the nipple line vertical watershed and the implications for tumour spread)
Taxonomy	Application
Borderline	0.6

9. Breast cancer can also metastasise through the venous system, where the cancer cells can spread to bone through the vertebral venous plexus. Through which of the following routes do the cells reach this plexus?

   A. Subclavian vein
   B. Intercostal veins
   C. Brachiocephalic vein
   D. Hemiazygos venous system
   E. Inferior vena cava

Objective	Comprehend venous drainage (noting communications) of the breast. Comprehend significance of venous spread (of tumours & infection)
Taxonomy	Recall
Borderline	0.3

10. While observing a mastectomy procedure on an elderly patient, the surgeon asks you to identify the artery that supplies the medial portion of the breast. Which of the following vessels is responsible for this function?

    A. Anterior intercostal
    B. Musculophrenic
    C. Superior epigastric
    D. Internal thoracic
    E. Thoracoacromial

Objective	Draw the surface markings of the internal mammary vessels Comprehend arterial supply (noting anastomoses) of the breast
Taxonomy	Recall
Borderline	0.5

UPPER LIMB

1. During a basketball game, the ball makes contact with the tip of Raoul's extended middle finger causing a forceful flexion at the distal interphalangeal joint. When examined by the sports physician, Raoul is diagnosed with a mallet finger. Which of the following structures is MOST LIKELY to have been affected?

   A. Flexor digitorium superficialis
   B. Extensor digitorium
   C. Flexor digitorium profundus
   D. Lumbricals 3 and 4.
   E. Interosseous muscles

Objective	Demonstrate and explain: the role of the dorsal digital expansion in finger movements (noting the intrinsic muscles of palm used in finger extension)
Taxonomy	Application
Borderline	0.7

2. Tracy, 27-years of age is expecting her first child and is 4-months pregnant. She has developed some weakness, numbness and pain sensations at night when her right wrist is flexed. On visiting the doctor, she is diagnosed with carpal tunnel syndrome. Based on your knowledge of anatomy, which of the following signs would be characteristic of this syndrome?

   A. Loss of sensation over the thenar eminence.
   B. Loss of innervation to flexor digitorium superficialis.
   C. Loss of innervation to flexor pollicis brevis.
   D. Loss of innervation to flexor digitorium profundus.
   E. Loss of sensation to skin of the palm of the hand

Objective	Indicate motor & sensory impairments (noting any reflex lost & deformity produced) from lesions to major nerves of the upper limb at sites where endangered by: compression (median at elbow compared to in carpal tunnel)
Taxonomy	Application
Borderline	0.3

3. Tracy has a carpal tunnel release operation. The day following the surgery, she is unable to abduct and flex her thumb. Which of the following nerves is MOST LIKELY to have been injured?

   A. Anterior interosseous nerve
   B. Palmar cutaneous branch of median nerve
   C. Deep branch of ulnar nerve
   D. Superficial branch of ulnar nerve
   E. Recurrent thenar branch of median nerve

Objective	Indicate motor & sensory impairments (noting any reflex lost & deformity produced) from lesions to major nerves of the upper limb at sites where endangered by: lacerations (median at wrist compared to of its thenar branch in the palm)
Taxonomy	Recall
Borderline	0.5

4. A patient with multiple lacerations to her anterior wrist and palm presents to the Emergency Room with severe bleeding. On examination, the patient is unable to hold a piece of paper placed between the thumb and index finger. The function of which of the following nerves is MOST LIKELY being tested?

   A. Median nerve
   B. Ulnar nerve
   C. Recurrent thenar branch of median nerve
   D. Superficial branch of ulnar nerve
   E. Deep branch of ulnar nerve

Objective	Indicate motor & sensory impairments (noting any reflex lost & deformity produced) from lesions to major nerves of the upper limb at sites where endangered by: entrapment (ulnar in cubital tunnel compared to in ulnar canal)
Taxonomy	Analysis
Borderline	0.3

5. George, a frequent tennis player is diagnosed with cubital tunnel syndrome due to compression of the nerve that sits posterior to the medial epicondyle of the humerus. Which of the following muscles would be affected by this syndrome?

   A. Flexion of proximal interphalangeal joints of digits 2-5
   B. Flexion of thumb
   C. Adduction of thumb
   D. Abduction of the thumb
   E. Flexion of distal interphalangeal joints of digits 2-5

Objective	Indicate motor & sensory impairments (noting any reflex lost & deformity produced) from lesions to major nerves of the upper limb at sites where endangered by: entrapment (ulnar in cubital tunnel compared to in ulnar canal)
Taxonomy	Application
Borderline	0.5

6. David, a swimming athlete visits his GP complaining of pain in his right shoulder region. On inspection, you notice a difference between the two sides, particularly superior to the spine of the scapula, with the right side appearing smaller than the left. There is no winging of the scapula but on examination, David is unable to externally rotate and initiate abduction of his arm. However, if the arm is assisted through the first 45 degrees of abduction, David is able to complete full abduction. Given this information, which of the following nerves would you suspect has been damaged?

   A. Axillary nerve
   B. Upper subscapular nerve
   C. Suprascapular nerve
   D. Dorsal scapular nerve
   E. Lower subscapular nerve

Objective	Identify ‘rotator cuff muscles’ of the shoulder joint and explain their major role. Indicate the sites & structures involved in: ‘painful arc syndrome’ (of shoulder)
Taxonomy	Analysis
Borderline	0.4

7. On your first rotation in the emergency room, a patient is brought in with extreme bleeding from a large stab wound to the shoulder region. The lesion is 2.5 cm long, located 1.5 cm below and 1 cm medial to the coracoid process. Following administration of intravenous fluids, a surgeon is called in to repair the artery. Once he exposes the area, he sees that this artery is closely associated with the cords of the brachial plexus. Which of the following vessels is MOST LIKELY damaged?

   A. Subclavian
   B. Axillary
   C. Brachial
   D. Costocervical trunk
   E. Thyrocervical trunk

Objective	Comprehend the key neurovascular contents in each of the major regions of the upper limb (pectoral region, axilla, anterior compartment of arm etc)
Taxonomy	Application
Borderline	0.4

8. Following surgery to repair the bleed, the doctor monitors the patient's recovery and notes that there are significant neurological deficits sustained from the lesion. He notes that the patient's wrist is in the flexed position, he is unable to extend his wrist and forearm and suffers from loss of sensation to upper lateral aspect of the arm and majority of the dorsal arm, forearm as well as dorsal aspect of his thumb, index and middle finger. Based on this information, which of the following structures is MOST LIKELY injured?

   A. Axillary nerve
   B. Radial nerve
   C. Posterior cord
   D. Lateral cord
   E. Posterior division of middle trunk

Objective	Comprehend the: Formation of limb plexuses by ventral rami, distribution of divisions of limb plexuses to their respective compartments, course of major peripheral nerves in the upper limb, branches & distribution of major peripheral nerves in the upper limb
Taxonomy	Analysis
Borderline	0.3

9. While driving home from work one afternoon, Julie comes across an accident and is transported to hospital due to a shoulder injury. On inspection, the lateral end of her right clavicle is elevated and separated from the acromion process. In addition, her right upper limb drops when not supported by her left arm. Which of the following ligaments would have to be completely ruptured for this to occur?

A. Superior glenohumeral ligament
B. Coracoacromial ligament
C. Coracoclavicular ligament
D. Sternoclavicular ligament
E. Transverse humeral ligament

Objective	Explain the mechanism, components torn and effect of a dislocated: acromioclavicular joint (in contrast to a subluxation) and shoulder joint (noting structures endangered & implication for reduction)
Taxonomy	Application
Borderline	0.6

10. You observe an intern doctor inserting an IV into the distal end of the forearm on the radial side. Which of the following veins is MOST LIKELY cannulated?

A. Cephalic vein
B. Basilic vein
C. Brachial vein
D. Median cubital vein
E. Median antebrachial vein

Objective	Comprehend the key neurovascular contents in each of the major regions of the upper limb (palm of hand, dorsum of hand etc)
Taxonomy	Recall
Borderline	0.6

BACK

EMQ 1 and 2 relate to the following options. Each option may be used once, twice or none at all.

A. C3
B. C4
C. C5
D. C6
E. C7
F. L1
G. L2
H. L3
I. L4
J. L5
K. S1

1. A rugby player suffers from a herniated (ruptured) intervertebral disk in the region of his neck. On imaging, the disk appears to be compressing the spinal nerve exiting the intervertebral foramen between the 4th and 5th cervical vertebrae. Which of the following spinal nerves has been injured?

   Answer – C

Objective	Indicate the particular spinal nerve which emerges from each intervertebral foramen (noting that there are 8 cervical spinal nerves yet only 7 cervical vertebrae).
Taxonomy	Recall
Borderline	0.6

2. A woman presents with a herniated intervertebral disc in the lumbar region between L5 and S1. If the spinal nerve **immediately posterior** to this disc is compressed, which nerve is affected?

   Answer – J

Objective	Explain sites, mechanism, degrees and effects of lumbar disc herniation (noting where discs are least supported).
Taxonomy	Application
Borderline	0.4

3. A 30-year old patient presents to the hospital with a severe headache, high fever and neck stiffness. The doctor suspects bacterial meningitis. In addition to ordering a blood sample, the doctor performs a lumbar puncture to obtain cerebrospinal fluid (CSF) for analysis. Which of the following would be the MOST APPRORIATE site to extract CSF?

   A. Epidural space between the level of L2/L3
   B. Epidural space between the level of L3/L4
   C. Subdural space between the level of L4/L5
   D. Subarachnoid space between the level of L2/L3
   E. Subarachnoid space between the level of L3/L4

Objective	Comprehend the meninges & associated spaces (extradural, subdural & subarachnoid). Indicate the level of termination of the spinal cord. Mark the ideal site for a lumbar puncture (noting the required posture of the patient and bony surface landmarks to determine the most appropriate level). Indicate the surface marking of the major structure endangered.
Taxonomy	Recall
Borderline	0.6

4. When performing the lumbar puncture, a line through which of the following landmarks could be used to determine the appropriate level for inserting the needle?

A. Anterior superior iliac spine
B. Posterior superior iliac spine
C. Superior aspect of Iliac crests
D. Transpyloric plane
E. Umbilicus

Objective	Mark the ideal site for a lumbar puncture (noting the required posture of the patient and bony surface landmarks to determine the most appropriate level).
Taxonomy	Recall
Borderline	0.4

5. Charles, a 45-year old man presents to the GP with intense back pain region following a golf session with his friends the previous day. On inspection and examination, the doctor concludes that the pain must be due to spasm of the erector spinae muscle. Which of the following structures is responsible for innervating this muscle?

    A. Dorsal root of spinal nerve
    B. Dorsal ramus of spinal nerve
    C. Ventral root of spinal nerve
    D. Ventral ramus of spinal nerve

Objective	Indicate the structures potentially affected in back injuries. Explain the anatomical basis for reflex muscle spasm (of erector spinae).
Taxonomy	Recall
Borderline	0.5

HEAD/NECK

1. Daisy has a thyroidectomy for a suspected malignancy in the right lobe of the thyroid gland. A month after surgery, Daisy's speech is normal but she informs her doctor that her voice fatigues easily and that she has difficulty producing high-pitched sounds. Which of the following nerves is MOST LIKELY to have been damaged for Daisy to have these symptoms?

   A. Phrenic nerve
   B. Cervical sympathetic nerves
   C. External branch of superior laryngeal nerve
   D. Internal branch of superior laryngeal nerve
   E. Recurrent laryngeal nerve

Objective	List the potential complications of thyroid surgery (noting the effects of each).
Taxonomy	Application
Borderline	0.3

2. One afternoon, a patient comes in to the clinic with extreme inspiratory stridor and acute upper airway obstruction. As it would take nearly 30 minutes to get to the nearest hospital, the doctor acts immediately and creates an emergency surgical airway in order to restore breathing. Which of the following sites is the MOST APPROPRIATE site to create an airway?

   A. At the jugular notch
   B. Through the 2^{nd} tracheal ring
   C. Just above the thyroid cartilage
   D. Just below the thyroid cartilage
   E. Just below the cricoid cartilage

Objective	Indicate the ideal site for a: - cricothyroidotomy The ideal site for a tracheostomy (in contrast to an emergency cricothyroidotomy) noting the layers pierced and structures endangered (particularly in a child).
Taxonomy	Application
Borderline	0.5

3. A lymph node biopsy is carried out in the mid-region of the posterior triangle of a patient's neck. Following this, the patient complains that his shoulder dropped on the right side and he is unable to raise his right hand above his shoulder. Which of the following nerves is MOST LIKELY to have been injured during the procedure?

   A. Axillary nerve
   B. Suprascapular nerve
   C. Accessory nerve
   D. Ansa cervicalis
   E. Transverse cervical nerve

Objective	Explain why the accessory nerve is endangered by lymph node biopsies in the posterior triangle of the neck (and even by superficial incisions or lacerations in this region). Indicate the effect of a lesion to the nerve at this site
Taxonomy	Recall
Borderline	0.6

4. Tony, a 45-year old man has transient ischaemic attacks with carotid artery bruit and a left common carotid artery stenosis. Tony is referred to a surgeon who performs a carotid endarterectomy. Following surgery, protrusion of the tongue results in deviation of the tongue to the left side. Which of the following nerves was most likely injured during this procedure?

   A. Right lingual nerve
   B. Left lingual nerve
   C. Right hypoglossal nerve
   D. Inferior alveolar nerve
   E. Left hypoglossal nerve

Objective	Comprehend the borders & key contents of anterior triangle Indicate motor &/or sensory impairments (noting any reflexes lost) from a lesion to each of the following cranial nerves: IX, X, XI, XII
Taxonomy	Application
Borderline	0.5

5. A 64-year old woman recently suffered a stroke, which paralysed parts of the right side of the body. In addition, she was having difficulty forming complete sentences. Neurological imaging reveal that she suffered from a thromboembolic episode that occluded blood supply to a part of the brain. Which of the following vessels was MOST LIKELY affected?

A. Anterior cerebral artery
B. Internal carotid artery
C. Middle cerebral artery
D. Middle meningeal artery
E. Posterior cerebral artery

Objective	Describe the main arterial supply of the brain and spinal cord(vertebral-basilar systems and circle of willis). Recognise the motor effects of strokes involving the main blood vessels of the brain.
Taxonomy	Application
Borderline	0.6

6. With a patients' eyes directed straight ahead, which direction would you ask the patient to divert his gaze to in order to test the integrity of the trochlear nerve?

A. Medial and superiorly
B. Medial and inferiorly
C. Lateral and superiorly
D. Lateral and inferiorly

Objective	Demonstrate eye movements (indicating the extra ocular muscles involved) Indicate the cranial nerves that supply the extra ocular muscles
Taxonomy	Application
Borderline	0.4

7. 14-year old Megan suffers from severe acne with numerous pimples on her face, particularly on her cheeks, and near her nose and lips. Self-conscious about her appearance, she starts to squeeze these pimples. A day later, she develops a high fever and Megan's parents rush her to the hospital where she is diagnosed with thrombosis in the cavernous sinus. Which of the following structures is the MOST LIKELY route for communications between the face and the cavernous sinus?

   A. Retromandibular vein
   B. Ophthalmic vein
   C. Internal jugular vein
   D. Maxillary vein
   E. Deep facial vein

Objective	Indicate sites of emissary veins (noting significance as potential avenues of intracranial spread for face & scalp infections).
Taxonomy	Application
Borderline	0.4

8. You are observing a surgery on a young male patient, Dave, whose left submandibular gland is being removed due to numerous stones (calculi). During the procedure, the surgeon asks you which artery is in direct relation to the gland and hence is in danger of being injured?

   A. Ascending pharyngeal artery
   B. Facial artery
   C. Lingual artery
   D. Maxillary artery
   E. Superior thyroid artery

Objective	Comprehend boundaries & contents of the floor of the mouth (sublingual region) Identify the orifices of the submandibular duct
Taxonomy	Recall
Borderline	0.5

9. Following the removal of the submandibular gland, Dave, finds that he is unable to fully depress the angle of his mouth on his left side. Which of the following nerves is MOST LIKELY injured in this case?

A. Buccal nerve
B. Facial nerve
C. Mandibular nerve
D. Marginal mandibular nerve
E. Ophthalmic nerve

Objective	Explain why special care is taken with incisions on the face and indicate the sites where motor nerve branches are endangered
Taxonomy	Application
Borderline	0.4

10. A boxer comes to the ER to be treated for a fractured zygomatic bone. His right cheekbone is depressed and on examination, there is no sensation to his right lower eyelid, lateral aspect of the nose and upper lip. Which of the following nerves is MOST LIKELY injured?

A. Supraorbital nerve
B. Zygomatic nerve
C. Infraoribital nerve
D. Superior alveolar nerve
E. Buccal nerve

Objective	Explain how a depressed fracture of the cheekbone can be detected (noting the bone involved). Indicate the nerve endangered and how its function is tested
Taxonomy	Application
Borderline	0.6

LOWER LIMB

1. A 55-year old woman is having surgery to treat her varicose veins where the long saphenous vein is stripped. Following surgery, she complains of lack of sensation to the medial aspect of her left leg and foot. Which of the following nerves is the MOST LIKELY affected?

   A. Femoral nerve
   B. Saphenous nerve
   C. Sural nerve
   D. Deep fibular (peroneal) nerve
   E. Superficial fibular (peroneal) nerve

Objective	Indicate sites where major nerves (particularly with somatic motor fibres) are endangered by a: - laceration
Taxonomy	Recall
Borderline	0.5

2. As a medical intern, you are asked to insert a central venous catheter into the femoral vein to monitor central venous pressure in an acutely ill patient. Which of the following sites is the most accurate landmark for inserting the needle?

   A. Lateral to pubic tubercle
   B. Lateral to femoral artery
   C. Medial to femoral artery
   D. Medial to femoral nerve
   E. Mid-inguinal point

Objective	Indicate an acceptable site for central venous catheterisation. Comprehend the boundaries of femoral triangle, gluteal region, popliteal fossa & tarsal tunnel and the key neurovascular contents in each of the above major regions
Taxonomy	Recall
Borderline	0.7

3. Pat is a 72-year old male who presents to the Emergency room with pain and inability to bear weight in his right hip following a fall on a slippery bathroom floor. Upon radiological examination, the doctor diagnoses Pat with a femoral neck fracture and calls for an orthopaedic consult. As a medical student observing this case, the doctor asks you to identify which vessel would be damaged in this case to cause avascular necrosis of the femoral head?

   A. Femoral artery
   B. Acetabular branch of obturator artery

C. **Medial circumflex artery**
D. Lateral circumflex artery
E. Deep femoral artery

Objective	Explain the mechanism & effects of a fractured: - neck of femur (noting supply to its head)
Taxonomy	Recall
Borderline	0.7

4. Fay is a 26-year-old bride-to-be who has been dieting and exercising in order to look good on her wedding day in 6 weeks time. As part of her routine, she has begun vigorously training and strengthening her leg muscles. The next morning, her glutes, hamstring and posterior leg muscles are extremely sore particularly on her right side. Her friend notices that when she lifts her left leg off the ground while walking, her pelvis drops down on the left side. Which of the following nerves is MOST LIKELY to be affected in this case?

A. Sciatic nerve
B. Inferior gluteal nerve
C. **Superior gluteal nerve**
D. Obturator nerve
E. Nerve to piriformis

Objective	Explain how the pelvis is normally stabilised when standing on only one foot. Indicate factors which can impair this (resulting in a positive 'Trendelenburg sign').
Taxonomy	Application
Borderline	0.4

5. 15-year old Jane spends one evening learning how to skate with her friends at the Icehouse in Melbourne. Jane has never worn ice skates before and so while trying to enter the ice rink, she slips on the ice and her right ice skate hits her left ankle, lacerating her skin just posterior to the medial malleolus. As she is bleeding, they rush her to the nearest hospital, where the doctor notes that the sole of her foot is cold and pale. Which of the following arteries has been damaged as a result of Jane's injury?

A. Anterior tibial artery
B. Deep fibular artery
C. Popliteal artery
D. **Posterior tibial artery**
E. Superficial fibular artery

Objective	Indicate sites where major vessels are endangered by a: - laceration (where arteries are palpable and across large superficial veins)
Taxonomy	Application
Borderline	0.6

6. Following the skating accident, Jane complains of pain sensations to the sole of her foot including her toes. Which of the following nerves is MOST LIKELY to be damaged?

   A. Anterior tibial nerve
   B. Common peroneal nerve
   C. Posterior tibial nerve
   D. Sural nerve
   E. Tibial nerve

Objective	Indicate sites where nerves are endangered by entrapment (particularly lateral femoral cutaneous, under the inguinal ligament and tibial, in tarsal tunnel)
Taxonomy	Application
Borderline	0.7

7. Chris had a fractured tibia and fibula which was treated via reduction and immobilisation. That night, Chris, complains of severe pain in his leg. You are concerned that he has anterior compartment syndrome of the leg. Which of the following findings would be the MOST PROMINENT with this syndrome?

   A. Loss of sensation to the dorsum of the foot
   B. Loss of eversion
   C. Loss of dorsiflexion of foot
   D. Loss of plantarflexion of the foot
   E. Loss of inversion

Objective	Explain the diagnosis & potential consequences of compartment syndrome in the leg (particularly the anterior compartment)
Taxonomy	Application
Borderline	0.5

8. Which of the following is the MOST APPROPRIATE site for finding the dorsalis pedis pulse?

   A. Posterior to popliteal fossa
   B. Posterior to medial malleolus
   C. Anterior to lateral malleolus
   D. Lateral to extensor hallicus tendon
   E. Anterior to medial malleolus

Objective	Palpate and draw surface markings of the: - dorsalis pedis artery (noting that it is occasionally absent)
Taxonomy	Recall
Borderline	0.6

9. Frank is crossing a pedestrian walk when a car that brakes hard to stop at the red light suddenly hits him. The car strikes him on the lateral side of his leg. Following the accident, Frank suffers from a foot drop. Every time he lifts his foot off the ground, it hangs loosely in plantar flexion. Frank is unable to extend his toes and evert his foot although inversion of the foot and flexion of the toes is unaffected. Given this information, which of the following is the MOST LIKELY nerve to be damaged?

   A. Tibial
   B. Common fibular
   C. Superficial fibular
   D. Deep fibular
   E. Medial plantar

Objective	Indicate sites where major nerves (particularly with somatic motor fibres) are endangered by a: - laceration (common fibular in popliteal fossa & behind head of fibula) Indicate the site where a major nerve is endangered by external compression (common fibular around neck of fibula, from a plaster cast that is too far up the leg)
Taxonomy	Analysis
Borderline	0.6

10. A football player complains of discomfort and pain in his right knee. To test the integrity of the ligaments of the knee joint, the GP applies an anterior force to the proximal tibia of the patient's flexed knee. The ensuing result is excessive displacement of the tibia anteriorly. This would indicate damage to which of the following ligaments?

   A. Tibial (medial) collateral ligament
   B. Fibular (lateral) collateral ligament
   C. Anterior cruciate ligament
   D. Posterior cruciate ligament
   E. Meniscofemoral ligament

Objective	Explain the mechanism & effects (noting blood supply & healing) of a ruptured: - cruciate ligament (anterior & posterior) of knee Test the integrity of: cruciate ligaments (anterior & posterior) of knee
Taxonomy	Application
Borderline	0.6

APPENDIX G

Research Interview Questions

Interview Questions for Phase Two
M.Machado –Ph.D

1 – Which year level of your 4-year graduate entry MBBS course are you currently in?
2 – What field is your undergraduate degree in?
3 – How satisfied are or were you with the teaching of anatomy during Year A of the MBBS course? (Elaboration probe)
4 – Do / did you find the resources available in Year A useful in learning anatomy?
5a – What contribution does cadaveric exposure make to learning anatomy?
5b – What other approaches to teaching supported your learning of anatomy in Year A e.g., body painting, projection of anatomical images onto a living body, imaging (ultrasonography, radiography), practising physical examination techniques etc.?
6a – Do you feel that the anatomy covered in Year A was adequate/sufficient? (for Year A participant)
6b – Do you feel that the anatomy covered in Year A was sufficient to help you through your clinical years? (for Year B/C/D participant)
6c – Have you received any subsequent formal teaching in anatomy? (elaboration probe)
7a – How do you learn anatomy?
7b – Have you attempted to keep your anatomical knowledge current? If so, how? (Link to 10?)
7c – What experiences have expanded your anatomical knowledge during your clinical years? (Year B/C/D participant)
8 – How you do rate the importance of anatomy relative to other basic science courses?
9a – Did you perform well in anatomy in Semester One of Year A (for year A participant)
9b – Did you perform well in anatomy during Year A (if participants are in Year B/C/D)
10a – How do you find your anatomy knowledge to be now compared to Semester one? (For Year A participant)
10b – How do you find your anatomy knowledge to be now compared to Year A (For participants in Year B/C/D)
11 – Is there a particular area within anatomy that you feel you need to work on? Why?
12a – Are there personal or professional challenges that have impacted your performance in anatomy in Year A? If so, can you explain? (Elaboration probe)
12b – Are there any personal or professional challenges that have impacted your performance in anatomy in the clinical setting? If so, can you explain? (Elaboration probe) (for Year B/C/D participant)