The relationship between classical languages, linguistic skills, and personality traits and their impact on medical education and student performance

Author: Shiby George Stephens

Supervisors: Professor Stephen Rutherford

Professor Bernard Moxham

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School of Biosciences, Cardiff University, Cardiff, Wales

Abstract

Medical students face the daunting task of perfecting a vast array of anatomical and medical terminologies, many of which derive from the barely taught classical languages of Greek and Latin in schools and at universities. This challenge is exacerbated by a reduction in anatomy contact hours and dissection room exposure, which diminishes students' understanding of anatomical relationships and hinders terminology acquisition. Through questionnaires, this study sought to analyse attitudes towards the importance of classical Greek and Latin in medical education at Cardiff University. The results revealed that the final-year students displayed scepticism about the relevance of these languages while first-year students acknowledged their importance. Further investigations confirmed that students with prior knowledge of Greek and Latin performed better than their peers in anatomical examinations, supporting the notion that prior linguistic knowledge might contribute positively to academic success in medical studies.

This performance disparity prompted a deeper exploration into the effects of multilingualism on spatial and verbal intelligence, involving medical students in the second-year. It was found that multilingual students exhibited higher levels of spatial and verbal intelligence compared to monolinguals, although this did not directly influence anatomy examination scores. The research highlighted the complex interplay between language skills, cognitive abilities, and academic performance, suggesting that enhanced spatial and verbal skills could benefit medical students, particularly in tests requiring spatial orientation.

The final part of the study investigated the role of personality traits in linguistic proficiency and academic achievement. Using the self-reported 'Big Five Inventory the 'Big Five Inventory', a comparative study amongst medical students in the UK and France, as well as psychology and business students in France, was undertaken and revealed differences in openness (O), conscientiousness (C), extraversion (E), agreeableness (A), and negative affectivity (N) with varying effects on examination performance. Notably, the Greek/Latin students were seen to have lower ‘conscientiousness (C) personality traits, indicating that their examination performance is more likely to be related to their ability to understand complex medical/anatomical terminologies.

This research underscores the multifaceted influences on medical students' learning processes and the potential benefits of integrating classical language education and cognitive skill development into medical curricula. Furthermore, it raises a question as to whether there is enough consideration during the early stages of a medical student’s training about the individual’s personal skills, knowledge and personality traits so that the student can be appropriately advised, and/or reflect upon, what they bring to medical school that is advantageous or disadvantageous to their studies.

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List of abbreviations

A.D.	Anno Domini
AAMC	American Association of Medical Colleges
AAMC	Association of Medical Colleges
A-Level	Advanced level (These are subject-based qualifications typically taken by students aged 16–18)
B.C.E	Before the Common (Current) Era
BFI	Big Five Inventory
BMJ	British Medical Journal
CAL	Computer Aided Learning
CLT	Cognitive Load Theory
EDI	Equality, Diversity and Inclusion
FIPAT	Federative International Programme for Anatomical Terminologies
fMRI	functional Magnetic Resonance Imaging
GCSE	General Certificate of Secondary Education (These are academic qualifications taken by students around ages 14–16)
GMC	General Medical Council
HEFCE	Higher Education Funding Council for England
IFAA	International Federation of Associations of Anatomy
MMI	Mini-Multiple-Interviews
MRI	Magnetic Resonance Imaging
MBSR	Mindfulness-based Stress Reduction
NHS	National Health Service
OCEAN	Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism
PBL	Problem-Based Learning
SD	Standard Deviation
STEM	Science, Technology, Engineering and Mathematics
TEL	Technology-Enhanced Learning
UK	United Kingdom

USA	United States of America
VAK	Visual, Auditory and Kinaesthetic techniques

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Publications and linking the areas of research addressed in this thesis

I have successfully published Chapters 3, 4 and 5.

1. Stephens, S. and Moxham, B. (2019) 'Do medical students who are multilingual have higher spatial and verbal intelligence and do they perform better in anatomy examinations?', *Clinical Anatomy*, 32(1), pp. 26-34. doi.org/10.1002/ca.23280 Chapter 5

   Contributions of the authors: Stephens and Moxham conceptualised the work and were responsible for the study design. Stephens undertook the literature review, was responsible for the data collection and analysis, and the initial drafting of the paper. Stephens and Moxham together undertook data interpretation. Moxham provided a critical perspective on the writing of the paper and was responsible for the submission to the peer reviewed journal. Stephens then was the corresponding author. And dealt with reviewer's comments.

2. Stephens, S. and Moxham, B. (2018) 'Gross anatomy examination performances in relation to medical students' knowledge of classical Latin and Greek', *Clinical Anatomy*, 31(4), pp. 501-506. doi.org/10.1002/ca.23056. Chapter 4

   Contributions of the authors: Stephens conceptualised the work, undertook the literature review, was responsible for the study design, the data collection and analysis, and was responsible the initial drafting of the paper. Stephens and Moxham together undertook data interpretation. Moxham provided a critical perspective on the writing of the paper and was responsible for the submission to the peer-reviewed journal. Stephens then was the corresponding author and dealt with reviewers' comments.

3. Stephens, S. and Moxham, B. (2016) 'The attitudes of medical students toward the importance of understanding classical Greek and Latin in the development of an anatomical and medical vocabulary', *Clinical Anatomy*, 29(6), pp. 696-701. doi.org/10.1002/ca.22700. Chapter 3

   Contributions of the authors: Stephens conceptualised the work, undertook the literature review, was responsible for the study design, the data collection and analysis, and was responsible the initial drafting of the paper. Stephens and Moxham together undertook data interpretation. Moxham provided a critical perspective on the writing of the paper and was responsible for the submission to the peer-reviewed journal. Stephens then was the corresponding author and dealt with reviewers' comments.

Linking the areas of research addressed in this thesis

The three areas addressed in the prior publications and the subsequent results chapters are intricately linked through their shared focus on understanding factors that influence medical education outcomes. These areas explore distinct but interconnected dimensions:

1. **Attitudes toward classical Greek and Latin**: Investigating the historical and linguistic foundations of medical terminology, and their impact on students' ability to acquire and retain complex anatomical terms.
2. **Impact of prior knowledge on anatomy performance**: Assessing how prior linguistic skills, particularly in classical languages, affect examination outcomes and learning efficacy in gross anatomy.
3. **The role of multilingualism and cognitive abilities**: Exploring how linguistic diversity influences cognitive skills like spatial and verbal intelligence and how these skills correlate with anatomy performance.

By addressing these areas together, the thesis provides a comprehensive understanding of how linguistic, cognitive, and attitudinal factors intersect to shape the

learning experiences and outcomes of medical students. This holistic approach allows for the integration of diverse insights, contributing to broader pedagogical strategies that enhance medical education.

Chapter 1

General introduction

In this thesis, I explore the relationship between prior knowledge of classical Greek and Latin and its impact on both the learning and teaching of anatomy within medical education, as well as on anatomy examination performance. Additionally, the study examines how first and final-year medical students' attitudes toward the influence of Greek and Latin affect their understanding of anatomy. Considering psychosocial elements, it investigates the connection between multilingualism and verbal-spatial intelligence, alongside the relationship between various personality traits on the acquisition and comprehension of anatomical terminologies. This research further investigates the relationship between personality traits, linguistic skills, and examination outcomes among medical students. Utilising the 'Big Five Inventory' (BFI) with its 44 items, the study contrasts medical students in the United Kingdom (UK) and France with psychology and business students in France. This comparison aims to identify variations in personality traits and examine how these differences may impact linguistic abilities and academic achievement in medical studies. Before presenting the hypotheses underlining these investigations, it is essential to provide an overview of the current status of anatomy in the medical curriculum, the brain's language and speech centres, the significance of Greek and Latin terminologies, learning preferences and capabilities, personality traits, and psychosocial factors such as verbal/spatial intelligence.

According to Harrold Ellis (2002), human anatomy, a fundamental pillar of medical education for centuries, has withstood the rigorous test of time, underscoring its enduring importance. Despite its historical significance, recent trends show a gradual reduction of anatomical content in medical curricula. The role of anatomical knowledge is multifaceted, including: enhancing patient examination, diagnostic formulation, and the effective communication of findings to patients and healthcare professionals alike. While the

relevance of various basic sciences may diminish over a doctor's career, necessitating a re-evaluation of their presence in a 'core curriculum,' the constancy of human anatomy ensures its continued relevance. It lays a foundational knowledge base applicable across all medical specialties. Frank and Danoff (2007) and Netterstrøm and Kayser (2008) both assert that understanding anatomy is crucial for safe clinical practices, but they differ in their approach to supporting this claim. Frank and Danoff's assertions are based on the CanMEDS framework (a competency-based framework developed by the Royal College of Physicians and Surgeons of Canada) and the well-accepted role of anatomy in medical training. However, they do not provide direct empirical evidence, making their statement primarily an assertion. In contrast, Netterstrøm and Kayser (2008) offer evidence through their study, published in *Anatomical Sciences Education*, which shows that integrating clinical practice into anatomy education enhances practical skills and anatomical understanding, directly linking their claim to research findings. Their research supports the idea that hands-on clinical exposure improves medical students' grasp of anatomical concepts. Thus, while both agree on the critical nature of anatomy, Netterstrøm and Kayser provide empirical support, whereas Frank and Danoff rely on established consensus.

1.1: Anatomy within the medical curriculum

However, according to Turney (2007), in the late 20th to early 21st century, however, the importance of human anatomy in medical curricula has been questioned. This appears to have a risen, at least in part, because of the explosion of knowledge in both the basic and clinical sciences. Furthermore, what could be deemed essential knowledge today may not be seen as being clinically important tomorrow (Drake *et al*., 2009). Yet, while anatomical

knowledge clearly provides a platform of knowledge for medical specialities, it also supports in general proper examination of a patient, is important in formulating a diagnosis, and helps communicate clinical findings to the patient and other medical professionals (Turney *et al.,* 2001; and Turney 2007). There have nevertheless been significant reductions in the number of teaching hours devoted to gross anatomy. For example, figure 1.1 shows that within the United States of America, it was recorded that the hours devoted to the teaching of gross anatomy had declined from just under 780 hours per annum in 1931 to about 340 hours in 1955 to nearly 120 hours in 2018 (Drake, 1998; Drake *et al.,* 2009; Drake *et al.,* 2002, Drake *et al.,*2014, Drake 2018). To put this into context, 120 hours is merely equivalent to three full weeks of tuition, or 1% of five-year medical course. While these trends highlight a global shift in anatomy education, it is essential to caveat the relevance of these findings within the UK context. The structure of medical education, curriculum design, and teaching methodologies differ between the USA and the UK, where cadaveric dissection has historically played a more prominent role in UK institutions (McHanwell *et al*., 2007).

Furthermore, the last data point in Figure 1.1 is from 2018, and recent curriculum changes, technological advancements, and shifts towards digital anatomy resources may have further influenced anatomy teaching hours in both the USA and the UK (especially after the enhanced use of digital education during the Covid-19 pandemic). More recent UK-based studies suggest that while reductions in dissection time have occurred, there remains a strong argument for maintaining cadaveric-based learning in medical curricula (Smith *et al*., 2019). Future research should therefore explore how these trends have evolved post-2018, particularly within the UK context, to assess the current state of anatomy education and its implications for medical training.

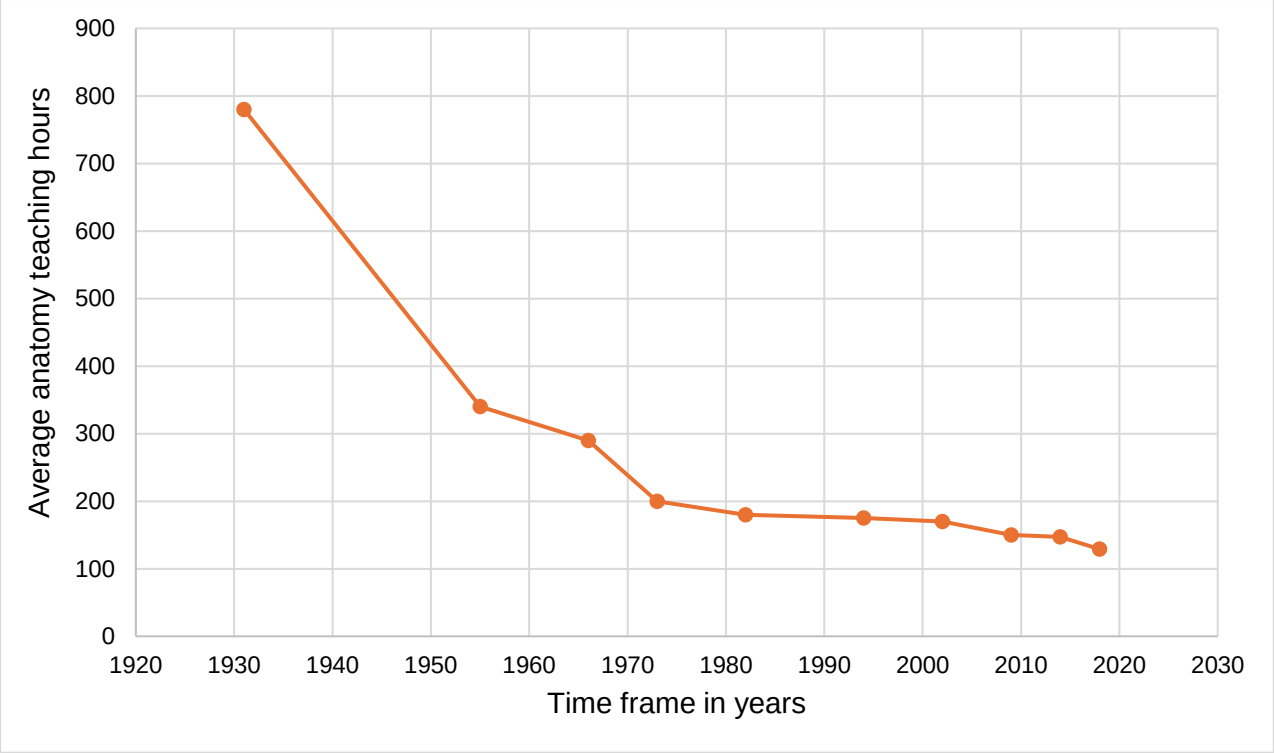


Figure 1.1: Decline in gross anatomy teaching hours in USA medical schools (1931–2018)

This figure illustrates the average number of teaching hours for gross anatomy in USA medical schools from 1931 to 2018 (Drake, 2018). The data shows a significant decline over the decades, with hours decreasing to approximately 120 in 2018. Post-2018, the trend suggests a potential stabilisation of teaching hours

The role of dissection is also under scrutiny (Rizzolo, 2002; Topp, 2004). According to a report of the Royal College of Surgeons (England), in 2009 a medical student in the UK would dissect for an average of 149 hours throughout their five years of training. A study by Smith *et al*. (2022) reported that, as of 2019, medical students in the UK and the Republic of Ireland were allocated an average of 85 hours of taught time for gross anatomy throughout their five-year programme. This represents a reduction from previous years. The above study also noted that 87% of medical schools used human cadavers to teach anatomy, with a total of 1,363 donors being used per annum. McBride and Drake (2018) have reported that, in the USA, the number of hours using cadavers has declined from just over 120 hours in 2002 to less than 80 hours in 2018 (Figure 1.2).

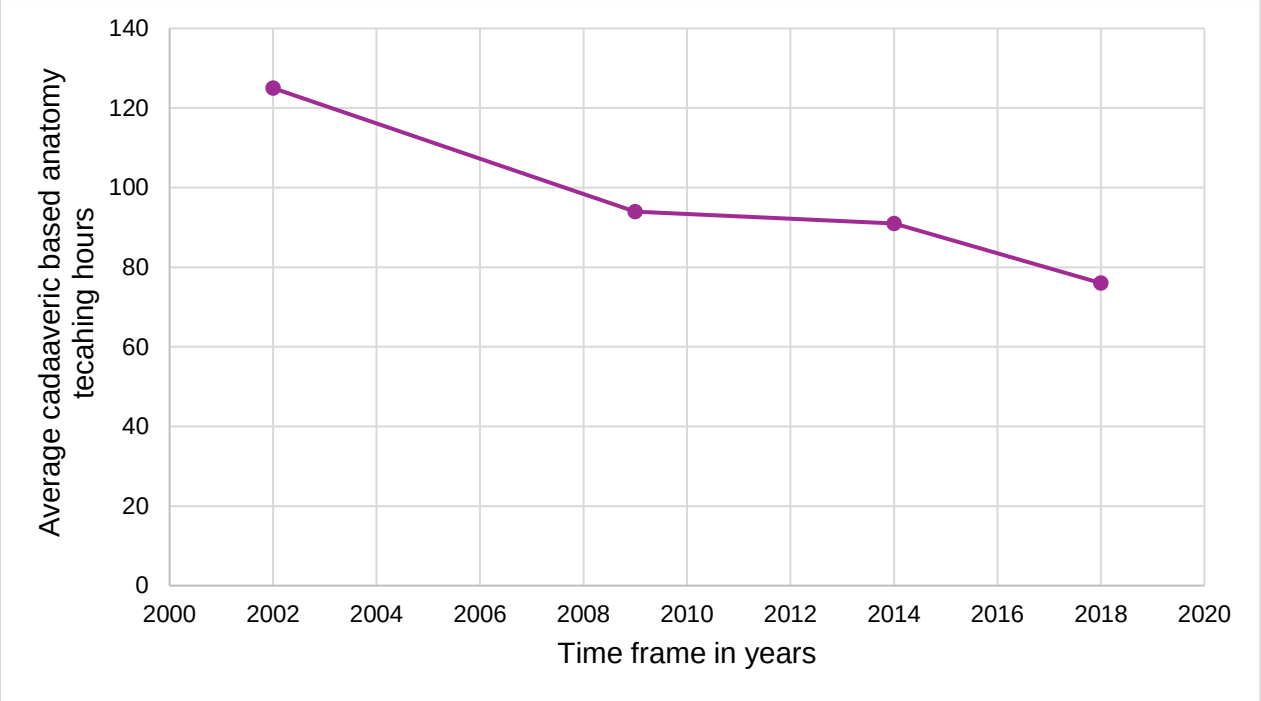


Figure 1.2: The reduction in cadaver-based teaching hours in U.S. medical schools (2002–2018). This figure illustrates average teaching hours using cadavers in USA medical schools (2002–2018). Hours declined from over 120 in 2002 to under 80 by 2018. Post-2018 trends suggest further adoption of technology-driven methods, replacing traditional cadaveric teaching (McBride and Drake 2018).

Again, to put it into context, 80 hours would be equivalent to less than two weeks. The UK has followed the European trend of reducing the number of hours for general anatomy teaching throughout the curriculum (Dyer *et al*., 2000; Plaisant et al., 2004; Gogalniceanu, 2009). In order to deal with the limited number of hours allocated to gross anatomy in the medical curriculum, medical schools are employing alternative teaching methods (e.g. self-directed learning, problem-based learning (PBL), and computer-assisted learning (CAL;Turney, 2007). Ahmad *et al*. (2020) highlighted the limitations of traditional anatomy education, including inadequate dissection opportunities and fragmented curricula, and proposed solutions such as the integration of system-based anatomical teaching and the use of TEL tools like 3D virtual dissection software. These innovations aim to bridge the gap created by reduced teaching hours while maintaining essential anatomical knowledge for clinical practice.

It could be argued that the marked reduction in time allocated to anatomy might be accompanied by a reduction in understanding of anatomical terminologies. This in turn might have knock-on effects on students' abilities to learn and retain terms that, to the newly recruited medical student, might appear almost as a foreign language (Smith *et al.,* 2019). Difficulties in acquiring this new medical and anatomical language might also have an influence on their learning and understanding of anatomy in general. Waterston *et al.,* (2005) reported that 64% of clinicians thought students had an insufficient knowledge of anatomy and that 61% believed that newly qualified doctors had unsatisfactory anatomical knowledge to practice medicine safely. Fitzgerald *et al.,* (2008) speculate whether such deficiencies may relate to different learning approaches, poor memory retention, lack of teaching, inadequate resources but poor linguistic skills might also be a factor.

Perhaps as a consequence of the reduction in the number of hours devoted to teaching anatomy, the number of staff taking up anatomy teaching posts has declined in the last two decades. 85% of medical schools surveyed relied on surgical trainees to act as anatomy demonstrators (Gossage *et al.,* 2003, Older 2004, Tibrewal 2006, Wilson *et al.,* 2020). With reduced numbers of teaching hours and reduced numbers of staff dedicated to teaching anatomy, there has been a reduction in anatomy departments and professors of anatomy (Gossage *et al.,* 2003,). According to Turney, 2007, this trend can be compared to earlier periods (i.e., mid to late 20th century) when anatomy had a more prominent role in medical curricula. As a consequence of these changes it is conceivable that less time and effort can be extended to allowing medical students to develop their linguistic skills and would find the learning anatomical terms challenging since they are derived from classical Greek and Latin, languages that nowadays students have little knowledge of before entering medical school. It is possible that the reason for the decline of classical Greek and Latin in schools relates to the perception that the job market has changed such that humanities are not so well appreciated as in the past. Indeed, many of the highly paid jobs such as computing, banking and business do not require the knowledge or understanding of classical languages and therefore many schools in UK and Europe have stopped offering these languages in their curricula (Turmezei, 2012).

1.2: History of Greek and Latin

The history of Greek and Latin is closely linked to the development of Western intellectual traditions, particularly in the fields of medicine, science, and philosophy (Tsiompanou and Marketos, 2013). As the primary languages of scholarship for centuries, they have shaped the terminology used in anatomy and medical education today. Greek, known for its precise and systematic approach to language, provided the foundation for many anatomical and medical terminologies. At the same time, Latin, through the expansion of the Roman Empire, became the universal language of science and scholarship in medieval Europe. Despite their decline in modern education, their legacy continues in the medical and anatomical vocabulary, demonstrating the lasting influence of classical languages on modern science. Understanding their historical significance provides valuable insight into the structure and meaning of medical terminology, aiding students in grasping complex concepts more effectively.

The Latin language has survived in one form or another for over 2,000 years. It is both the cognate and mother of many modern languages. Originally spoken by small groups of people living along the lower Tiber River in Italy, Latin spread to new geographical regions with the expansion of Roman Empire, primarily throughout Italy and subsequently throughout Western and Southern Europe and the Central and Western Mediterranean coastal regions of Africa (Varvaro, 2018).

The Latin alphabet is derived from Etruscan and Greek. Latin is thought to be one of the oldest members of the Indo-European language family, which traces its origins to the Indo-European proto-language, spoken several thousand years ago. This proto-language gave rise to descendant languages such as Latin, Sanskrit, and Greek. It likely originated in the Pontic-Caspian steppe or Anatolia. This large language family also includes Greek, Celtic, and Germanic languages (Pei and Gaeng, 1976).

The ancient Greeks (1600 BCE to 600 CE) were pioneers to thoroughly study the field of Medicine (including Anatomy) and to develop suitable terminologies. The Romans (27 BCE–476 CE) continued this study, regularly altering the Greek terms which they adapted as

necessary to fit their alphabet and grammar (Kaba and Sooriakumaran, 2007). Latin then continued as the language of science, the law, and the Church throughout Western Europe until the Eighteenth century. Consequently, most of the vocabulary of scientific medicine in use today stems directly from these Latin roots (Santacroce, 2017).

English, and Medical English have had many linguistic influences, originating in Greek, and being heavily altered due to invasion and rule of England in the past 2500 years (Dzuganova 2002; Christiansen 2015). Greek was Latinised by the Roman Empire from the 2nd century BCE, and was brought into England by invasion. Norse (8th–11th centuries CE) and French invasion (1066 CE) also shaped many English and Medical English terms (Dzuganova 2002), however the Graeco-Latin roots have remained hugely present. The global presence of English commenced with the global empire and the Commonwealth.

1.2.1: Influence of Greek and Latin in anatomy and medicine

Anatomy is the branch of biology that studies the morphology and structure of organisms. The word ‘Anatomy' is derived from the Greek ‘Ana'- meaning-up; and ‘tome'-meaning –‘a cutting’. As might be assumed from its etymology, the learning and understanding of anatomy depend profoundly on dissection (Porter *et al.,* 1997, Conti, 2011). It is estimated that approximately 75% of medical terminology is derived from classical Greek (Conti *et al.,* 2019). The main reason for this is that the Greeks were the founders of rational medicine in Europe, during the golden age of Greek civilisation in the 5th Century BCE. The Hippocratic School and, later, Galen (the Greek from Asia Minor who lived in Rome in the 2nd century A.D.) developed theories which subjugated medicine up to the beginning of the 18th Century (Hajar, 2021). A second reason for the substantial number of Greek medical terminologies is that the Greek language is appropriate for the building of compound words. When additional terms were needed, with the rapid expansion of medical science during the 18th and 19th centuries, Greek words or Latin words with Greek endings were used to express the new ideas, conditions, or instruments (Banay 1948). The new words follow the older models so closely that it is impossible to distinguish the two by their forms. The fact is that about half of our medical terminology is less than a century old (Wulff, 2004 and Wetzel, 2006). A third

reason for using the classical roots is that they form an international language thus making it easier for the scientific community to communicate irrespective of geographical boundaries (Wulff, 2004) (Figure 1.3).

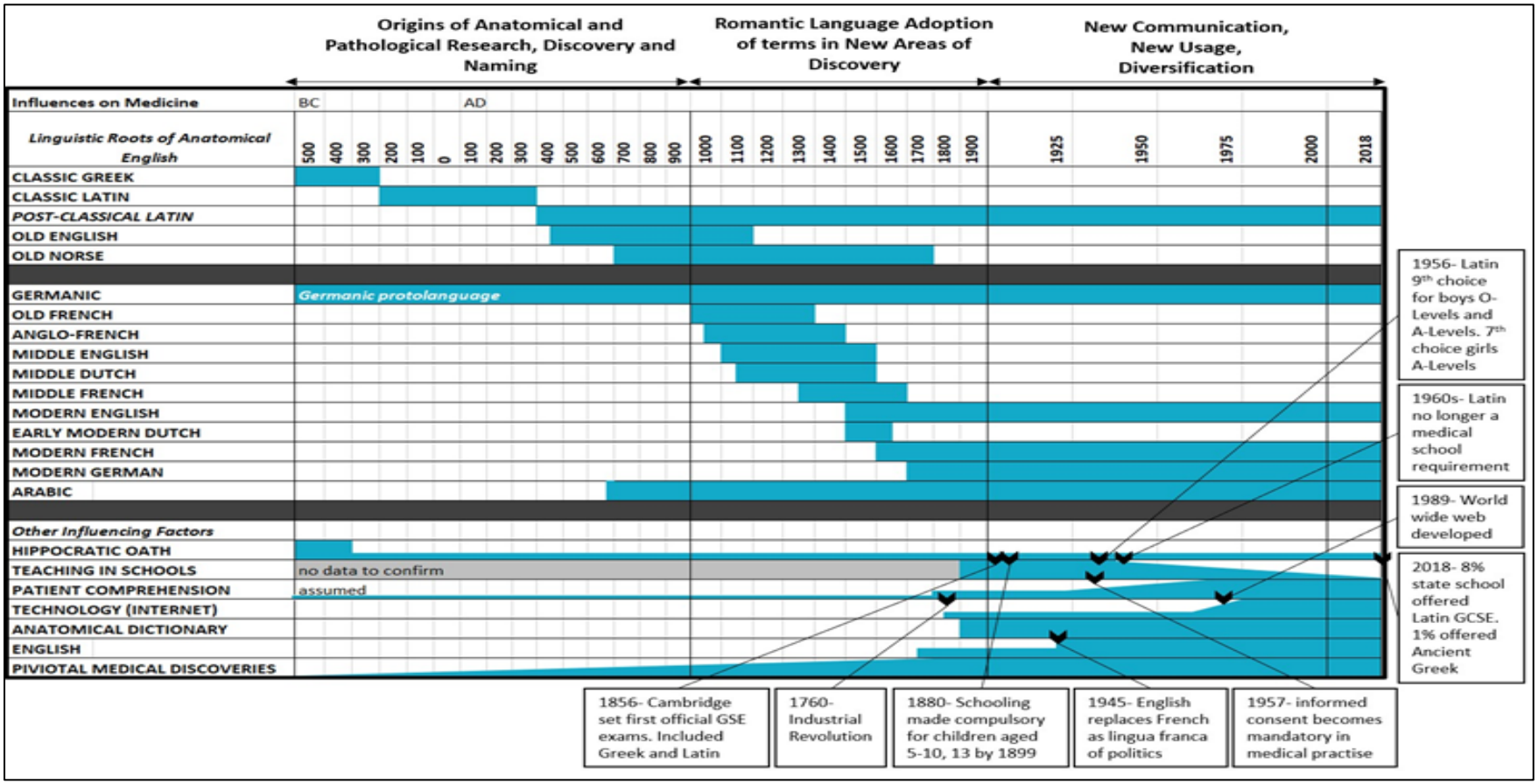


Figure 1.3: Evolution of medical language and education: a chronological overview. This Gantt chart provides a chronological representation of key events, cultural shifts, and academic advancements that have shaped medical language and education over time. The timeline spans from ancient civilizations to modern influences, illustrating how medicine and its terminology have evolved across different historical periods. Adapted data from: Department of Education and Skills (2006). Cambridge Assessment (2008), Turmezei (2012), Graham and Brookey (2008), Hajar (2015), and Oxford Reference (2019). Work of Harvey G, Cardiff University 2018-19.

The study reported in this thesis aimed to investigate the attitudes of first and final year medical students at Cardiff University towards the importance of understanding classical Greek and Latin in their medical training. It also explores how these attitudes might influence their approach to learning medical and anatomical terminologies, considering the challenges posed by the roots of these terms in languages not commonly taught today and the reported reduction in anatomy exposure and dissection room contact hours.

1.2.2: Greek and Latin in anatomical and medical terminologies

The influence of the ancient Greeks and Romans on modern medicine is exerted mainly through linguistics and philosophy and the Greeks moved medicine away from religious superstition towards rational science (Tountas, 2009). Anatomical terminology, and most other medical terminologies, are derived from Greek and Latin (or a hybrid thereof) because they provide concise, descriptive explanations of anatomy and medical procedures (Micic, 2013; Melaschenko, 2018), as well as ensuring no linguistic, geo-political biases. For instance, the term 'brachial artery' originates from the Greek word 'brachion,' meaning 'arm,' and accurately describes the artery supplying blood to the upper limb.'

Consequently, newly defined medical terms are still given Greek or Latin-based names internationally through *Terminologia Anatomica*, *Terminologia Embryologica*, and *Terminologia Histologica* (Federative Committee on Anatomical Terminology, 1998) These are standardised nomenclatures for anatomy, embryology, and histology, respectively. They serve as official reference systems for naming the structures and features within these fields (Wulff, 2004; Baethge, 2008;). Ancient Greek and Latin therefore helps define the base for an international language of medical communication. Turmezei (2012) and Baig and Mallu (2018) claim that the reduction of classical learning in schools influences medical learning and impacts on the efficient practice of medicine (Smith *et al* 2007). However, Wulff (2004) and Christiansen (2015) postulate that since international medical communication is nowadays greatly technologically based, and therefore predominantly in English, medical language in the future may become more Anglocentric.

1.3: Multilingualism

Multilingualism, the ability to use multiple languages, has long been a subject of interest in cognitive science and education. Its impact extends beyond communication, influencing brain structure, cognitive functions, and social interactions. Understanding the role of multilingualism is particularly relevant in medical education, where diverse linguistic skills and cognitive flexibility can enhance both learning and patient care.

The term 'language' is defined in the Oxford English Dictionary as a method of communication consisting of the use of words in a structured and conventional way. The use of language is believed to be unique to humans and the way in which the human brain process language (McNeil and Pratt, 2001). According to Grosjean 2010; and Cenoz 2013, multilingualism is defined as the ability to speak more than one language fluently (i.e., the ability to convey the message unhaltingly) and proficiently (i.e., the ability to understand and communicate in the language). It is estimated that half of the world's population is multilingual (Marian and Shook, 2012).

1.3.1: History of research in language processing

According to Tate *et al*, (2014), the language and speech areas are situated in the dominant hemisphere of the brain and are involved in the interpretation, analysis and understanding of the written and spoken language. Broca's area, in the frontal lobe of the brain, mainly deals with the expression of spoken and written language while Wernicke's area, situated in the temporal lobe of the brain, is involved in comprehension and understanding of written and spoken language.

Wernicke (1874) hypothesised a singular language stream, where a centre in the superior temporal gyrus, Wernicke's area, would be a sole centre for sensory recognition of speech and language, on the basis that subjects had Wernicke's aphasia, characterised by an inability to understand language, when that area was lesioned. It was postulated that this stream led to Broca's area (Figure 1.4), the speech motor centre located in the frontal lobe. Lesions here caused aphasias that were characterised by an understanding of, but inability to produce, spoken language (Mohr *et al.,* 1978; Biondo *et al.,* 2024).

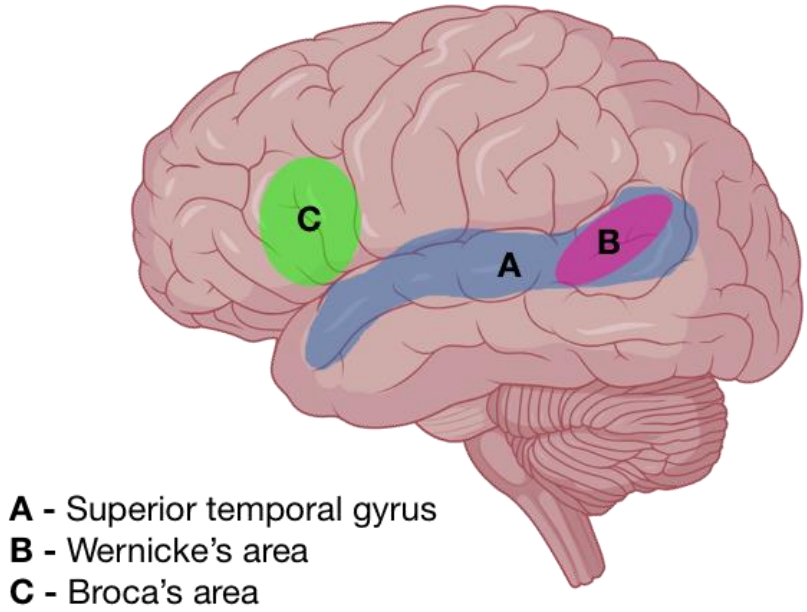


Figure 1.4: Brain regions involved in language processing. This figure provides a schematic representation of the primary brain regions associated with language processing, as proposed by early research in neurolinguistics. These regions play a crucial role in speech production, comprehension, and overall linguistic ability. A) Superior temporal gyrus; B) Wernicke's area; C) Broca's area (Biondo *et al.,* 2024).

1.3.2: Processing of multilingualism

There is some dispute as to the extent to which language processing differs in multilingual subjects. Older studies believed that multilingual infants developed a 'dual lexicon', where the two languages were learned as one 'hybrid' language and the infant's ability to differentiate between the two languages developed at a later stage (Vihman, 1985). The generally accepted view more recently, however, is that infants exposed to bilingual environments develop two or more separate language repertoires, and both monolinguals and multilinguals are able to discriminate between similar languages in infancy, as young as 4-months-old (Bosch and Sebastián-Gallés, 2009, Ferjan Ramírez *et al.,* 2024).

In either case, it is clear that a multilingual individual may experience cognitive challenges that are not experienced by monolingual subjects: notably, the need to distinguish between their two or more fluent languages, both in the hearing and processing of them, and in the production of speech in the language that is appropriate to the context. According to Sweller, Ayres and Kalyuga, (2011), Cognitive Load Theory (CLT), these challenges may increase the intrinsic load due to the complexity of managing multiple language systems. At the same time, multilinguals develop germane load through schema-building, enabling them to organise and store linguistic information more efficiently. This process strengthens cognitive control mechanisms, helping them to switch languages, resolve conflicts, and reduce interference, as suggested by research (Gollan and Acenas, 2004; Argyri and Sorace, 2007; Gollan *et al.,* 2008).

As a result, the constant balancing of two or more languages creates a need to control how much a person accesses a language at any given time. From a communicative standpoint, this is an important skill—understanding a message in one language can be difficult if the other language interferes. Likewise, if a multilingual person frequently switches between languages when speaking, it can confuse the listener, especially if that listener knows only one of the speaker's languages (Marian and Shook, 2012).

Studies using functional Magnetic Resonance Imaging (fMRI), a non-invasive neuroimaging technique, allow researchers to measure brain activity by detecting changes in blood flow. Increased blood flow highlights areas of neural activation, providing insights into brain function during specific tasks, including language processing. Kovelman *et al.,* (2008) suggest that monolingual individuals use specific, restricted regions of the brain to process language, whereas multilinguals employ a broader neural network, including the frontal and bilateral cortex. fMRI studies further reveal that multilinguals exhibit increased grey mater volume in the left inferior parietal lobe (Kim *et al.,* 1997; Dehaene *et al.,* 1997; Hernandez *et al.,* 2000; Hahne and Friederici, 2001; Marian *et al.,* 2003). These structural changes are associated with cognitive benefits and long-term brain health, including delayed onset of Alzheimer's-type dementia (Bialystok *et al.,* 2007; Alladi *et al.,* 2013; Bialystok *et al.,* 2014).

To maintain the relative balance between languages, the multilingual brain relies on executive functions, a regulatory system of general cognitive abilities that includes processes such as attention and inhibition. Because a multilingual person's language systems are always active and competing, that person uses these control mechanisms every time they speaks or listens.

This constant practice strengthens the control mechanisms and changes the associated brain regions (Abutalebi *et al.,* 2008; Abutalebi *et al.,* 2011; Bialystok *et al.,* 2012). Recent studies have substantiated the claim that this ability to balance all the languages creates consequences more generally for bilinguals and multilinguals that enhance the ability to ignore irrelevant information, to switch from one task to another, and to resolve conflict across different alternatives (Prior and MacWhinney, 2010; Bialystok *et al.,* 2012).

The bilingual language-learning advantage may be rooted in the ability to focus on information about the new language while reducing interference from the languages they already know. This ability would allow bilingual people to more easily access newly learned words, leading to larger gains in vocabulary than those experienced by monolingual people who aren't as skilled at inhibiting competing information (Kaushanskaya and Marian, 2009 and Tran, Arredondo and Yoshida, 2021). This advantage is particularly relevant to the study of anatomy, where students must rapidly acquire and retain complex terminology, often derived from Latin and Greek, while filtering out interference from familiar but unrelated words.

1.3.3: Development of multilingualism

Approximately half of the world's population is bilingual (Grosjean, 2010). The majority of Europeans are able to communicate in a language other than the official language of their country, and 25% are confident in holding a conversation in at least two additional languages (European Commission, 2012). As human society grew, due to communication with other humans, individuals started speaking more than one language and evolved as bilingual and/or multilinguistic. Studies have suggested that both internal (such as, chronological age, age of second language acquisition and onset, etc) and external factors (such as, parents' education, parents' occupation, family size, etc.) play a role in determining the individual to be bilingual or multilingual (Armon-Lotem, 2011).

There are approximately 5000 languages spoken around the globe today (a third of them in Africa), but evolutionary linguists and researchers organise them into relatively smaller groups - perhaps fewer than twenty. These smaller groups/families of languages are based on their descent from a common ancestral or parent language called the proto-language

(Rowe *et al.,* 2014). Thus, languages may be linked to each other by common words or sounds or grammatical structures. It is thought by the evolutionary linguist, that the original language might have been spoken in relatively recent times –a few thousand years ago (Hockett, 1960). This diversity reflects a complex interplay of cultural, historical, and geographical factors shaping language development. The concept of proto-languages suggests that languages evolve and diverge over time from shared ancestors, implying an ongoing process of linguistic change and adaptation (Chang *et al*., 2015).

The neuroscience of cognitive abilities provides insights into how different brain regions correspond to specific learning strengths. For example, linguistic abilities involve activating Broca's and Wernicke's areas, which are responsible for language production and comprehension. Spatial reasoning engages the parietal lobes, critical for spatial intelligence. Similarly, kinaesthetic skills are linked to the cerebellum and motor cortex, which control movement and coordination (Binder, 2015).

These neural connections mentioned above support the idea that different abilities depend on specific brain pathways. For example, the activation of Broca's and Wernicke's areas for linguistic processing directly supports findings in the thesis regarding the importance of language skills in effective communication and collaboration in medical education. Similarly, spatial reasoning, linked to parietal lobe activity, aligns with findings on the critical role of visualisation and spatial relationships in mastering 3D orientation in anatomy and performing complex surgical tasks that involve dexterity. These insights highlight the role of linguistic and spatial reasoning in contributing to students' adaptability and success in medical education, particularly in areas like anatomy and patient communication. By understanding these neural correlations, educators can design targeted teaching strategies that align with students' strengths, enhancing their learning experience. This is particularly significant in anatomy education, where mastering complex terminology and understanding three-dimensional spatial relationships are essential for accurately identifying structures, visualising their spatial orientation, and applying this knowledge in clinical and surgical contexts.

1.4: Learning approaches and strategies

1.4.1: Learning preference theories

When describing the approaches that students may choose to use when studying, the term ‘learning preferences’ is more appropriate and avoids the misconceptions often associated with the concept of ‘learning styles’. Learning preferences refer to the individual ways in which students engage with and process information, rather than rigidly categorised styles of learning.

Recent work has critically examined the continuity of learning preference theories in educational contexts. For example, Brown (2023) critiques the ubiquity of the belief in matching teaching methods to learning preferences, identifying it as a neuromyth that lacks empirical support. Hall (2016) also explores the strength of these preferences in educational discourse, questioning their validity and long-term influence on teaching practices. Additionally, Lodge, Hansen, and Cottrell (2016) argue for a shift in focus from sensory modalities to more robust, evidence-based approaches that enhance learning outcomes.

These works highlight the importance of understanding learning preferences as a flexible concept while cautioning against oversimplified or unsupported educational applications.

The integration of advanced visualisation tools has been shown to support the development of spatial abilities in medical education. Keenan and Powell (2020) discuss the importance of understanding transitions between two-dimensional (2D) and three-dimensional (3D) visualisation in anatomy learning. This highlights how tools that simulate 3D-2D transitions can strengthen students’ spatial intelligence and improve their understanding of anatomical structures. Similarly, Keenan and Ben Awadh (2019) advocate for the inclusion of 3D visualisation technologies in undergraduate anatomy education, emphasising their role in enhancing spatial awareness and comprehension. These studies underline the growing significance of innovative educational approaches in fostering cognitive skills crucial for medical training.

1.4.2: Spatial abilities

Spatial abilities play a critical role in medical education, especially in anatomy, where understanding three-dimensional structures is essential. Multimodal three-dimensional visualisation techniques have been shown to enhance the interpretation of cross-sectional anatomy for novice learners (Ben Awadh *et al*., 2022). Additionally, Fernandez *et al*. (2011) highlight significant differences in spatial abilities among novices, intermediates, and experts, emphasising the developmental nature of these skills over time. Research by Langlois *et al*. (2017, 2020) highlights the importance of spatial abilities training in anatomy education and advocates for integrating such training into curricula. These findings suggest that incorporating spatial awareness techniques early in medical education can strengthen foundational anatomy knowledge and skills.

The diversity of students enrolling in higher education continues to increase, with learners coming from varied ethnic and cultural backgrounds, socio-economic circumstances, training programmes, and institutions, each bringing different learning preferences (Romanelli, 2009). This diversity has prompted many educators to reconsider traditional teaching methods that cater to a single type of learner (Newble and Entwistle, 2003; Lubawy, 2003). Learning preferences refer to the various ways people understand, organise, and represent information. American psychologist Howard Gardner relates different learning preferences to his theory of multiple intelligences. Students who recognise their learning preferences are often empowered to adopt techniques that enhance their understanding, potentially leading to greater educational satisfaction (Pashler *et al.,* 2008).

1.4.3: Modality Appropriateness Model

The Modality Appropriateness Model offers several advantages over traditional learning styles approaches. Unlike learning styles theories that focus on individual preferences, this model emphasises selecting sensory modalities based on the nature of the task. For example, spatially complex information, such as anatomical structures, is best expressed

through visual formats like diagrams and 3D models, while verbal concepts are more effectively communicated through auditory or textual means (Hildebrandt, Rohde, van Dam and Cañal-Bruland, 2022). By aligning instructional methods with the inherent characteristics of content rather than learner preferences, this approach enhances learning efficiency and reduces cognitive load (Lodge, Hansen and Cottrell, 2016). Furthermore, it aligns with Cognitive Load Theory (Sweller, Ayres and Kalyuga, 2011), which emphasises the importance of presenting information in ways that remove barriers to learning rather than catering to subjective preferences.

However, the Modality Appropriateness Model has certain limitations. Some studies suggest it may overstate sensory modality at the expense of other key factors in learning, such as prior knowledge, cognitive abilities, and contextual influences, limiting its applicability across diverse learning scenarios (Pashler *et al*., 2008). Additionally, empirical support for the model has been inconsistent, with research on multisensory integration suggesting that the dominance of a particular sensory modality can vary depending on context and individual differences (Shams and Seitz, 2008). Furthermore, it does not fully address the benefits of multisensory learning, where combining multiple sensory inputs can enhance understanding and retention (Mayer and Fiorella, 2014). Examples of multisensory inputs include visual-auditory integration, such as using narrated animations to explain complex processes, tactile-kinaesthetic learning, where students manipulate 3D models to understand anatomical structures, and visual-text combinations, like pairing diagrams with explanatory text. By integrating these approaches, educators can remove barriers to comprehension and provide more inclusive learning experiences.

Similarly, learning preferences, which describe how students engage with and process information, have been widely debated in educational research (Pashler *et al.,* 2008). While many educators design instruction based on learning preferences, studies have shown that matching teaching methods to preferred modalities does not necessarily improve learning outcomes (Pashler *et al.,* 2008; Brown, 2023). Instead, effective teaching strategies should focus on task-appropriate modalities and cognitive engagement. Designing instructional approaches that prioritise reducing cognitive barriers—such as excessive extraneous load or poor modality alignment—may lead to more effective learning experiences.

Despite the insights provided by these models, the Modality Appropriateness Model and learning preferences were not examined in detail in this thesis for several reasons. Firstly,

the research primarily focused on linguistic skills, multilingualism, and personality traits in anatomy learning rather than sensory modalities. Secondly, the empirical data collected did not include direct assessments of modality effectiveness in learning anatomy, as the study concentrated on broader cognitive and psychosocial factors. Finally, while the literature on modality appropriateness in medical education is growing, further research is needed to establish its specific implications for anatomy instruction.

Nevertheless, integrating task-appropriate modalities that remove barriers to learning into curriculum design could enhance student engagement and comprehension, particularly in medical education, where spatial and verbal skills are critical for anatomy learning. Future research could explore how different modes of content delivery impact cognitive processing and learning outcomes, moving beyond learner preferences to more evidence-based instructional strategies.

Within the Cardiff University medical curriculum, anatomy remains a major component, with an introduction to general anatomy of systems in Year 1, followed by further anatomy teaching in Year 2. To accommodate diverse learners, anatomy is taught using a combination of instructional methods, reinforcing the importance of inclusive, evidence-based educational strategies rather than an emphasis on learning preferences alone.

1.5: Spatial and verbal intelligence and their centres

According to Gardner (1983) spatial intelligence is defined as one's ability or skill to solve spatial problems, visualisation of items from different angle and space (three-dimensional rotation), face recognition and attention to fine. While verbal intelligence is defined as one's ability to read, write and memorise words along with dates. In the hierarchy of multiple intelligence, both verbal and spatial intelligence are classified as most important in comparison to others (Gardener and Hatch, 1989).

As spatial intelligence encompasses three-dimensional rotation and visualisation of the object, both occipital lobe (main visual processing centre) and parietal lobe (visual perception centre) are involved. While for verbal intelligence, both the Broca's area and Wernicke's area need to be activated along with frontal lobe which process general intelligence (van Asselen, 2006). It is suggested by Midrigan-Ciochina and colleagues (2024) that monolinguals use restricted and specific processing areas of the brain to analyse information while the multilinguals employ a greater neural profile. As they use larger brain areas to process language information there could be activation and overlap of different control centres spanning over different lobes thus making them better at both verbal and spatial intelligence. Spatial intelligence is defined by a capacity for mentally generating, rotating, and transforming visual images. As this intelligence is inter-depended on the visual ability, the occipital and parietal regions of the right hemisphere help with the interpretation of spatial intelligence (Nazreth *et al*, 2019). The verbal/linguistic skills are processed and interpreted in the left temporal and frontal lobes, and requires the help of auditory region of the brain. As multiple intelligence (such as verbal-spatial intelligence) are interdependent, there may be a connection between the different processing centres/regions within the brain (Barbey 2013, Nikolaidis and Barbey, 2016).

The subsequent chapters aim to explore the relationship between multilingualism and cognitive abilities, specifically spatial and verbal intelligence, in medical students, and how these abilities impact their academic performance in anatomy. At Cardiff University we undertake active dissection of donors along with prosections. Cadaveric dissection is a multidimensional educational tool that significantly contributes to the development of spatial and verbal intelligence among medical students by providing a real-world context for applying theoretical knowledge, enhancing three-dimensional understanding, expanding anatomical vocabulary, and fostering critical thinking and problem-solving skills.

1.6: Personality traits

In the realm of medical education, the success and effectiveness of future healthcare professionals are not solely determined by their cognitive abilities and academic

achievements. Emerging research suggests that non-cognitive factors, particularly personality traits, play a pivotal role in shaping medical students' academic performance and their future professional conduct within the healthcare sector. Personality traits are defined as habitual patterns of behaviour, thought, and emotion (Kassin and Kiechel, 1996). According to trait psychologists, there are a limited number of these dimensions, and each individual falls somewhere on each dimension, meaning that they could be low, medium, or high on any specific trait (Matthews *et al.,* 2003).

One commonly-used framework for personality traits is the 'Big Five' framework. Among the Big Five personality traits—openness, conscientiousness, extraversion, agreeableness, and neuroticism—neuroticism has drawn considerable attention due to its profound implications for mental health and professional resilience (Oshio, Taku, Hirano and Saeed 2018) Medical education is inherently stressful, with rigorous demands and high expectations, which can exacerbate neurotic tendencies and lead to a vicious cycle of anxiety and underperformance.

Conversely, students with lower levels of neuroticism, often referred to as having emotional stability, tend to demonstrate better stress management skills, resilience, and adaptability (Hayat, Kohoulat, Amini and Faghihi, 2020). These traits are vital for maintaining mental well-being in high-pressure environments and are associated with lower rates of burnout and higher professional satisfaction.(Yusoff, Hadie and Yasin, 2021). Recognising the role of neuroticism in shaping mental health outcomes highlights the importance of integrating mental health support systems into medical training. For instance, mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1990) and resilience training programmes can be particularly effective in helping students manage neurotic tendencies and maintain psychological balance. MBSR helps manage stress and enhance resilience through mindfulness meditation and self-awareness techniques.

The findings reported in this thesis seek to explore the intricate relationship between personality traits and the academic and professional outcomes of medical students in diverse educational contexts using the Big Five Inventory (BFI). In 1999, John and Srivastava, developed the Big Five Inventory (BFI). Studies have demonstrated the BFI's strong internal consistency and test-retest reliability (John and Srivastava, 1999; Soto and John, 2017). Its validity has been supported across diverse populations and cultural contexts (McCrae and Costa, 2004), making it suitable for examining personality traits in academic and professional settings. These sets of inventories help to establish personality traits in an individual.

Personality traits are defined as unique qualities or characteristics that make an individual's personality. The Big Five personality traits, encompassing Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (often abbreviated as OCEAN), play a crucial role in various domains of life, including medical education and practice. Knowing the personality traits, the teacher could design effective strategies to adapt the teaching requirements to the learner's psychological needs. Understanding the significance of these traits in the context of medical education, excellence, and examinations can offer valuable insights for educators, students, and professionals in the healthcare field.

1.6.1: Educational success and personality traits

Personality traits play a significant role in shaping educational success, influencing learning behaviours, academic performance, and adaptability to various teaching methods. Corresponding to Lee and Klein, (2002) and Preckel, Holling and Vock, (2006), conscientiousness is consistently associated with academic success across disciplines, including medical education. It reflects qualities such as diligence, perseverance, and a strong work ethic, which are essential for mastering the voluminous and complex material in medical training.

Abouzeid *et al.,* (2021) reported that openness influences a student's learning style and adaptability to innovative teaching methods. Open individuals are more likely to engage with and benefit from diverse educational experiences, including problem-based learning and clinical simulations, fostering a deeper understanding of medical concepts.

1.6.2: Professional excellence and patient care

A cross-sectional study amongst first and second-year Chinese medical students by Song and Shi, (2017) stated that agreeableness and empathy are closely related, with agreeable individuals often demonstrating a greater ability for empathy towards patients. This trait is critical in developing trust and relationship, essential components of effective patient care and communication.

According to Cavaness, Picchioni and Fleshman (2020) extraversion can be valuable in collaborative settings and leadership roles within medicine. Extraverts are often more secure in social interactions, enabling teamwork, patient interaction, and networking within the medical community.

1.6.3: Resilience and stress management

A cross-sectional study conducted among 241 Malaysian medical students by Yusoff, Hadie and Yasin (2021) established that neuroticism or its opposite, emotional stability, is an important predictor of resilience and stress management in challenging environments such as medical school and clinical practice. Reduced levels of neuroticism are associated with better-coping strategies and reduced burnout rates among medical professionals Students with high conscientiousness are more likely to perform well in both written and practical examinations due to their thorough preparation and persistent effort (Syed and Syed 2013).

According to Ferguson, James, and Madeley (2002) and Liu, Cai, Chen and Shi (2022), openness and extraversion may contribute to better performance in oral examinations and clinical assessments, where adaptability, communication skills, and interpersonal interactions are evaluated. As medical education evolves to include more interdisciplinary approaches, digital learning tools, and patient-centred care models, traits like openness to experience and agreeableness become increasingly significant. They enable students and professionals to adjust to changes and incorporate new methodologies and technologies.

The Big Five personality traits are often used as a framework for understanding how individual differences affect learning processes, examination performance, professional interactions, and patient care in the medical field (McCrae and Costa, 1999). However, the extent to which these traits reliably predict academic and professional success remains debated, as the model is based on broad assumptions about personality stability and its direct influence on performance (Block, 1995; Fajkowska, 2022). Some studies suggest that traits like conscientiousness are positively correlated with academic performance in medical students (Poropat, 2009; Abouzeid *et al*., 2021), while others highlight cultural limitations in the model's applicability beyond Western populations (De Raad, 2000; Gurven *et al*., 2013). Recognising

and fostering these traits can assist in the selection and development of medical students and professionals who are not only academically competent but also capable of delivering compassionate, patient-centred care (Borges *et al*., 2010). Moreover, integrating awareness of these traits into medical education can aid in developing curricula and support systems that improve students' strengths and address their challenges, ultimately contributing to the advancement of medical excellence (Lievens *et al*., 2009). In anatomy learning specifically, these traits influence study approaches, interpersonal collaboration, and stress management, highlighting the importance of tailored educational strategies to support medical students and professionals (Hojat *et al*., 2015).

1.6.4: Interdisciplinary study to understand personality traits

The work presented in this thesis undertook comparative studies analysing personality traits. By comparing the personality traits of medical students from the UK and France with those of psychology and business students in France, this research reveals significant differences in traits such as openness, conscientiousness, extraversion, agreeableness, and negative affectivity among these undergraduate student groups. A comparative study of personality traits across various student cohorts offers several advantages. According to McCullers and Plant (1964), cultural influences shape personality development, highlighting the need for tailored educational approaches to nurture desirable traits in future professionals. Similarly, Warren and Warren (2023) suggest that understanding personality dynamics within and across disciplines can facilitate interdisciplinary collaboration, which is essential in modern healthcare delivery.

However, it is important to critically examine the extent to which these findings are genuinely ‘evidence-based’ given that personality assessments, such as the Big Five, rely on self-reported measures that may be influenced by social desirability, cultural bias, and the assumption that personality traits remain stable over time (Block, 1995; Fajkowska, 2022). While such comparative analyses contribute to a broader understanding of the connection between personality traits and professional aptitude, they must be interpreted with caution, recognising that the relationships identified may be correlational rather than causative.

This perspective not only enhances understanding of the non-cognitive factors influencing academic and professional success but also underscores the importance of integrating personality development into educational curricula in a way that is informed by robust, critically appraised evidence rather than unchallenged assumptions.

1.7: Aims of the study

In order to develop hypothesis relating to these aims, much of the initial and middle chapters provides a context by summarising the position of anatomy within the modern medical curriculum, the influence of ancient Greek and Latin for anatomical and medical terminologies, importance of Greek and Latin terminologies, learning preferences and learning abilities, psychosocial elements such as verbal/spatial intelligence, linguistic skills and multilingualism and educational and psychological characteristics that might influence linguistic skills. The final chapter evaluates the importance of non-cognitive functions, particularly personality traits, on the academic and professional success of medical students. Utilising the 'Big Five Inventory' (BFI) with 44 items, the study compared the personality traits of medical students in the UK and France to those of psychology and business students in France. The study sought to determine how these traits might affect linguistic skills and examination performance in anatomy.

The anatomy assessment scores (formative and summative) were obtained from the Assessments wing of the Medical Undergraduate office. Depending on the study, the data collected from questionnaires were analysed and compared with the performance marks from anatomy examinations. These results were used to conclude the influence of various aspects such as linguistic skills, personality traits and learning preferences on anatomy performances.

1.7.1: Theoretical underpinnings and conceptual framework

This study is reinforced by key educational theories, including constructivism and social learning theory, which emphasise the active role of learners in constructing knowledge through interaction with their environment and peers. Constructivism suggests that knowledge is built upon prior understanding (Allen, 2022) making it particularly relevant in

exploring how medical students integrate complex terminologies and concepts. Social learning theory highlights the significance of observation, imitation, and modelling in acquiring new skills, which is central to medical education's reliance on hands-on learning and collaborative environments (Horsburgh, and Ippolito, 2018). The conceptual framework for this research is informed by evidence-based educational theories and prior research on student learning. It explores the relationship of classical language knowledge, multilingualism, cognitive abilities, and personality traits, linking these elements to academic success in anatomy examination. This approach provides a clear framework to understand how these factors influence student learning and performance, as well as the broader implications for medical education. In line with this, Dennick (2008) highlights the constructivist perspective by emphasising that learning is shaped through active engagement with educational experiences, rather than passive reception of information. His work highlights how prior knowledge and interactions with the learning environment play a crucial role in meaning-making, further validating the importance of learner-centred approaches in medical education.

1.8: How can this study enhance medical education?

Medical students face significant challenges in mastering anatomical and medical terminologies, primarily because many of these terms originate from Greek and Latin, languages not commonly included in modern educational curricula. This linguistic gap leads to difficulties in understanding complex terminologies, contributing to emotional overload. Additionally, the reduction in contact hours within the dissection lab undermines students' ability to grasp anatomical relationships, further complicating terminology acquisition. The study also highlights that student with a background in Greek and Latin had better understanding of medical terminology. According to Grundy, Anderson and Bialystok (2017), a multilingual students had better verbal and spatial intelligence. Verbal intelligence is crucial for effective communication in the medical field, aiding in the precise explanation of complex ideas and fostering clearer interactions with peers and patients. Enhanced spatial intelligence is essential for understanding the spatial complexities of human anatomy and for processing and retaining medical information more effectively (Langlois, Bellemare, and Gagnon(2023). Furthermore, the above research explores how personality traits, such as openness and conscientiousness, impact learning, indicating that these non-cognitive factors also play a

role in students' academic performance. The presence of such cognitive and personality factors in medical education suggests the significance of a comprehensive educational strategy that addresses both linguistic and cognitive challenges. By enhancing cognitive skills through targeted educational practices and considering personality traits in medical admissions and curriculum design, medical schools could potentially enhance student experiences while reducing burnout and dropout rates. Moreover, these insights can guide policy and curriculum adjustments in medical education, ensuring that training aligns with the needs of contemporary medical practice and sufficiently prepares students for their future roles in healthcare.

1.9: Study goals

The learning of anatomy for medical students, particularly those entering directly from school, presents unique challenges compared to other academic subjects. As a result, significant medical pedagogic research has focused on how best to teach anatomical sciences, including the founding of *Anatomical Sciences Education*, an academic journal by the American Association for Anatomy (AAA).

This study explores the relationship between linguistic skills (including knowledge of classical Latin and Greek), personality traits, and spatial and verbal intelligence in the context of anatomy education. It adopts a positivist epistemological approach, recognising its limitations, which are discussed in later chapters. This approach serves as a foundational step for future research utilising diverse epistemological perspectives.

The study's primary research question asks whether students with advanced linguistic skills (including multilingualism and knowledge of classical languages) exhibit advantages in learning anatomy. Consequence questions address whether educators should focus on developing such skills to enhance student learning outcomes. To investigate these questions, this study employed questionnaires to assess linguistic skills, multilingualism, and their perceived importance among medical students, along with an evaluation of examination performance and personality traits.

1.9.1: Research Questions

1. Do medical students with knowledge of classical Latin and Greek perform better in anatomy examinations?
2. Does multilingualism enhance spatial and verbal intelligence in medical students?
3. Do personality traits correlate with linguistic skills and anatomy learning outcomes?
4. How do spatial and verbal intelligence contribute to anatomy learning and performance?

1.9.2: Hypotheses

The following hypotheses were tested to explore the complex interplay between personality traits, linguistic skills, and cognitive abilities, and their combined impact on academic performance and professional development in medical education.

Table 1.1 Presents an overview of the hypotheses tested across all chapters of this thesis. Each hypothesis is aligned with the respective research questions and objectives, highlighting key areas of investigation.

Chapters	Hypothesis tested
Chapter 3	Students throughout the medical curriculum have a negative attitude toward the importance of classical Greek and Latin
Chapter 4	Regardless of attitude, students in the early years of medical education perform better at both formative and summative anatomical examinations if they have prior knowledge of Greek and Latin.
Chapter 5	Medical students who are multilinguistic have higher spatial and verbal intelligence.
	There are sex differences in spatial and verbal intelligence, female medical students perform better verbally but not spatially

	Medical students who are multilingual have higher spatial and verbal intelligence; they perform better at anatomy examinations.
	Students with low spatial intelligence perform poorly at anatomy examinations
Chapter 6	No personality differences would be discerned between French and UK medical students.
	The expectation is that the business students will have lower 'O' trait (openness), 'E' trait (extraversion), and 'A' trait (agreeableness) but higher 'C' trait (conscientiousness).
	The expectation is that the business students will have lower 'E' trait (extraversion)
	The expectation is that the business students will have a lower 'O' trait (openness).
	Students with prior knowledge of Greek and/or Latin have a lower 'E' trait (extraversion).
	Students with prior knowledge of Greek and/or Latin have a higher level 'C' trait (conscientiousness) and higher 'N' trait (negative affectivity)
	Multilingual students will have a high 'E' trait (extraversion) compared to monolingual students.
	Multilingual students will have a high 'A' trait (agreeableness) compared to monolingual students.
	Monolingual students will have a higher 'N' trait (negative affectivity).
	Female students perform better in anatomy examinations

1.9.3: Definitions

Key terms used in this study are defined as follows:

Term	Definition	Citation
Personality	Habitual patterns of behaviour, thought, and emotion measured by the Big Five traits (OCEAN).	Matthews *et al.,* 2003, Soto and John, 2017

Verbal intelligence	The ability to read, write, and memorise words effectively.	Gardener and Hatch, 1989, Boyle *et al*, 2023
Spatial intelligence	The ability to mentally generate, rotate, and transform visual images.	Nazareth *et al*., 2019
Multilingualism	The ability to fluently communicate in more than one language.	Marian and Shook, 2012, Antoniou *et al*, 2023
Three-dimensional visualisation	The mental ability to understand and manipulate 3D structures, especially in anatomy.	Keenan and Ben Awadh, 2019
Positivist epistemology	An approach that relies on observable and measurable phenomena to understand relationships.	Bryman, 2015, Ryan 2018

This sub-section provides a comprehensive framework for the study, linking the research objectives with theoretical underpinnings and practical applications.

Chapter 2

Methodology

2.1: Scope of the study and research questions

2.1.1: Scope of the study

This study explores the relationship between classical languages, linguistic skills, and personality traits, and their combined impact on medical education. Specifically, it investigates how these factors influence anatomy learning and academic performance, with an emphasis on cognitive abilities such as spatial and verbal intelligence. The research focuses on how these interdisciplinary factors interplay to shape student success, and how the insights gained can contribute to enhancing medical education curricula.

The study involves a wide range of participants, including medical students from Cardiff University (first and final-year students from the 2014-15 cohort, and second-year students from the 2018-19 cohort), as well as comparative cohorts from psychology and business disciplines in France (Sorbonne University (University of Paris, Descartes). By incorporating both local and international perspectives, the study captures diverse insights into the role of linguistic and personality-related factors in shaping educational outcomes.

2.2: Ontological and epistemological frameworks

2.2.1: Research paradigm and ontological framework

The research adopts a pragmatist paradigm, which prioritises practical solutions to real-world problems and supports the incorporation of multiple methodologies to address complex phenomena (Tashakkori and Teddlie, 2021). The ontological stance recognises the versatile nature of reality, acknowledging that students' experiences and academic performances are influenced by an interplay of linguistic, cognitive, and personality-related factors. For instance, linguistic factors such as multilingualism have been linked to personality traits like openness and extraversion, with multilingual students often demonstrating greater adaptability and communication skills (Dewaele and Botes 2020)

This has been attributed to their ability to view language from multiple perspectives, adopting higher verbal intelligence and more effective social interactions. In contrast, monolingual students were found to exhibit higher negative affectivity, potentially linked to greater linguistic insecurity in social settings (Aspanani, Sadeqhi and Omid 2023). Cognitive factors, particularly spatial intelligence, also play a critical role in medical education, with students possessing higher spatial abilities tending to perform better in anatomy examinations (Gutierrez *et al*., 2018) This suggests that incorporating advanced visualisation techniques, such as 3D models, into the curriculum could enhance students' comprehension of anatomical structures. Furthermore, personality traits such as conscientiousness, openness, and agreeableness significantly impact academic success and professional development. Conscientiousness, for example, has been strongly associated with diligence, perseverance, and a structured work ethic (Oshio, Taku, Hirano and Saeed 2018)- qualities essential for managing the demanding workload of medical training. Similarly, openness has been linked to a student's ability to engage effectively with innovative teaching methods, such as problem-based learning and clinical simulations, fostering a deeper understanding of medical concepts (Yusoff, Hadie and Yasin 2021). This approach allows the study to address both measurable phenomena, such as academic performance and cognitive test scores, and subjective experiences, such as perceptions of the relevance of classical languages, ensuring a comprehensive analysis of the factors influencing medical education. These findings highlight the importance of an integrated approach to medical education that accounts for the intricate interactions between linguistic abilities, cognitive strengths, and personality traits, ensuring a more holistic and effective learning experience.

2.2.2: Epistemological framework

The epistemological approach combines positivist and interpretivist elements. Positivism reinforces the quantitative components of the study, such as statistical analyses of examination performance and intelligence test results. In contrast, interpretivism guides the qualitative exploration of student attitudes and experiences, recognising the value of subjective insights into how students perceive and engage with classical languages and medical education (Koro-Ljungberg *et al*. (2009).

2.3: Recruitment of participants

2.3.1: Medical curriculum at Cardiff University

The medical curriculum at Cardiff University is structured to provide a comprehensive foundation in clinical and theoretical knowledge while integrating elements of professional development. The programme follows an early specialisation model, wherein gross anatomy is prioritised in the preclinical years (first and second years) but is not formally reinforced in later clinical training. The curriculum incorporates an 11-week intensive dissection module during these early years, after which no formal lectures or tutorials on anatomical terminology are provided. Additionally, there is no structured integration of linguistic knowledge into clinical training.

2.3.2: Rationale for participant sample populations

Participants were drawn from Cardiff University's medical school, alongside psychology and business students from Sorbonne University (University of Paris, Descartes), to provide comparative perspectives. This diverse sampling enabled the study to explore variations in linguistic skills, cognitive abilities, and personality traits across different disciplines and cultural contexts. Medical students at different stages of their education (first-year, second-year, and final-year) were included to capture changes over time.

The inclusion criteria required participants to have completed at least one academic term to ensure familiarity with their programme's demands. Multilingual students, students with prior exposure to Greek or Latin, and monolingual students were included to facilitate a comprehensive analysis of linguistic factors.

2.3.3: Recruitment methods

Participants were recruited using purposive sampling, with advertisements distributed through university networks, email lists, and academic contacts. Hard copies of the questionnaire were distributed to first-year medical students at the end of a timetabled lecture under the supervision of the principal investigator. For final-year students, the questionnaires were made available through the online tool SurveyMonkey, with distribution facilitated by academic contacts. Both first-year and final-year students had opportunities to seek clarification from the principal investigator before completing the questionnaire, ensuring they fully understood the study and their participation.

2.4: Data generation

2.4.1: Data collection methods

The study employed a range of tools to collect comprehensive data:

Questionnaires: Designed to assess attitudes towards classical languages in medical education, these included both closed-ended Likert-scale items and open-ended questions to capture detailed perceptions.

The Big Five Inventory (BFI): A validated personality assessment tool that measures five dimensions of personality: openness, conscientiousness, extraversion, agreeableness, and neuroticism (John and Srivastava, 1999). This instrument provided insights into how personality traits influence linguistic proficiency and academic performance.

Cognitive tests: Verbal and spatial intelligence tests were administered to assess cognitive abilities. These tests were adapted from established methodologies to align with the linguistic and cognitive contexts of the participants. A subset of these questions was sourced from the British Mensa website, ensuring that the assessment of spatial intelligence relied on well-established problem-solving and reasoning tasks. Each student received a score between 0 and 10 for both verbal and spatial intelligence.

Performance metrics: Examination results, particularly in anatomy, were collected to evaluate academic outcomes and their relationship with linguistic and cognitive variables. The examination marks, including both formative and summative assessments, were obtained from the Medical Assessment Office at Cardiff University by the principal examiner. The data collected were anonymised but were linked to questionnaire responses through a unique coding system. The principal investigator had no direct access to these codes, which were securely managed by staff at the Medical Assessment Office. This ensured that the analysis maintained confidentiality while still allowing for the examination of correlations between academic performance and cognitive or linguistic factor.

Examination structure and assessment details: To evaluate the relationship between anatomical knowledge and student performance, both **f**ormative and summative assessments were analysed. These assessments were conducted during the Spring and Summer terms as part of the medical curriculum and followed standardised institutional guidelines. The study was carried out immediately after the summative exam in 2015**,** ensuring that student responses reflected their most recent examination experience. The formative examination was a standard-set standalone assessment**,** designed specifically to test anatomical knowledge. It consisted of a practical "spotter" component, where students identified anatomical structures on prosections or cadaveric specimens, combined with short-answer questions requiring written responses. This format aimed to assess students' ability to recognise and describe anatomical features in a structured, time-constrained setting. The summative examination**,** in contrast, was integrated with basic sciences and assessed a broader range of knowledge beyond anatomy. This examination followed a multiple-choice question based format**,** testing students on their understanding of anatomy within the context of medical sciences. The integration of anatomy with other disciplines aimed to reflect its application in a clinical and interdisciplinary setting.

2.4.2: Ethical considerations

Ethical approval was obtained from Cardiff University's Ethics Committee. Participants provided informed consent, and all data were anonymised to protect confidentiality. Data storage complied with GDPR (UK Data Protection Act, 2018) regulations, ensuring that all information was securely stored and accessible only to authorised researchers.

Ethics statement

This study was conducted in accordance with the ethical principles outlined by the Cardiff School of Biosciences Research Ethics Committee, which granted ethical approval (Stephens 0115-2).

Informed consent

All participants were provided with an information sheet detailing the study's aims, objectives, and procedures. Participation was entirely voluntary, and students were informed that they could withdraw at any time without penalty. Informed consent was obtained in writing before any data collection began.

Equity of experience

Efforts were made to ensure equity of experience for all participants. Surveys and questionnaires were distributed in formats accessible to all students, including online platforms for final-year students and hard copies for first- and second-year students. Participants were assured that their responses would not influence their academic standing or assessment outcomes.

Confidentiality and anonymity

All participant data were anonymised during collection, analysis, and reporting. Unique identifiers were assigned to maintain confidentiality. No personally identifiable information was included in the analysis or presentation of findings.

Data usage and secure storage

Data were stored securely on encrypted university servers, with access limited to the principal investigator and authorised members of the research team. Hard copy data, such as consent forms and physical surveys, were kept in locked filing cabinets within the university premises. Data will be retained for a period of five years after the study's completion and then securely destroyed in compliance with institutional guidelines.

Participant welfare

The study design minimised any potential risks or discomfort to participants. No invasive procedures were involved, and the questionnaires were designed to be non-intrusive and

respectful of individual beliefs and experiences. Students were offered the opportunity to discuss any concerns with the principal investigator or a designated faculty member.

By adhering to these ethical standards, this study ensured that participant rights were respected, and data integrity was maintained throughout the research process.

2.5: Data analysis

2.5.1: Analytical frameworks

The data were analysed using both quantitative and qualitative approaches to ensure a comprehensive understanding of the research questions:

- **Quantitative analysis**: Statistical analyses, including correlation and regression models, were conducted to examine relationships between linguistic skills, cognitive abilities, personality traits, and academic performance. Descriptive statistics provided an overview of the data, while inferential statistics tested specific hypotheses.
- **Qualitative analysis**: Thematic coding of open-ended questionnaire responses was conducted to identify patterns and insights into students' perceptions of classical languages and their relevance to medical education.

2.5.2: Coding and interpretation

Quantitative data were categorised based on key variables, including linguistic proficiency, personality traits, and examination scores, allowing for a structured analysis of potential correlations and patterns. Linguistic proficiency was classified according to students' prior exposure to Greek and Latin, as well as their multilingual status, with performance levels ranked from beginner to advanced. Personality traits were assessed using the Big Five Inventory (BFI), assigning numerical values to traits such as openness, conscientiousness, extraversion, agreeableness, and neuroticism. Examination scores were grouped into

formative and summative assessments, ensuring that both short-term and long-term academic performance were considered.

For qualitative data, responses from open-ended survey questions and student reflections were coded iteratively, following a structured thematic analysis (Braun and Clarke 2006 and Nowell, Norris, White and Moules 2017). Initial codes were developed based on key themes identified in the literature, such as perceived relevance of classical languages, cognitive challenges in terminology acquisition, and the role of personality in learning anatomy. These codes were then refined through a constant comparative method (Boeije, 2002) in which emerging themes were continuously compared against existing data to ensure consistency. This approach allowed for the identification of nuanced perspectives, ensuring that the analysis remained focussed in the data while addressing the study's central research questions.

By employing this dual-method approach, the study ensured both statistical robustness and contextual depth, capturing the complex interplay between linguistic skills, cognitive abilities, and personality traits in medical education. This methodology provided a comprehensive framework for understanding the factors influencing student success, offering insights that could inform curriculum development and pedagogical strategies.

2.6: Representations of data

2.6.1: Presentation of findings

The findings are presented through a combination of statistical graphs, tables, and thematic narratives. Quantitative results highlight key trends and relationships, while qualitative insights provide depth and context to the numerical data.

2.6.2: Validity and reliability

The validity and reliability of this study were ensured through multiple strategies to enhance accuracy, credibility, and consistency. Validity was strengthened through triangulation of data sources, including questionnaires, cognitive tests, and academic performance metrics, ensuring that findings were cross-verified and not reliant on a single measure. Content validity was maintained by designing assessment tools based on established theories and expert evaluations, with a panel of 25 independent judges, including basic scientists, anatomy faculty members, and surgical trainees, reviewing the attitudes questionnaire statements and assigning numerical ratings to assess their relevance and appropriateness. Construct validity was confirmed through factor analysis, demonstrating alignment between linguistic proficiency, personality traits, and their theoretical dimensions, particularly using the Big Five Inventory (BFI), which has well-documented psychometric properties (Costa Mastrascusa *et al*., 2023). Criterion validity was reinforced by correlating cognitive and linguistic assessments with academic performance scores, using statistical analyses such as Anderson-Darling normality tests, Whitney-Mann U tests, and ANOVA to verify significant associations.

Reliability was enhanced through pilot testing, refining questionnaires and cognitive tests before full implementation to improve clarity and interpretation. This preliminary stage ensured that all assessment items were clearly understood by participants and minimised potential misinterpretations. Standardised tools, such as the Big Five Inventory (BFI), ensured measurement consistency, providing a reliable framework for assessing personality traits in relation to academic performance and linguistic skills.

The study employed a test-retest reliability approach, whereby certain cognitive and linguistic assessments were re-administered to a subset of participants at different time points. This method confirmed response stability over time and reduced the likelihood of measurement errors due to temporary variations in participant responses.

Cronbach’s alpha was used to assess internal consistency within questionnaire scales. Statistical analyses, including Anderson-Darling normality tests, Whitney-Mann U tests, ANOVA tests, and t-tests, were applied to ensure the robustness of findings and verify that data distributions met the assumptions required for inferential statistics.

By implementing these methodological safeguards, the study ensured that findings were both robust and reproducible, supporting their validity for application in medical education research. This rigorous approach strengthens the reliability of the results and provides a strong foundation for future studies investigating the interplay between personality traits, linguistic abilities, and cognitive factors in academic performance.

2.7: Literature search method

A systematic literature search was conducted to identify relevant studies and sources, using electronic databases such as PubMed, Google Scholar, ScienceDirect, and Cardiff University's library resources. These databases were utilised to access peer-reviewed articles, books, conference proceedings, and archived materials not available through standard electronic searches. Keywords such as "anatomy education," "Greek and Latin in medicine," "multilingualism," "verbal and spatial intelligence," "personality traits," and "medical education performance" were employed. Boolean operators (AND, OR) were used to refine search results, ensuring the inclusion of diverse and relevant studies. For example, phrases like "classical languages AND medical education," "anatomy education OR dissection techniques," and "multilingualism AND cognitive skills OR spatial intelligence" were used to retrieve focused and comprehensive results.

Each database offered unique advantages: PubMed provided access to a vast collection of reliable, peer-reviewed biomedical literature; Google Scholar facilitated cross-disciplinary searches with a broad scope; ScienceDirect ensured access to high-impact journals; and Cardiff University's institutional resources enabled the retrieval of specialised content and subscription-only journals. Inclusion criteria prioritised publications from the last 20 years, but older, groundbreaking studies and highly cited research were also included to provide historical and foundational perspectives. Priority was given to peer-reviewed articles, systematic reviews, and meta-analyses to ensure the reliability and validity of sources. Historical and contemporary perspectives were integrated to provide a balanced view of the topic. Data extraction focused on methodologies, key findings, and implications for medical education. The gathered literature was critically reviewed to establish connections between linguistic skills, cognitive abilities, and medical education, highlighting the impact of these factors on academic and professional outcomes.

2.8: Conclusions

This methodology was designed to comprehensively explore the interplay between classical languages, linguistic skills, personality traits, and academic performance in medical education. By integrating quantitative and qualitative approaches, the study provides robust insights into the factors that influence student success and offers valuable recommendations for curriculum development and student support strategies.

Chapter 3

The attitudes of medical students toward the importance of understanding classical Greek and Latin in the development of an anatomical and medical vocabulary

Abstract

Students on entering medical school are confronted with the challenge of acquiring new, and voluminous, anatomical and medical terminologies. One of the main reasons why acquiring these terminologies may be tough relates to the fact that majority of these terms derive its roots from classical Greek and Latin; languages scarcely taught at school nowadays. Another reason could be that the often-documented reduction in exposure to anatomy, and contact hours spent in the dissection room, debilitates the students' knowledge and understanding of anatomical relationships, and thus further impedes the acquisition of the terminologies. Until date, there have been no studies that have quantified the attitudes of medical students towards the importance of understanding classical Greek and Latin during their medical training. In order to assess these attitudes, this study was undertaken for the first year and final year medical students at Cardiff University. They were distributed with a brief questionnaire that was designed in accordance with Thurstone and Chave (1951) principles and with ethical approval. One hundred and eighty first year students and one hundred and nineteen final year students responded. The preliminary hypothesis was that students throughout the medical curriculum have a negative attitude towards the importance of classical Greek and Latin. This hypothesis was backed by the final year students but not agreed by the first year medical students. While one would still recommend that first year medical students should attain some knowledge and understanding of and have some formal or informal tuition in, classical Greek and Latin as they pertain to anatomical terminologies, I recognise that final year students are anticipated to have become fairly accomplished in the etymology of medical terminologies without formal guidance.

This chapter is based on the publication: *Stephens, S. and Moxham, B. (2016) 'The attitudes of medical students toward the importance of understanding classical Greek and Latin in the development of an anatomical and medical vocabulary', Clinical Anatomy, 29(6), pp. 696-701. doi.org/10.1002/ca.22700.*

Statement of Contributions: Stephens and Moxham conceptualised the work and were responsible for the study design. Stephens undertook the literature review, collected and analysed the data, and prepared the initial draft of the paper. Stephens and Moxham jointly interpreted the data. Moxham provided a critical perspective on the writing of the paper and managed submission to the peer-reviewed journal. Stephens acted as the corresponding author and addressed the reviewers' comments.

This study was published in 2016, making it eight years old. While its findings on the impact of Greek and Latin on anatomy learning remain relevant, medical education has evolved, with increased reliance on digital tools and changes in curriculum design. These developments may have influenced how linguistic knowledge supports anatomical learning. However, the persistence of classical languages in medical terminology ensures the study's continued relevance. Future research should reassess these findings in light of modern teaching methods to provide updated insights.

3.1: Introduction

Anatomy has long been the foundation for medical curricula, providing basic knowledge, skills and attitudes for all medical specialities (Turney *et al.,* 2001; Patel and Moxham, 2006; Turney, 2007; Sugand *et al.,* 2010; Papa and Vaccarezza, 2013). During the late 20th Century to the present day (particularly from the 1990s onwards),an international debate has highlighted the importance of anatomy in modern medical curriculum and has tried to find answers to two basic questions - "How much anatomy is necessary in the medical curriculum?" and "Should traditional cadaveric dissection be replaced or assisted by prosection or other technological advancements such as computer-aided learning?" (Pabst, 2009). Due to such arguments, in recent times anatomy has been represented as being 'banausic', 'archaic', 'didactic', 'traditional', 'overtly factual' and 'unable to readjust to contemporary educational methods' (Turney, 2007, Moxham and Plaisant, 2020). In 1993,

the General Medical Council (GMC) in the UK issued guideline stating that the proportion of factual information in all basic sciences within the medical curriculum to be compressed. This has culminated in reducing the number of teaching hours for anatomy within the medical curriculum and the students exposed to fewer contact hours dissecting. According to a study by Pryde and Black, 2005, over the past 20 years in Scotland, the total percentage of teaching staff in anatomy (full time, part time and honorary) has declined by over 24%, full time teaching staff numbers have dropped by more than 33% and the number of clinical demonstrators fell by more than 70%. However, the intake of medical student has surged by 38% and the total number of medical, dental and science students experiencing anatomy teaching has multiplied, resulting in a current 1:58 staff: student ratio. This has also impacted the average contact hours in anatomy which has decreased by over 60% in the past 20 years. In the United States of America, following the guidance from the American Association of Medical Colleges (AAMC), the proportion of teaching hours dedicated towards teaching anatomy has been substantially reduced (Drake, 1998; Drake *et al.,* 2002 and Drake *et al.,* 2009). The reduction in the weight of anatomy in the medical curriculum has impacted the number of qualified anatomy staff (Turney *et al.,* 2001; Lockwood and Roberts, 2007). Studies by McCuskey and colleagues (2005) reported that "more than 80% of the chairs of departments responsible for teaching anatomy anticipated having 'moderate' to 'great' difficulty recruiting qualified staff to teach gross anatomy". These challenges in employing anatomy faculty has resulted in a reduced understanding of anatomical terminologies amongst students thus impacting their capability to learn and retain newly introduced terminologies (Kulkarni, 2014; Singh *et al.,* 2015).

Since anatomical terminologies stems from classical languages such as Greek and Latin, it is thought that newly recruited medical students perceive these new terminologies challenging (Smith *et al.,* 2007). The students who enter medical schools have little, or no, prior knowledge of these classical languages as fewer schools in the United Kingdom offer these languages as part of their curriculum. According to the data released by Cambridge School Classics Project (2008), out of 4,725 secondary schools within the United Kingdom (3972 state-funded and 753 independent schools), only 20% of the state-funded schools offer Latin and Greek compared to 60% of the independent schools in their curriculum. From this it can be concluded that only 5-7% of the school population have access to the learning of classical languages in the United Kingdom (http://www.cambridgescp.com/downloads/Latin_in_UK_secondary_schools_2008.pdf).

In the UK, the teaching of Greek and Latin has been declining measurably since 1956, when both languages were among the top 10 Advanced Level (A-level) choices for male and female students. A-levels are qualifications typically taken after the General Certificate of Secondary Education (GCSE), usually between the ages of 16 and 18, and focus on specific subjects required for university entry. GCSEs, on the other hand, are qualifications taken earlier, between the ages of 14 and 16, covering a wide range of subjects and marking an important step in education after primary school. Today, only 7% of schools offer Latin at the GCSE level, and a mere 1% offered Ancient Greek in 2018 (Department of Education and Skills, 2006; British Council, 2018).

A study by Drury and colleagues (2002) estimated that Latin courses offered in UK schools have reduced by 75% in the last 30 years. This demise in classical languages is also noted by the removal of Latin as a medical school entry requirement in the 1960s (Lister, 2015). The rationale for decline in teaching classical Greek and Latin in secondary schools relates to the demands of the job market. The requirement for highly paid jobs such as business, computing and banking do not entail the knowledge and understanding of classical languages. This may have impacted schools offering these languages as part of their regular curricula as humanities are not well recognised in the current, competitive job market (Smith and Johnson, 2020).

In order to understand and learn intricate and tough anatomical terminologies, students devise and employ various learning approaches and styles, albeit, these may vary between individual students. A popular method of learning anatomical terminologies is with mnemonics (memory aids that use patterns, associations, or strategies to enhance recall of information). This method of learning is classified under ‘superficial approach’ since this pragmatic way is based on simple recalling of facts. Mirghani *et al*. (2014) documented that medical students in the initial years of training (pre-clinical years) apply this superficial learning technique as a foundation to build deep learning (i.e. applying knowledge) for future clinical years. In a recent study of medical students at Cardiff University and at the University of Sorbonne, Morgan *et al*. (2014) observed that first year medical students knew limited mnemonics (on average 1-8). Additionally, just over quarter (26%) of the students who participated had no knowledge of mnemonics, approximately a third (30-34%) knew just one mnemonic and only a minority (1-2%) knew more than 10. first year medical students would

rather employ an array of learning preferences while studying anatomy (Heidi *et al.,* 2006). Medical schools cater for these needs by means of dissection, lecture and small group teaching. With the reduction in the number of hours the students spent within the dissecting room, more students are engaging in different approaches and learning preferences to enhance their anatomical knowledge. These include a growing dependence on evolving technological advances such as Technology-Enhanced Learning (TEL) applications and virtual learning.

Howbeit, despite the type of technology used, medical students will be exposed to new and complex anatomical terminologies which will challenge them to expand their vocabulary. Therefore, attitudes to these classical languages plays an important role in understanding how first year medical students perceive the task of learning anatomy. To date, there has been no study into the attitudes of medical students to classical Greek and Latin in studying and practising medicine.

The aim of the study was to compare the attitudes between the first and final year medical students at Cardiff University towards classical languages. This was achieved by using a Thurstone and Chave (1951) questionnaire and it tested the hypothesis that medical students have a negative attitude towards Greek and Latin and they do not value the relevance of these languages in the learning and practice of anatomy and medicine.

To aid the reader in navigating through the research, Figure 2.1 below provides a mind map that highlights some of the essential features, including findings and the implications of those findings.

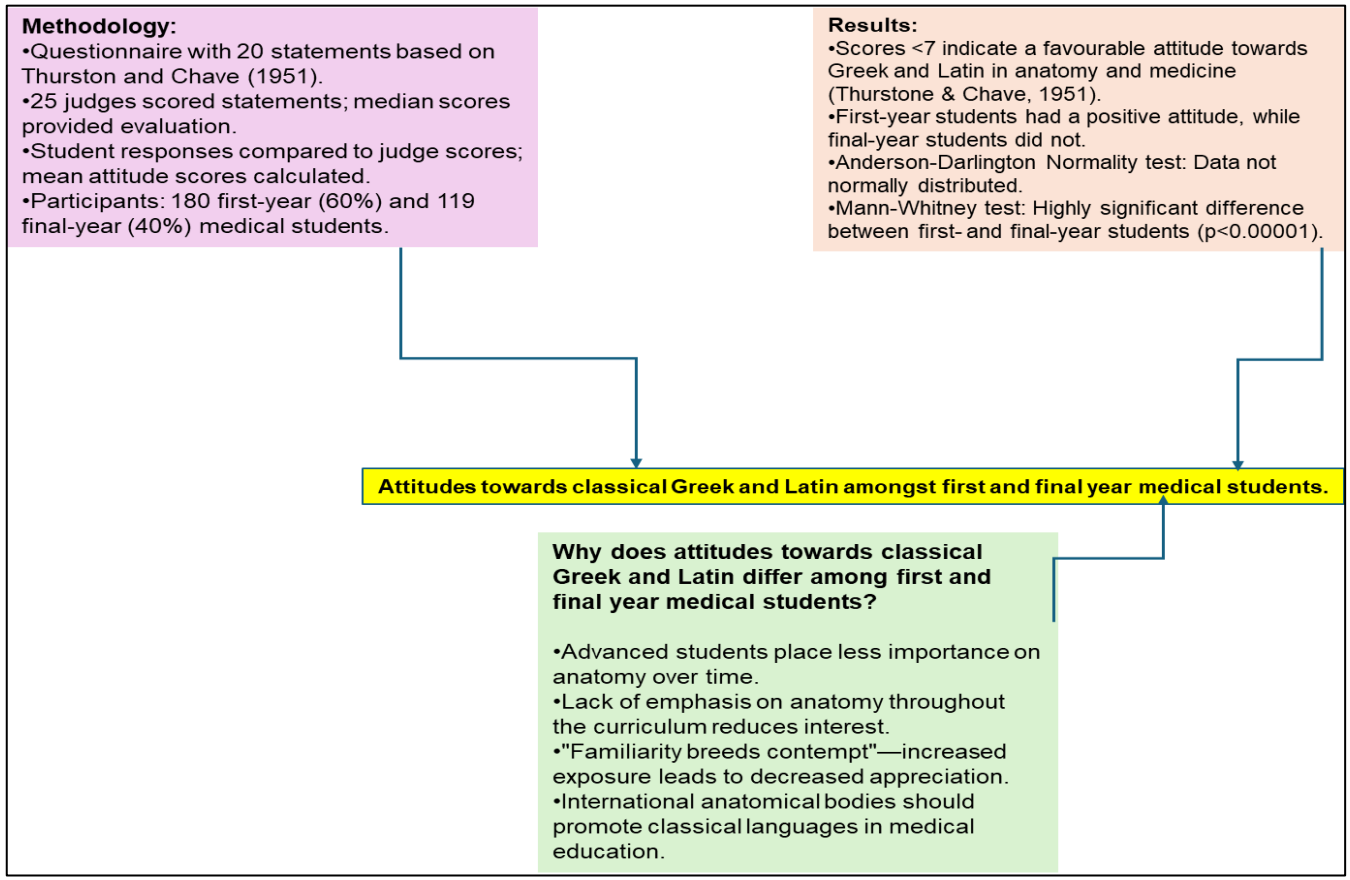


Figure 3.1: Understanding medical students' attitudes toward classical languages in medical terminology. This figure illustrates a structured visual representation of the essential elements of the study, highlighting the relationships between key themes, findings, and their broader implications in medical education. The mind map serves as a cognitive framework, allowing for an integrated understanding of the attitudes of medical students toward the significance of classical Greek and Latin in the development of medical terminology.

3.2: Methods

The questionnaire for this study was designed following the principles of the *Equal Appearing Interval Scale* outlined by Thurstone and Chave (1951). This psychometric method enables the measurement of attitudes across a continuum, from extremely favourable to extremely unfavourable, ensuring reliability and validity. A panel of 25 independent judges, comprising basic scientists, anatomy department staff, and surgical trainees, was selected to evaluate the questionnaire statements. These judges, who did not participate further in the study, were tasked with assigning a numerical rating between 1 (extremely favourable), 6 (neutral), and 11 (extremely unfavourable) to each of the 20 statements. The scores provided by the judges were aggregated, and the median was calculated for each statement. The use of the median as a measure of central tendency ensured robustness by minimising the influence of outlier scores. These medians were then used to position the statements along a continuum, ensuring that the questionnaire captured a comprehensive range of attitudes towards the relevance of classical Greek and Latin in medical education. This systematic process, supported by the expertise of the diverse panel, ensured the content validity of the questionnaire. The detailed scores and medians for each statement are presented in Appendix 2, Chapter 3, Document 2, with Table 3.1 providing a comprehensive overview of the evaluated statements and their respective scores. The *Equal Appearing Interval Scale* is widely regarded as a robust psychometric tool, offering a structured approach to quantifying subjective attitudes. Supporting references include Thurstone and Chave (1951), Lemon (1973), and Rajecki (1990), which provide further validation for the use of this methodology.

Subsequently, after receiving ethical approval from the School Research Ethics Committee of the Cardiff School of Biosciences (Stephens 0115-2 -Appendix 2 Chapter 3, document 3), the questionnaires were distributed amongst the first and final year medical students. The questionnaire consisted of a consent form and an information sheet that explained the aims and objectives of the study. It was reiterated that their participation was voluntary. Hard copies of the questionnaire were distributed to the first year medical students at the end of a timetabled lecture under the supervision of the principal investigator. While for the final year students, the questionnaires were made available with the help on online tool - “Survey Monkey”. Both the first and final year students had opportunities to clarify any queries they had to the principal investigator prior to completion of the questionnaire. In order to complete

the questionnaire, the students were asked to tick only those statements which they were in complete agreement. Once completed, the statements that the students selected were compared using the 'judges' scores and a mean attitude score for every participant was calculated. The data were analysed using Excel spreadsheets, Minitab 17 statistical software, Anderson-Darling normality test, General Linear Model, Whitney-Mann U test and t-tests.

Table 3.1. Statements in the questionnaire used to assess the attitudes of medical students toward the importance of understanding classical Greek and Latin in the development of an anatomical and medical vocabulary according to the method devised by Thurstone and Chave (1951).

Question number	Statements regarding the attitudes towards classical Greek and Latin	Judge's scores
1	Greek and Latin terminology develops the vocabulary for Medicine.	4
2	The knowledge of Greek and Latin terminology is useful only during the preliminary years of Medicine and not when the doctor is experienced.	7
3	Better the knowledge of Greek and Latin terminology better is the doctor at diagnosing the disease.	2
4	The knowledge of Greek and Latin terminology is a ''necessary evil'' in Medicine.	6
5	The knowledge of Greek and Latin terminology is of some use in clinic, but its importance may be exaggerated.	8
6	The knowledge of Greek and Latin terminology is of some importance since it displays that doctors are learned.	5
7	Greek and Latin terminology are old fashioned and that it has no importance in contemporary medicine.	10

8	The knowledge of Greek and Latin terminology is not required by the doctor as the treatment consists of understanding the aetiology of the disease and not terminology.	8
9	The knowledge of Greek and Latin terminology is required only to understand basic sciences such as Anatomy.	7
10	Every doctor must have knowledge of Greek and Latin.	2
11	If alternative and Eastern Medicine can do without the knowledge of Greek and Latin, so can Western Medicine.	11
12	It is impossible to conceive of good medical training without a major Greek and Latin component.	3
13	Not all specialities in Medicine require the knowledge of Greek and Latin terminology.	7
14	Medicine cannot exist without the knowledge of Greek and Latin terminology.	1
15	The knowledge of Greek and Latin terminology improves the ability to write medical prescription by doctors.	3
16	Greek and Latin are redundant since it is replaced by contemporary English terminologies.	9
17	Only a limited knowledge of Greek and Latin terminology is required for satisfactory medical practice.	7
18	Many doctors from the East do well in treating the patients without any basic knowledge of Greek and Latin terminology.	10
19	The knowledge of Greek and Latin terminology is not required to diagnose and treat a patient.	9
20	Without the knowledge of Greek and Latin terminology, the doctor is of limited effectiveness.	3

Note that the above “attitude scale” deemed appropriate by the “judges” are included here in the final column but were not provided in the questionnaire distributed to potential respondents.

3.3: Results

A total of 180 first year medical students (60% of the cohort) and 119 final year medical students (40% of the cohort) completed the questionnaires.

According to the ‘attitude scale values’ defined by Thurstone and Chave (1951), scores less than 7 are regarded to be favourable attitude towards the importance of classical Greek and Latin for the learning and practice of anatomy and medicine. A low score indicates the attitude that classical languages have high significance to medicine, while a high score indicates that the classical languages are perceived as having low significance. Hence it can be concluded that the first year medical students had a positive attitude towards the importance of Greek and Latin while the final year students did not share this view.

A comparative histogram showing the attitudes between the first and final year medical students towards the importance of classical Greek and Latin for the learning and practice of anatomy and medicine is shown in Figure 3.2 (Appendix 2 Chapter 3, document 4).

The Anderson-Darlington Normality tests confirmed that the data were not normally distributed. To validate the findings, a General Linear Model test was applied, along with Whitney Mann and t-tests (justified as $n > 100$). These tests revealed a highly significant statistical difference ($p < 0.00001$) between the mean attitude scores of first-year and final-year students toward the importance of Greek and Latin in medical education. Specifically, first-year students had a higher mean attitude score, indicating a more favourable perception of the relevance of classical languages, whereas final-year students exhibited a significantly lower mean score, suggesting greater scepticism. This suggests a clear shift in perceptions as students progress through their medical training.

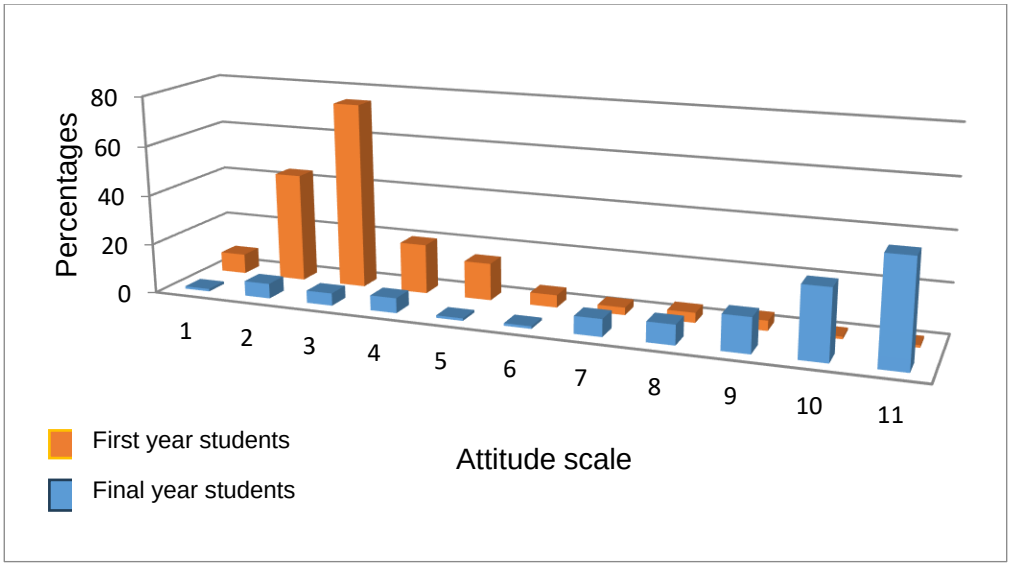


Figure 3.2: Attitudes of first- and final-year medical students toward classical languages in medical education. This histogram provides a comparative visual representation of the attitudes of first- and final-year medical students at Cardiff University regarding the relevance of classical Greek and Latin in medical education. The responses highlight differences in perception across different stages of training and suggest a potential shift in attitudes as students progress through medical school. A low score indicates the attitude that classical languages have high relevance to medicine, while a high score indicates that the classical languages are perceived as having low relevance.

3.4: Discussion

A total of 180 first-year students (60% of the cohort) and 119 final-year students (40% of the cohort) responded to the questionnaire. In line with the hypothesis, final-year students exhibited a more negative attitude towards the importance of classical Greek and Latin, whereas first-year students had a more positive perception. However, the decline in perceived relevance raises critical questions about how medical curricula influence students' perceptions of foundational knowledge and whether this shift is due to genuine irrelevance or curricular shortcomings.

3.4.1: What is the optimum survey response rate?

According to Visser et al. (1996), survey response rates between 40% and 59% are moderate, while 60% and above are high. Both high and moderate response rates are statistically justifiable for producing reliable data for hypothesis testing. In this study, first-year response rates were high (60%), while final-year response rates were moderate (40%).

To ensure the study's sample sizes were adequate, power calculations were performed with $\alpha = 0.05$, statistical power = 0.80, and a medium effect size (Cohen's $d = 0.5$). The required sample per group for a two-sample t-test was 64 participants, which was exceeded in both cases (180 first-year and 119 final-year students). This confirms that the study was statistically powered to detect meaningful effects, minimising the risk of Type II errors (failing to detect a true effect). Detailed calculations and parameters are provided in Appendix 2 Chapter 3, document 4.

Although internet-based surveys are widely used due to their cost efficiency and accessibility, they are prone to lower engagement and higher dropout rates (Brtnikova, 2018). Unlike in-person data collection, online surveys lack direct oversight, increasing the risk of selection bias, as individuals with strong opinions are more likely to participate (Podsakoff *et al*., 2012). This could have exaggerated the polarisation of attitudes between first- and final-year students, particularly if those who responded were either highly invested in the topic or held extreme views. Additionally, final-year students may have deprioritised participation due to

clinical workload pressures, leading to a lower representation of neutral perspectives (Porter *et al*., 2004). Studies suggest that in-person administration of surveys improves both engagement and response accuracy (Aquilino, 1992; Cooley *et al*., 1998; Tourangeau et al., 2001), and future studies may benefit from a hybrid approach, combining digital distribution with in-person follow-ups (Daikeler *et al*., 2020).

3.4.2: Why does attitudes towards classical Greek and Latin differ among first and final year medical students?

The data revealed that only 11% of students at Cardiff University had prior exposure to Greek or Latin, yet first-year students generally regarded these languages as useful for learning anatomy and practising medicine (mode score = '3', range 1–5). In stark contrast, final-year students exhibited a significant shift, with a mode score of '9', suggesting that students nearing the completion of their studies strongly disagreed with the relevance of classical languages. This pattern contradicts the hypothesis that medical students would hold consistently negative attitudes; rather, it suggests that final-year students actively devalue classical languages over time.

One probable explanation for this shift lies in cognitive load theory, which posits that when individuals process large amounts of complex information, they instinctively filter out what they perceive as non-essential (Sweller *et al*., 2011). As students advance in medical school, their focus shifts from theoretical knowledge to clinical application, leading them to deprioritise the etymology of medical terms in favour of diagnostic and treatment-based learning. This may explain why final-year students, despite having benefited from classical terminology in earlier years, begin to view it as an unnecessary academic burden.

However, an alternative explanation can be found in the Dunning-Kruger effect (Kruger and Dunning, 1999), which describes how individuals who become proficient in a skill tend to underestimate the effort required to learn it. This phenomenon is well documented in language acquisition research, where bilinguals often fail to recognise the cognitive effort needed to become fluent (Bialystok *et al*., 2009). Similarly, final-year students, having internalised medical terminology, may no longer consciously recognise the role of Greek and Latin in their learning process. As a result, they may attribute their mastery of medical

vocabulary to intuition rather than formal linguistic knowledge, leading them to perceive classical languages as redundant rather than foundational.

Another key factor in the declining appreciation for classical languages is the structure of the medical curriculum at Cardiff University, which follows an early specialisation model where gross anatomy is front-loaded into the preclinical years but not formally reinforced in later clinical training. The current programme relies on:

- An 11-week intensive dissection module,
- No formal lectures or tutorials on anatomical terminology, and
- No structured integration of linguistic knowledge in clinical years.

This approach contrasts with curricula that integrate classical etymology into anatomy education, which have been shown to improve long-term retention of anatomical knowledge and student performance (Turmezei, 2012). Additionally, studies by Sugand *et al*. (2010) indicate that curricula that reinforce anatomy teaching throughout all medical years result in better clinical application of anatomical knowledge. Without continued exposure, final-year students may disengage from the linguistic foundations of anatomy, leading them to dismiss classical languages as irrelevant.

Finally, international bodies responsible for defining anatomical terminologies around the globe such as the International Federation of Associations of Anatomy (IFAA). Under its auspices, a Federative International Programme for Anatomical Terminologies (FIPAT) has to date published three volumes outlining anatomical terms (*Terminologia Anatomica*, 1998, *Terminologia Histologica*, 2008 and *Terminologia Embryologica*, 2013). These bodies, while acknowledging that modern languages such as English are in frequent use in anatomy and medicine, they insist that international terminologies must endure to use classical Greek and Latin derivatives and etymologies. Therefore, the significance of classical languages is affirmed and subsequently, medical students should be made conscious of these languages as they progress in their medical curriculum.

3.5: Limitations

The study in this chapter measured the student's attitude as expressed by the acceptance or rejection of opinions. This would imply that they need not necessarily act in accordance with the opinions that they have endorsed.

The attitudes of the students may change, of course, from one day to the next. The attitudes may be influenced by persuasive factors such as reading of a discourse on the issue in question or clinical experience on the day. It was beyond the scope of this study to measure such changes in everyday attitudes.

It was assumed that an attitude scale was used only in those situations in which one may reasonably expect participants to tell the truth about their opinion. There was no objective measure followed that tested the reliability of their opinion.

As the rank values of all items with which a participant agreed were summed and an arithmetic average determined. It was impossible to pinpoint the exact statements they either agreed or disagreed with.

3.6: Recommendations

The results from the study support the opinion that newly-recruited medical students would acknowledge some form of formal teaching lesson or instructions in classical Greek and Latin as they influence the understanding of anatomy. In the lack of any formal lessons, students should be made aware of the vast amount of resources available such as dictionaries and books that can aid their learning (for example, Lewis 1990; Dennerll 2002; Marcovitch 2009; Martin 2015). It could be debated however that, because the Final Year students in this study did not have favourable attitudes towards the importance of classical languages, no formal instruction is required. Nonetheless, it is probable that their attitudes could have been more positive if they have had formal instruction and indeed their understanding of the terminologies could have consequently been improved.

Chapter 4

Gross anatomy examination performances in relation to medical students' knowledge of classical Greek and Latin

Abstract

Classical languages such as Greek and Latin could influence the ability of medical students to acquire, learn and retain anatomical and medical terminologies. It was previously reported by Stephens and Moxham (2016), that students in their initial years of medical curriculum (first year medical students) have a highly favourable attitude towards Greek and Latin while final year students did not see any benefit. The main aim of this chapter is to test the hypothesis that, regardless of attitude, students in the early years of medical education perform better at both formative and summative anatomical examination if they have prior knowledge of Greek and Latin. This study involved the same cohort of medical students who participated in the previous study concerning the attitudes towards classical Greek and Latin. The examination marks for the cohort were obtained from the Medical Assessment Office at Cardiff University. Two hundred and twenty-seven students responded to the questionnaire (83% of the class). The respondents were divided into seven groups according to their linguistic abilities (knowledge and skills) and compared their performance in both formative and summative examination. Following analysis, the conclusions were consistent with the hypothesis that students with prior knowledge of Greek and Latin performed better in both formative and summative anatomical examinations.

This chapter is based on the publication: *Stephens, S. and Moxham, B. (2018) 'Gross anatomy examination performances in relation to medical students' knowledge of classical Latin and Greek', Clinical Anatomy, 31(4), pp. 501-506. doi.org/10.1002/ca.23056.*

Statement of Contributions: Stephens conceptualised the work, undertook the literature review, designed the study, collected and analysed the data, and prepared the initial draft of the paper. Stephens and Moxham jointly interpreted the data. Moxham critically reviewed the writing and handled submission to the peer-reviewed journal. Stephens served as the corresponding author and responded to reviewers' comments.

This chapter was published in 2018, and remains relevant as it established a link between multilingualism, cognitive abilities, and anatomy learning. However, since then, advancements in digital education, AI-driven learning tools, and curriculum reforms may have influenced how linguistic skills impact spatial and verbal intelligence in medical students. Additionally, globalisation and evolving language exposure could affect multilingualism's role in medical education. While the study provides a strong foundation, further research is needed to reassess its conclusions in the context of modern teaching methods and technological developments.

4.1: Introduction

For doctors, investigation, intervention and examination of the human body is crucial in their profession. The study and understanding of anatomy in some form will be essential to maintain a safe level of medical practice (Turney, 2007). Despite anatomy being one of the basic sciences and providing fundamental knowledge, skills and approaches to all medical specialities (Turney *et al.,* 2001; Patel and Moxham, 2006; Turney, 2007; Sugand *et al.,* 2010; Papa and Vaccarezza, 2013), recent publications reveal that the importance of anatomy is severely undervalued in the current medical curricula (Gogalniceanu *et al.,* 2008 and Drake *et al.,* 2014). Over the years, the relevance of anatomy in medical curriculum has been much debated, as many medical schools are following the trend to reduce what is apparent as the 'weight of factual information' within the medical curriculum ((e.g. Association of Medical Colleges (AAMC) and GMC (Craig *et al*, 2022). Undeniably, there has been a substantial reduction in the contact and teaching hours dedicated to gross anatomy (Drake *et al.,* 2014). Drake *et al.,* (2002, 2009, 2014) have all reported the decline in the anatomy teaching hours within the United States of America. They recorded that hours have waned off from just under

780 hours per annum in 1931 (Reid, 1931) to about 340 hours in 1955 (Berry *et al.,* 1956) to 147 hours in 2014. The traditional teaching of anatomy, established on topographical anatomy taught through didactic lectures, tutorials, small group teaching and dissection of the body, has been substituted by an array of other teaching modalities aided by technology in order to substitute the lack of teaching staff (Dobson, 2007, Wilson *et al*., 2022).

It is thought that with marked reduction in the teaching hours dedicated to anatomy, there will be substantial reduction in the anatomical knowledge attained by the students. This will also have a knock-on effect on the students' ability to learn, retain, recall, newly introduced terminologies (Kulkarni, 2014; Singh *et al.,* 2015, Stephens and Moxham, 2016). Increasing surgical errors amongst junior surgeons has been documented to this decline in anatomical knowledge and consequently, increase in medico-legal litigation (Ellis, 2002 and Ahmad *et al*, 2020).

It is thought that newly recruited medical students find newly introduced anatomical terminologies challenging as they are derived from Greek and Latin, languages scarcely taught at school nowadays (*Terminologia Anatomica*, 1998, 2009, 2013). Stephens and Moxham (2016), reported in Chapter 2 that first year medical students have a favourable attitude towards the importance of understanding these classical languages for their medical training – a view not shared by the final year medical students. In this Chapter, I will be investigating the relationship between prior knowledge of Greek and Latin and its effect on formative and summative anatomy examination performance. It is hypothesised that students with prior knowledge of classical languages perform better at anatomy examinations, irrespective of attitudes. In order to investigate the hypothesis, medical students at Cardiff University were provided with questionnaires that tested their linguistic fluency and proficiency. The results from the questionnaire were them compared to the anonymous examination performance data that were provided by the Medical Assessment unit at Cardiff.

To aid the reader in navigating through the research, Figure 4.1 below provides a mind map that highlights some of the essential features, including findings and the implications of those findings.

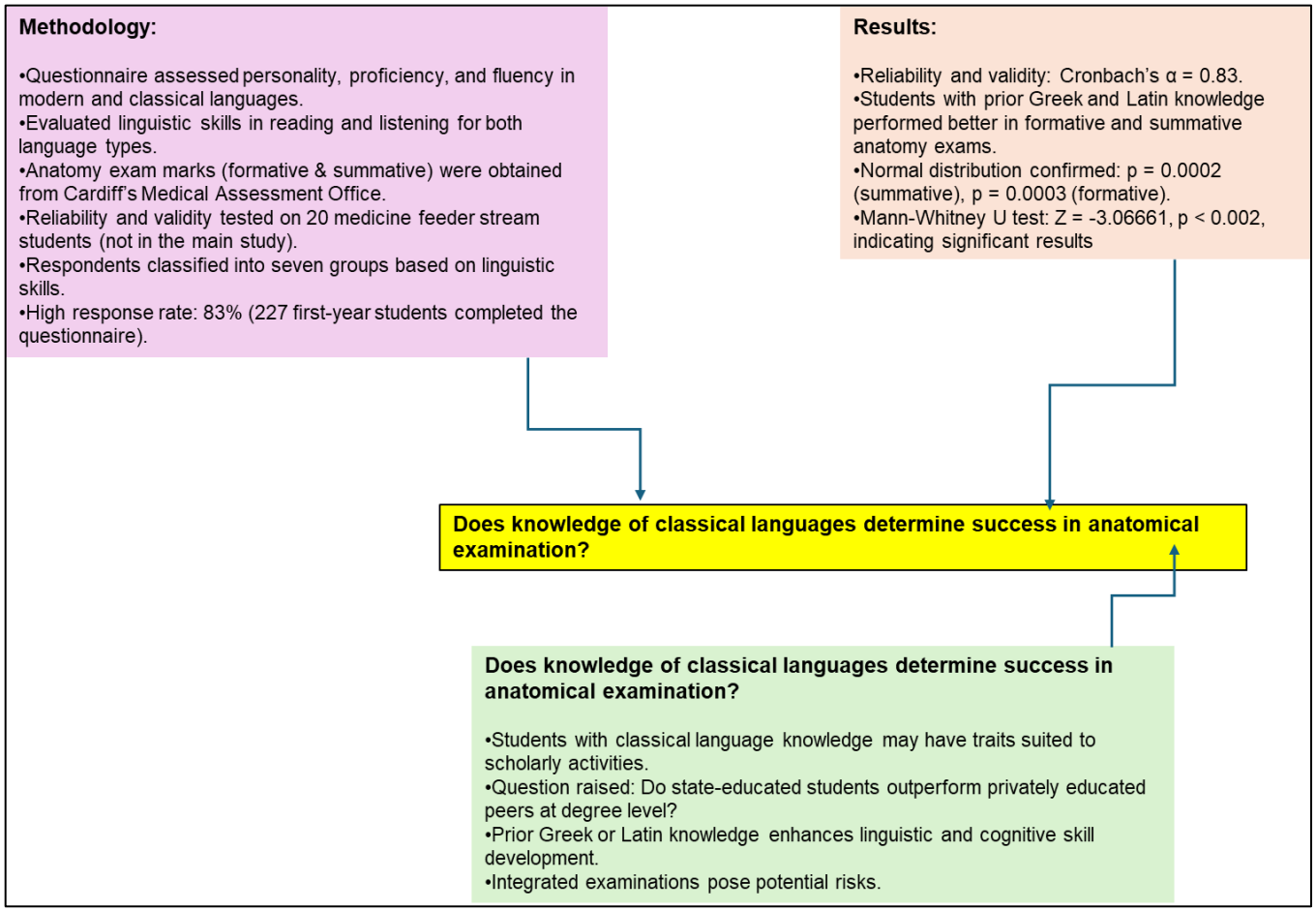
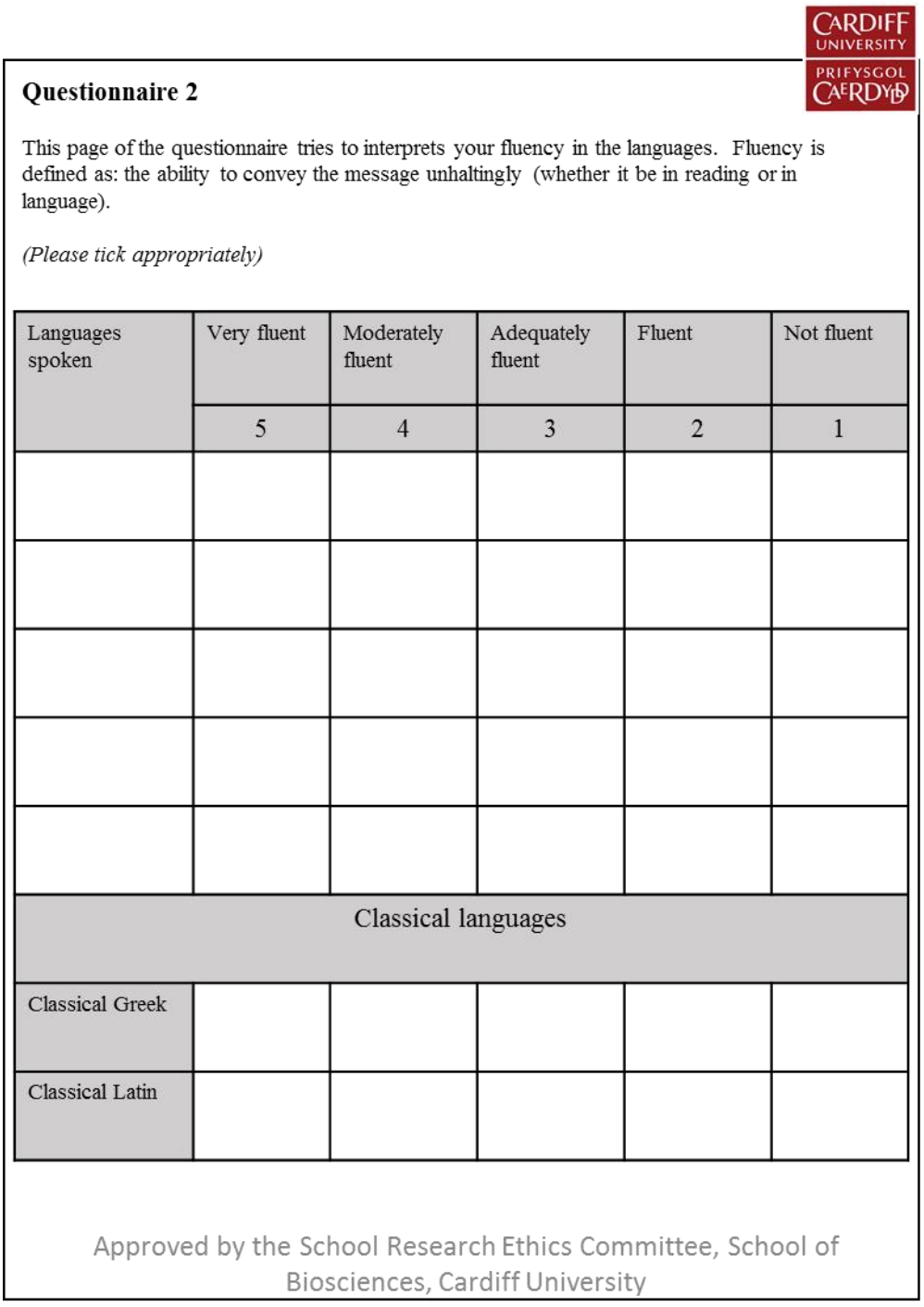


Figure 4.1: Conceptual mind map of linguistic skills, intelligence, and academic performance in medical education. This figure presents a conceptual mind map summarising the key aspects of the study, including significant findings and their broader implications. The diagram serves as a visual representation of the relationships between different variables explored in the research, aiding in the understanding of complex interactions between linguistic skills, intelligence, and academic performance in medical education.

4.2: Methods

Following ethical approval from the Research Ethics Committee at the Cardiff School of Biosciences, questionnaires were disseminated among the first year medical students at Cardiff University. The questionnaire comprised of series of matrices that assessed the participant's personality, proficiency and fluency in both modern and classical languages. Similarly, the questionnaire also helped evaluate their linguistic skills for reading and listening to both modern and classical languages. Figure 3.2 provides an example of a matrix within the questionnaire. The questionnaire consisted of an information sheet and a consent page. It was reiterated that their participation was voluntary, and they could withdraw from the study at any point. The participants had time to ask any questions to the principal investigator before finishing the questionnaire. The complete questionnaire is attached in Appendix 2 Chapter 3, document 1.



Questionnaire 2

This page of the questionnaire tries to interprets your fluency in the languages. Fluency is defined as: the ability to convey the message unhaltingly (whether it be in reading or in language).

(Please tick appropriately)

Languages spoken	Very fluent	Moderately fluent	Adequately fluent	Fluent	Not fluent
	5	4	3	2	1
Classical languages					
Classical Greek					
Classical Latin					

Approved by the School Research Ethics Committee, School of Biosciences, Cardiff University

Figure 4.2: Example of a matrix-style question assessing linguistic background and proficiency. This figure presents an example of a matrix-style question used in the questionnaire distributed to first-year medical students at Cardiff University. The matrix format was chosen to systematically assess participants' linguistic background, fluency, and proficiency in both modern and classical languages, as well as their cognitive abilities in reading and listening comprehension.

The anatomy examination marks (formative and summative) were obtained from the Medical Assessment Office at Cardiff by the principal investigator. The data collected were anonymised but could be linked to the responses of the questionnaire with the help of a unique code. The principal investigator had no access to the unique code and could only be identified by the staff at the Medical Assessment Office (Figure 4.3).

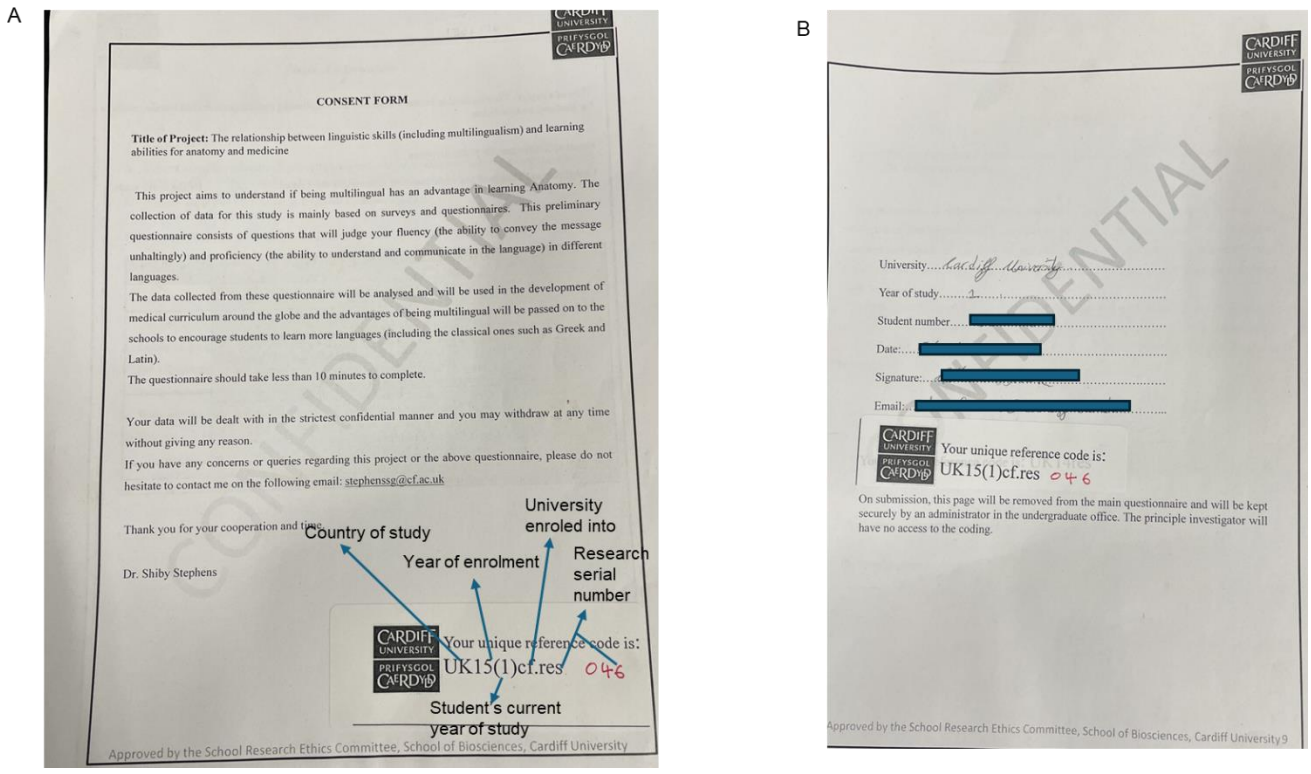


Figure 4.3: Anonymisation process and data security measures in the study. This figure illustrates the anonymisation process and data security measures employed in the study to ensure confidentiality while maintaining the ability to link questionnaire responses to examination performance data. The system involved a unique coding method, allowing the Medical Assessment Office to match responses with academic performance while preventing the principal investigator from accessing identifiable student information. A. Shows the anonymised front page of the questionnaire that is accessible to the principal investigator. B. Shows the page with the details of the student that is retained by the staff at the Medical Assessment Office.

In order to evaluate the reliability and validity of the questionnaire, a set of 20 students from medicine feeder stream (who did not involve in the current study) were nominated. They were asked to complete the same questionnaire twice three weeks apart from each other.

Data collected were analysed using Excel spreadsheets, Minitab 18 statistical software. Anderson-Darling normality tests, Whitney-Mann U tests, Levene's tests, ANOVA tests, t-tests and Cronbach's alpha tests.

4.3: Results

The questionnaire had a high response rate of 83% as two hundred and twenty-seven students completed the questionnaire. The respondents were categorised into seven groups depending on their linguistic skills. These groups are shown in Table 4.1.

Table 4.1: Linguistic backgrounds of medical students and their correlation with intelligence and academic performance. This table provides an overview of the different linguistic backgrounds of the medical students who participated in the study. The categorisation was designed to assess whether linguistic proficiency, particularly knowledge of classical languages, correlates with spatial and verbal intelligence and academic performance in anatomy examinations.

Groups	Categories	Number of respondents in each category
Group A	Students who had prior knowledge of Greek and/or Latin from school (Pre GCSE) (age less than 14 years)	13
Group B	Students who have studied Greek and/or Latin in GCSE (aged 14-16 years)	21
Group C	Students who are very fluent in English and other European language	22
Group D	Students who are very fluent in English and also other non-European languages	12
Group E	Students who are fluent in English only	24

Group F	Students who are moderately fluent in English with high fluency in other non-European languages	11
Group G	Students who are very fluent in English with moderate fluency in other European and non-European languages	124

In order to evaluate the reliability and validity of the questionnaire, Cronbach's alpha test was employed. An ɑ coefficient of 0.83 was calculated. A ɑ coefficient between 0.65 and 0.8 states that the questionnaire is highly reliable and valid (Tavakol and Dennick,. 2011).

The questionnaire was analysed, and a histogram was plotted. Through the histogram it was concluded that students with prior knowledge of Greek and Latin (Groups A and B) performed better in both formative and summative anatomy examinations than their peers with a $p=0.002$ which is highly significant at $P < 0.01$(Figure 4.4).

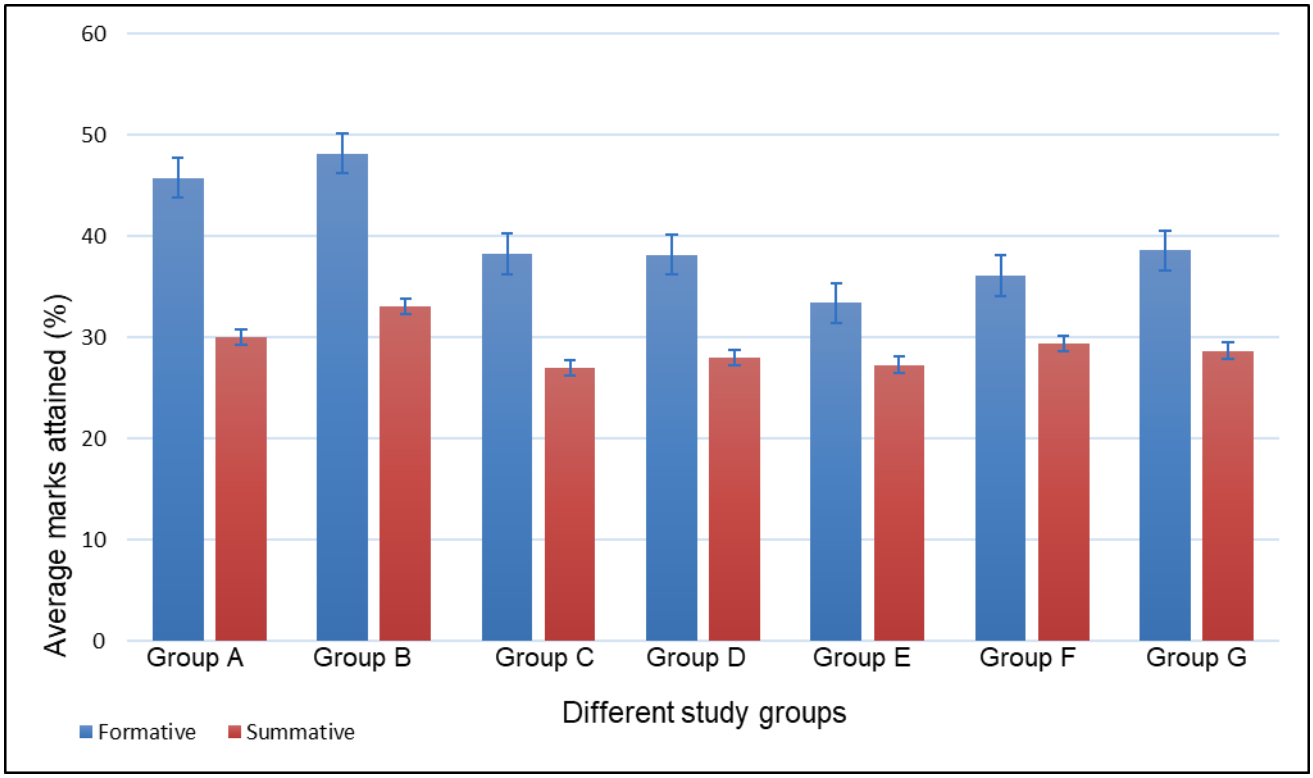


Figure 4.4: Impact of classical language knowledge on anatomy examination performance. This figure presents a comparative analysis of the formative and summative anatomy examination scores of first-year medical students, focusing on the impact of prior knowledge of classical languages (Greek and Latin). The graph illustrates differences in performance between students who had studied classical languages before entering medical school (Groups A and B) and their peers who had not.

To validate the findings from the histogram in Figure 4.4, and to check if the data were normally distributed, Anderson-Darlington normality tests were employed (Appendix 2 Chapter 4, document 2).

A p=0.0002 for summative examination and p=0.0003 for formative examination concluded that the data were normally distributed. ANOVA single factor tests were performed to evaluate the statistical significance between the formative and summative examination performance. Histogram Figure 4.4 also suggest that the respondents from all groups performed better (p=0.002) in formative than summative examinations. A p-value of 0.002 indicates a highly significant difference between formative and summative examination performance, as it is well below the conventional P < 0.05 threshold for statistical significance and also below P <

0.01, which is often used to denote high significance. In order to substantiate the findings in Figure 4.4 and to calculate the hypothesis that the difference in the two groups of medians were statistically significant, Whitney-Mann U tests were conducted. As the Z score was -3.06661 with $p< 0.002$ the results of the test were significant. Thus, the difference in two medians is statistically significant, meaning that the probability of the difference being due to chance is less than 0.002 (Appendix 2 Chapter 4, document 2).

In order to determine the statistical significance between different groups of students, t-tests were employed. In order to select a suitable t-test, it was important to determine if the variants were equal or unequal. By performing Levene's tests it was established that the variants were unequal as the intervals did not overlap and the standard deviation were significantly different (Figure 4.5). Multi t-tests for unequal variants were consequently performed between groups of formative and summative examination data. It was concluded that students in Group A and B (those who had prior GCSE knowledge in classical languages) were statistically significant and were different from other groups ($p=0.002$). It was thus established that students with previous knowledge of classical Greek and Latin performed better in the anatomical examinations than their peers (Appendix 2 Chapter 4, document 3).

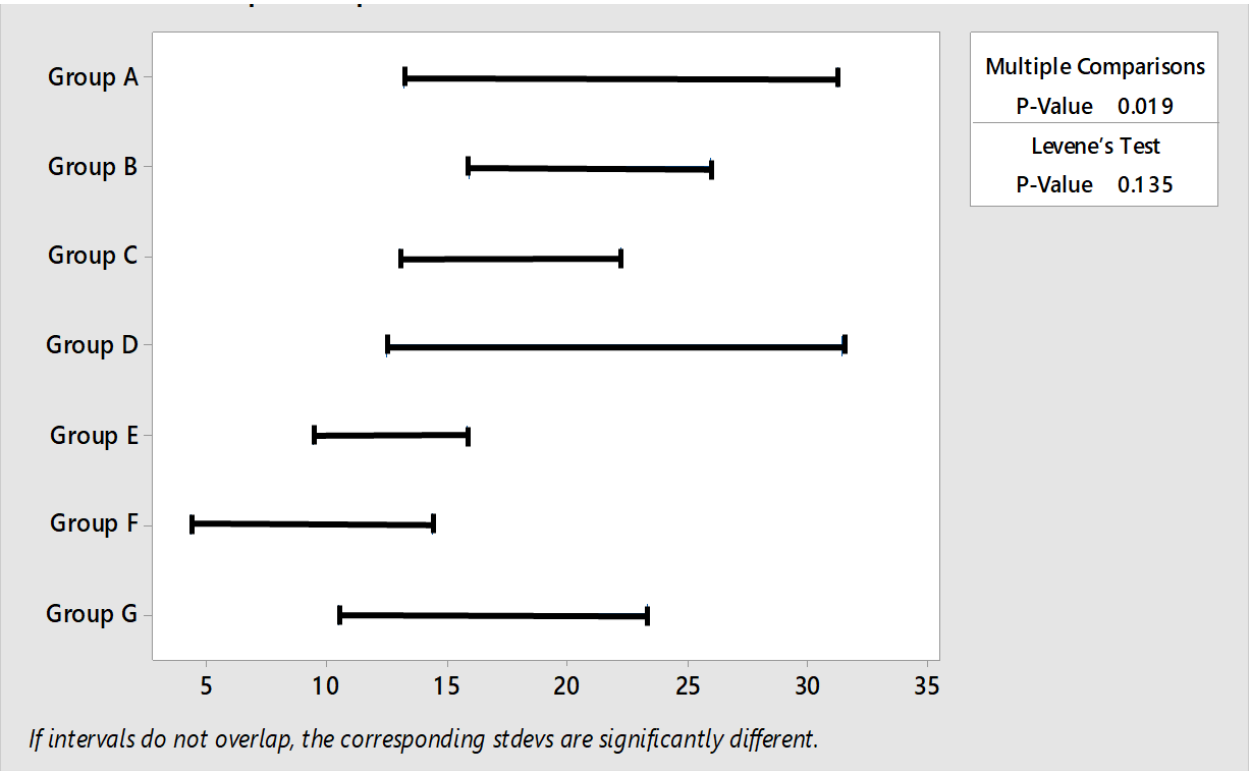


Figure 4.5: Levene's test results for groups A-G: assessing variance homogeneity. Graph showing the results of the Levene's test conducted on groups A-G. As the intervals do not overlap, the standard deviations are accepted to be significantly different.

4.4: Discussion

Although, this study concluded that students who had prior knowledge of Greek and Latin performed better in anatomical examinations, the findings can apply only to students in the initial stages of their medical education. In order to evaluate whether this benefit continues through different years of medical training, it is recommended that a longitudinal study be carried out since Stephens and Moxham (2016) in Chapter 3 proposes that final year medical students have unfavourable attitudes towards the importance and understanding of classical languages. Nevertheless, it is supposed that, if there is an advantage for some students, all other students ought to be offered opportunities to improve similar skills at an early stage through formal lesson in these classical languages.

4.4.1: Are state-funded schools better than independent schools?

Additional analysis of the highest scoring groups for anatomy examinations (Groups A and B) revealed that, out of 13 students, in Group A, 10 were educated in independent/private schools while three attended grammar schools. In Group B, 18 out of 21 students attended independent/private schools while two attended grammar schools. This finding contradicts a report published by the Higher Education Funding Council for England (HEFCE) in 2013/14. The report claimed that students educated in state schools perform better at degree level that privately educated peers (HEFCE report, 2015). These reports stated that 82% of graduates from state schools attained first or upper second-class degrees compared to 73% of graduates from independent/private schools. The report proposed that pupils from state schools perform better at university since such schools are under resourced compared to private/independent schools so that the pupils from state school are able to grasp better the equal opportunities provided by the university. Indubitably, other justifications are possible, including association between social status and motivation to perform well at university, better and effective teaching at private schools that might mask true academic potential, or private school student believing that their social standing goes beyond the need for excellence at university (Cambridge Assessment's research division (2015)). Nevertheless, the conclusions are consistent with the hypothesis that anatomy examination performances can be influenced by prior knowledge of classical languages.

4.4.2: How accurate are self-assessments of personality traits?

It could be debated that medical students with prior knowledge of Greek and Latin from school were not particularly advantaged by their knowledge of these classical languages but may have benefitted from being open to more liberal thoughts or may have personality traits more appropriate to scholarly activities. Part of the questionnaire where the student self-evaluated their personalities is relevant to this matter (Hayat *et al.,* 2020). It was established that 75% of students who were multilingual (having knowledge of more than one language – either classical or modern) categorised themselves as being curious, outgoing, organised and friendly. On the contrary, 85% of monolingual students identified themselves as being easy going, cautious, reserved and detached. Therefore, self-assessment of personality traits needs further robust investigation using established personality assessment inventories such as Big Five Inventory test (BFI) John and Srivastava (1999).

4.4.3: A prior knowledge of Greek and Latin can increase anatomical understanding and thus improved anatomy examination scores

Modern English is heavily influenced by classical languages such as Greek and Latin. It is estimated that 50% of modern English vocabulary is rooted in Latin and 20% from Greek. Latin is the official language of anatomy, as defined by the Federative Committee on Anatomical Terminology and the International Federation of Associations of Anatomists in the Terminological Anatomica. Most medical terminology (nearly three-fourths) is derived from Greek, Latin or a combination thereof because they provide succinite explanations in anatomy and medicine (Banay 1948, Micic 2013, Melaschenko 2018). It has been said that "Greek is the language of pathology (the study of diseases) and Latin is the language of anatomy (the structure of the body)" (Grigonvté. 2016). Internationally, newly defined medical terms often draw on Greek or Latin terms and are infused with modern languages like English or Swedish (Wulff 2004; Baethge 2008). It can only be speculated the causes for such developments, but all importance must be the fact that the Greeks were the pioneers of rational medicine during the 5th century B.C.E (Banay 1948; Moxham and Plaisant, 2014; Moxham and Sprumont, 2016). Hippocrates and Galen formulated the terminologies which dominated anatomy and medicine up to the beginning of the 18th century B.C.E. It can be reasoned, therefore, that having a prior knowledge of Greek and Latin can increase anatomical understanding and also one's vocabulary in general. Marković (2007) documented that, with a wide-ranging knowledge of Latin, one can improve the understanding of basis grammar and be able to apply that knowledge to other languages. Thus, it is plausible that students with prior knowledge of Greek or Latin tend to improve linguistic and cognitive skills more rapidly, thus assisting them to understand and learn anatomy as a new language. It is also thought that students with prior knowledge in a language or subject, being categorised as having 'higher expertise levels', own more concepts for easily integrating and relating additional information (Hailikeri *et al*, 2008). If so, this might be an additional reason why students with prior knowledge of Greek or Latin achieved better results in their anatomy examinations.

It has been previously documented that students perform better in formative examinations as they are presented with clear objectives and outcomes (Dunn and Mulvenon, 2009). It is assumed that formative assessments also help students recognise their strengths and weakness and improve areas that need help or additional work (Chappuis and Stiggins,

2002). As these formative examinations are ‘low stakes’, the student is under less academic pressure to perform.

4.4.4: Does assessment drive learning?

Newble and Jaeger (1983) recognised the relationship between assessment and learning behaviour and coined the phrase ‘assessment drives learning. Consequently, this phrase has been extensively used as an important rule in medical education such that, assessment has been viewed as an educational device by educationalist (Wood 2009, Krupat and Dienstag, 2009). There has been much talk about whether a student in higher education should embrace deep learning strategies or being ‘examination conscious’ and remain as strategic learners (Chin and Brown, 2000).

According to Hudson and Bristow (2006) and Roediger and Karpicke (2006) different forms of examinations (such as formative and summative) and their significances can alter the learning behaviour of the student. A student tends to learn more effectively and efficiently for a summative examination due to the consequence of probable failure. The motivation for formative examination is little as it is mainly to generate feedback that would help with examination preparation.

For the above-mentioned explanations, it is often presumed that students perform better at summative examinations than formative examinations. This results from this study shows a converse relationship. I suggest this might relate to the way in which formative and summative anatomy examinations are conducted at Cardiff University. Formative examinations primarily test their anatomical knowledge while the summative examination is integrated and covers a vast variety of basic science subjects. It is, therefore concluded that there is risk in integrated examinations of students not studying anatomy as well as they would should only anatomical knowledge be assessed (Ten Cate, 2020).

4.5: Limitations

A key limitation of this study is the absence of longitudinal data, making it uncertain whether the observed benefits of Greek and Latin persist throughout medical training. A previous study suggested that final year students showed more-negative attitudes towards classical

languages than their first year counterparts. . A long-term study tracking students across all five years would help determine whether early advantages in anatomy lead to sustained academic success or clinical performance.

Furthermore, the study reported in this chapter found that students performed better in formative than in summative anatomy exams, which contradicts expectations since summative assessments usually drive higher performance due to failure consequences. One explanation could be that Cardiff University's summative exams are highly integrated, covering multiple basic sciences. Students may allocate less time to anatomy revision, leading to weaker performance. Further research should compare anatomy-specific summative exams with integrated assessments to determine the impact of exam format on knowledge retention.

4.6: Recommendations

As this study has concluded that prior knowledge of Greek and Latin impacts examination results, it would be a good practice to have regular and scheduled lectures/lessons that help the students appreciate, and apply, these languages for the understanding of anatomy. Maybe, such formal lessons might be better appreciated and be useful to those who have not learned these classical languages in school. Kalyuga and Renkl (2010) and Ormrod (2012) documented that the main driving force for any learning process is the learner's prior knowledge of the subject. It is thought that through learning, students make intricate connections/pathways between newly attained facts and previous knowledge (known as retrieval pathways), pursue structure within the material, explore principles and integrate facts across domains. So as to enhance the number of retrieval pathways, the given context should be made relevant to the content to be learned (Bergman *et al*, 2015). Through these retrieval pathways and the process of 'elaboration' (i.e, the student is able to make significant connections between prior and new contents) the student is able to increase the amount of knowledge (Schmidt, 1993, Kalyuga, 2009). Koens *et al.,* (2003) recommend that factors such as relevance and familiarity with the subject play an important part in the acquisition and recall of knowledge. In a previous study by Stephens and Moxham (2016), it was stated that first year medical students have a favourable attitude towards the importance of classical languages and thus would be open to having some additional formal lessons in these

languages. However, the final year medical students do not feel the need for such tuitions, and it could be concluded that ‘familiarity has bred contempt’!

Chapter 5

Do medical students who are multilingual have higher spatial and verbal intelligence and do they perform better in anatomy examinations?

Abstract

It has been previously reported that medical students with prior knowledge of Greek and Latin achieve better marks in anatomy examinations. Previous research has revealed that fluency in more than one language can impact spatial and verbal intelligence. The hypothesis for this chapter is that medical students who have multilinguistic skills develop higher spatial and verbal intelligence compared with their monolingual peers, that there are sex differences, and that there are positive effects on performance in anatomy examinations.

In order to study the spatial and verbal intelligence, a questionnaire consisting of questions adapted from the British MENSA website was designed. The questionnaire was distributed amongst the second year medical students at Cardiff University. One hundred and seventy-three students responded to the questionnaire giving a response rate of 63%. For analysing the data, the students were divided into various groups based on their linguistic knowledge and skills.

There was no sex difference established for either spatial or verbal intelligence across all groups. Monolingual students (fluent and proficient in English only) had a lower spatial and verbal intelligence than the multilinguals. Students who were had fluency in English and non-European languages showed higher spatial and verbal intelligence than all other groups. However, there was no substantial improvement in their anatomy examination marks, although the examination performance might be complicated by cultural considerations. Another finding from this study was that, if an anatomy examination required spatial orientation using cadaveric specimens (e.g spotter examinations), students with low spatial intelligence had significantly poorer performances.

As reported in Chapter 3, medical students with prior knowledge of classical Greek and Latin perform better in anatomy examinations. It is advocated that, when all newly-recruited medical students are tutored in medical terminologies to help them develop the e^{x}tensive vocabulary required for their professional careers, they should also be made aware of any deficiencies in spatial and verbal skills that could affect their learning abilities. Given that I would expect students to benefit in their careers from developing spatial and verbal skills, I also recommend that examination tests in anatomy should avoid the exclusive use of multiple-choice questions.

This chapter is based on the publication: *Stephens, S. and Moxham, B. (2019) 'Do medical students who are multilingual have higher spatial and verbal intelligence and do they perform better in anatomy examinations?', Clinical Anatomy, 32(1), pp. 26-34. doi.org/10.1002/ca.23280.*

Statement of Contributions: Stephens conceptualised the work, undertook the literature review, designed the study, collected and analysed the data, and prepared the initial draft of the paper. Stephens and Moxham jointly interpreted the data. Moxham provided a critical perspective on the writing of the paper and handled submission to the peer-reviewed journal. Stephens acted as the corresponding author and addressed reviewers' comments.

5.1: Introduction

According to a European Commission report published in 2006, multilingualism relates both to a situation where several languages are spoken within a specific geographical area and to the ability of a person to master several languages. Marian and Shook (2012) reported that most of the world's population is bilingual or multilingual and they claimed that the 'bilingual brain' is better adapted for switching between tasks (i.e., multi-tasking) because of the ability to inhibit one language in order to imply the another.

The rewards of being multilingual are not restricted just to linguistic knowledge. Benefits also appear to extend into cognitive, social, personal, academic, and professional attributes (Thomas and Collier, 1998; Cook and Vivian, 1999). It has been established that much of language functioning is processed in two areas in the cerebral cortex, Wernicke's area (the posterior superior temporal gyrus) and Broca's area of the frontal lobe (Price *et al.,* 1996; Binder *et al.,* 2011; Gębska-Kośla *et al.,* 2017; Stefańczyk and Majos; 2017). These areas are usually located in the dominant hemisphere (i.e., the left hemisphere in 97% of people) and are considered the most important areas for language processing (e.g., Fitzpatrick *et al.,* 2004; Beharelle *et al.,* 2010). It has been suggested that monolingual persons use specific, and restricted, regions of the brain to process language in comparison to multilingual persons who employ a greater neural profile (frontal and bilateral cortex recruitment) (e.g., Kim *et al.,*

1997; Dehaene *et al.,* 1997; Hernandez *et al.,* 2000; Hahne and Friederici, 2001; Marian *et al.,* 2003). A structural imaging study of grey matter within multilinguals revealed that their volume of grey matter was increased in the left inferior parietal lobe (Miller *et al.,* 1980; Mechelli *et al.,* 2004), this area being concerned with language processing and with balancing knowledge between multiple languages, mathematical operations, and sensory information (Fabbro *et al.,* 2000). Owing to the larger neural profile and overlap of the control centres in the brain, it is thought that multilinguistic persons are better at both spatial and verbal intelligence (Bialystok *et al.,* 2012).

I have already reported that medical students in the early stages of their course strongly believe that it is important to have some understanding of classical Greek and Latin since these languages form the basis of anatomical and medical terminologies (Stephens and Moxham, 2016). I have shown that medical students who received tuition in classical Greek and Latin prior to entering medical school performed highly significantly better in anatomy examinations ($p=0.0001$, $P < 0.001$), providing strong statistical evidence that their prior language training is associated with improved performance. Medical students provide a useful group of university students to assess the importance of multilingualism in developing spatial and verbal intelligence. They are often regarded as being academically talented and they have a demanding curriculum and educational training regime (there being a considerable body of knowledge to acquire and many precise skills to attain). Furthermore, excepting for those who enter medical school as graduates, their medical/university education is generally unlike anything they have experienced in school prior to entering university. Indeed, because of the new and extensive medical terminology they must acquire, it is as if they have to learn a new language. Although I would advocate that an appreciation of a newly-recruited medical student's linguistic skills is required, it is noteworthy that, in a study to ascertain anatomists requirements of the skills and attributes of newly-recruited medical students, linguistic skills were only regarded as being 'desirable' and not as being 'required' (Moxham *et al.,* 2018). Notwithstanding this finding, in the present study, I test the following hypotheses:

- that medical students who are multilinguistic have higher spatial (the ability to visualise, manipulate, and reason about spatial relationships between objects) and

verbal (the ability to understand, use, and communicate through language effectively) intelligence

- that there are sex differences in spatial and verbal intelligence, female medical students performing better verbally but not spatially (this hypothesis is in line with the findings of Downing *et al*. (2008) and Zaidi (2010))
- that, if medical students who are multilingual have higher spatial and verbal intelligence, they perform better at anatomy examinations.

I tested these hypotheses by means of questionnaires distributed to medical students at Cardiff University whose examination performances were available anonymously and in line with agreed directives from the ethical committee of Cardiff University.

To aid the reader in navigating through the research, Figure 5.1 below provides a mind map that highlights some of the essential features, including findings and the implications of those findings.

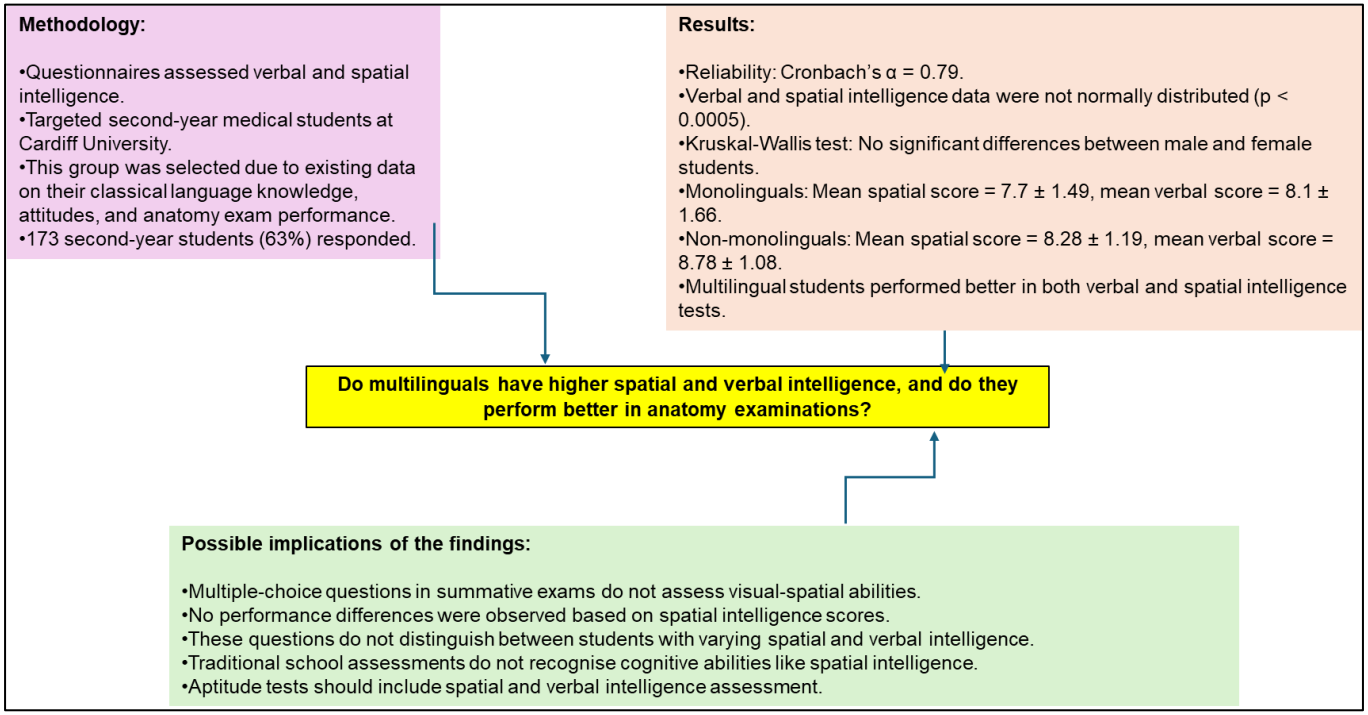


Figure 5.1: Mind map of personality traits, linguistic abilities, and academic performance in medical students. This figure presents a mind map that encapsulates key aspects of the study, summarising the relationships between personality traits, linguistic abilities, and academic performance in medical students. The diagram serves as a structured visual representation of findings and their implications, making it easier to interpret how different psychological and cognitive factors interact in a medical education context.

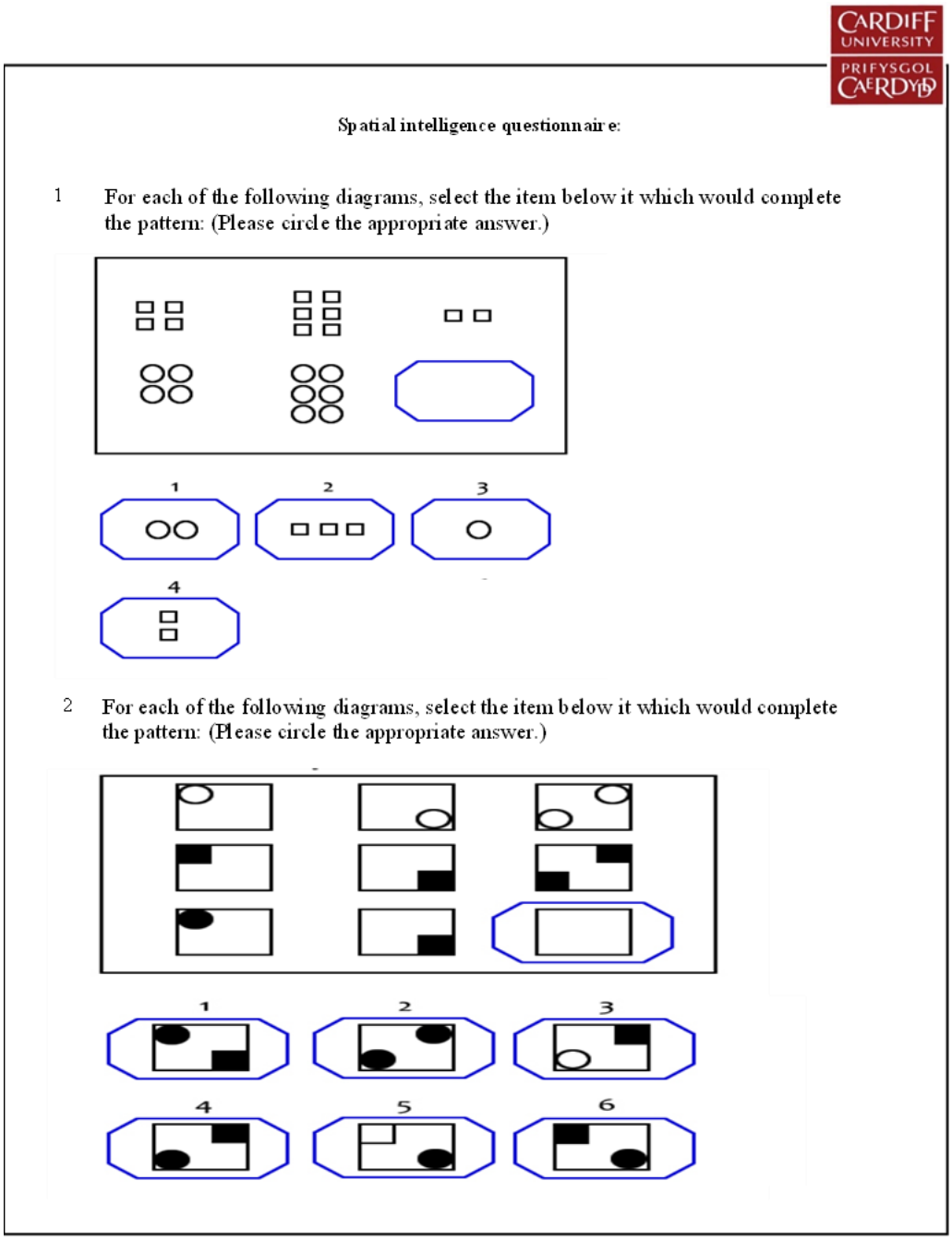
5.2: Methods

Following ethical approval from the Research Ethics Committee at the Cardiff School of Biosciences (Stephens 0115-2), questionnaires were distributed to all second year medical students at Cardiff University. Second year students were chosen as I already have data for this group with respect to their knowledge of, and attitudes towards, classical languages and also have detailed information concerning their performances in anatomy examinations.

In order to assess the reliability and validity of the questionnaire by means of Cronbach's alpha tests, a group of 20 students who were not involved in the present study completed the questionnaire twice, the second time three weeks after initially completing the questionnaire.

The medical students in the cohort being investigated were given an information sheet and a consent form that emphasised that their participation in the study was voluntary. The students had time to ask questions to the principal investigator before responding to the questionnaire.

The questionnaire consisted of two sections that tested verbal intelligence and spatial intelligence, each section comprising ten questions. These questions were adapted from the British MENSA website (www.mensa.org.uk). Figure 5.2 provides examples of the questions employed to assess spatial intelligence. From the responses to the questions, each student could be assigned scores between 0-10 for both spatial and verbal intelligence. Complete questionnaire is attached in Appendix 2 Chapter 5, document 1.



Spatial intelligence questionnaire:

1 For each of the following diagrams, select the item below it which would complete the pattern: (Please circle the appropriate answer.)

2 For each of the following diagrams, select the item below it which would complete the pattern: (Please circle the appropriate answer.)

Figure 5.2: Sample questions assessing spatial intelligence in second-year medical students. This figure presents a selection of sample questions designed to evaluate spatial intelligence in second-year medical students at Cardiff University. These questions were adapted from the British MENSA website and formed part of a structured cognitive ability assessment aimed at investigating the relationship between spatial intelligence, verbal intelligence, and academic performance in anatomy.

Two sets of data relating to the surveyed students' examination performances were available for analyses. Firstly, the students undertook formative tests in anatomy that were comprised mainly of questions requiring identification of anatomical structures from human cadaveric specimens. These questions therefore required spatial intelligence abilities. Secondly, the students sat summative examinations that consisted of multiple-choice questions more suited to requiring verbal intelligence abilities.

Data were placed into Excel spreadsheets and analysed using Anderson-Darling normality tests, Mann-Whitney U tests, Cronbach's alpha tests, and Kruskal-Wallis tests.

5.3: Results

One hundred and seventy-three students responded to the questionnaire. The student cohort comprised 275 and therefore the response rate was 63%. As mentioned in the methods section, Cronbach's alpha tests were used to assess the reliability of the questionnaire. The alpha coefficient calculated was 0.79 (a coefficient between 0.65 and 0.8 showing that a questionnaire is reliable and valid. For both verbal and spatial intelligence data, since a p value <0.0005 was calculated for these tests, the data were not normally distributed (Appendix Chapter 5, document 2)

From the questionnaire, a maximum score for both verbal and spatial intelligence was ten. Our findings showed that 59% of the students scored between 7 and 10 for spatial intelligence and 60% between 7 and 10 for verbal intelligence. Figure 4.3 provides a histogram comparing the average performance between male and female students in spatial and verbal intelligence**.** Kruskal-Wallis tests were conducted to establish the significance between the performances of male and female students. H values (critical values) of -570.4 and -572.7 were derived for female verbal and spatial intelligence respectively. H values (critical values) of -637.9 and -638.2 were calculated for male spatial and verbal intelligence respectively. As all the values were less that the χ^2 value of 7.81, it was concluded that there were no significant differences between the performances of male and female students (Appendix 2 Chapter 5, document 3 and 6).

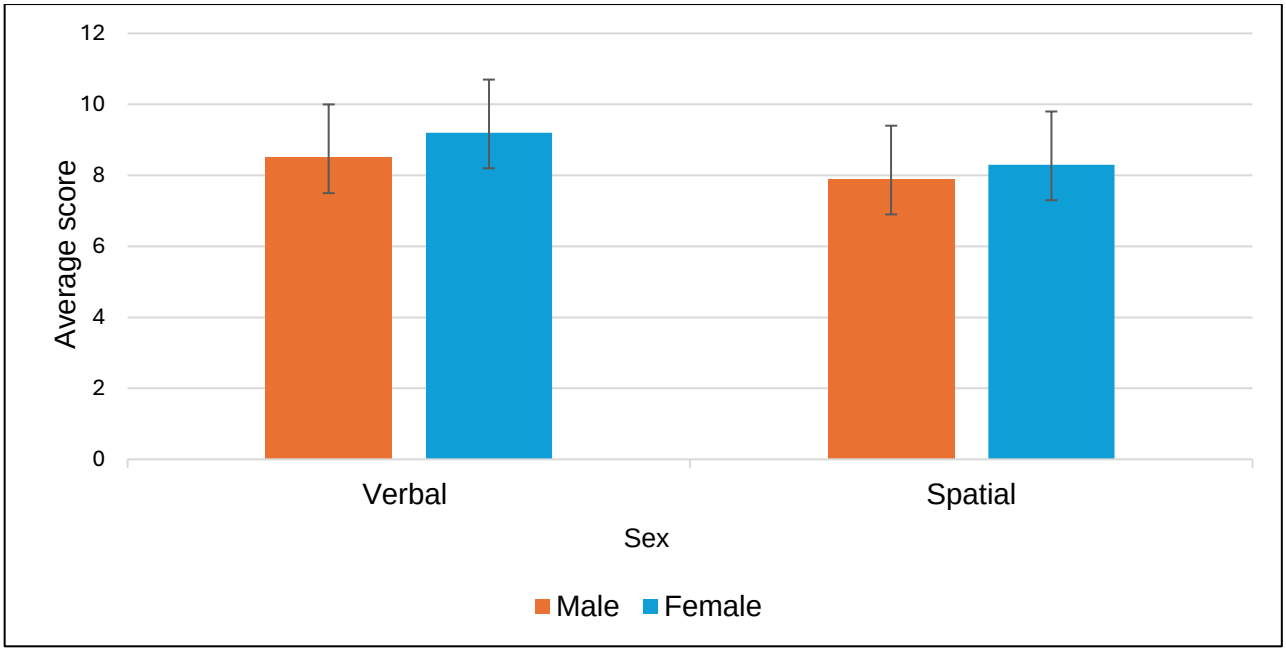


Figure 5.3: Comparative analysis of spatial and verbal intelligence scores by sexes. This figure presents a comparative analysis of the spatial and verbal intelligence scores of male (orange bars) and female (blue bars) second-year medical students at Cardiff University. The graph includes error bars representing standard deviations, illustrating the variability within each group's performance.

Whitney-Mann U tests were then conducted to compare students who were monolingual (English language only) with those who were multilingual and/or had knowledge of classical and modern languages. For the monolingual group, the mean spatial score was 7.7 ± 1.49 SD and the mean verbal score was 8.1 ± 1.66 SD. For the students who were not monolingual, the mean spatial score was 8.28 ± 1.19 SD and the mean verbal score was 8.78 ± 1.08 SD. As the Z score for the Whitney-Mann U tests was 1.86 for verbal intelligence and 0.97 for spatial intelligence ($p< 0.05$), the difference in the means between monolingual and multilingual students is statistically significant and the probability of the difference being due to chance is less than 0.05%. with $P < 0.05$, indicating a statistically significant difference in means between monolingual and multilingual students. This suggests that the probability of this difference occurring by chance is less than 5%. Thus, students who are monolingual (fluent in English only) show less verbal and spatial intelligence compared to the multilingual groups (Appendix Chapter 5, document 4 and 5).

From the responses to the questionnaire, the respondents could be categorised into eight groups (Table 5.1).

Table 5.1: Categorisation of medical students by linguistic background for cognitive and academic analysis. This table categorises medical students into eight distinct groups based on their linguistic background, allowing for a comparative analysis of how language proficiency may impact cognitive skills and academic performance. The classification was determined through responses to a questionnaire distributed among second-year medical students at Cardiff University.

Groups	Categories	Number of students
Group A	Students who had prior knowledge of Greek and/or Latin from school (Pre GCSE) (age less than 14 years)	10
		5 males, 5 females
Group B	Students who have studied Greek and/or Latin in GCSE (aged 14-16 years)	18
		7 males, 11 females
Group C	Students who are fluent in English and other European language	21
		8 males, 13 females
Group D	Students who are fluent in English and also other non-European languages	14
		7 males, 7 females
Group E		25

	Students who are fluent in English only	15 males, 10 females
Group F	Students who are moderately fluent in English with high fluency in other non-European languages	11
		5 males, 6 females
Group G	Students who are fluent in English with moderate fluency in other European and non-European languages	74
		43 males, 31 females
Group H	Students who have studied Greek and/or Latin from school and have fluency in English and another modern language	24
		10 males, 14 females

Figure 5.4: Provides a histogram comparing the average scores attained by the various categories of second year medical students for spatial and verbal intelligence. This suggests that students who are fluent in English and other non-European languages (Group D) perform better in both verbal and spatial intelligence tests. The histogram also suggests that students from all the categories performed better in verbal intelligence than in spatial intelligence tests. In order to ascertain whether there are statistical significant differences between different groups of students, Kruskal-Wallis tests were employed. It was found that Group D students who are fluent in English and in other non-European languages were statistically significantly different from other groups (H value (critical value) 15.49 is greater than χ^2 value of 14.06 for verbal intelligence, while H value (critical value) of 56.11 is greater χ^2 value of 14.06 for spatial intelligence) (Appendix 3 Chapter 5, document 6).

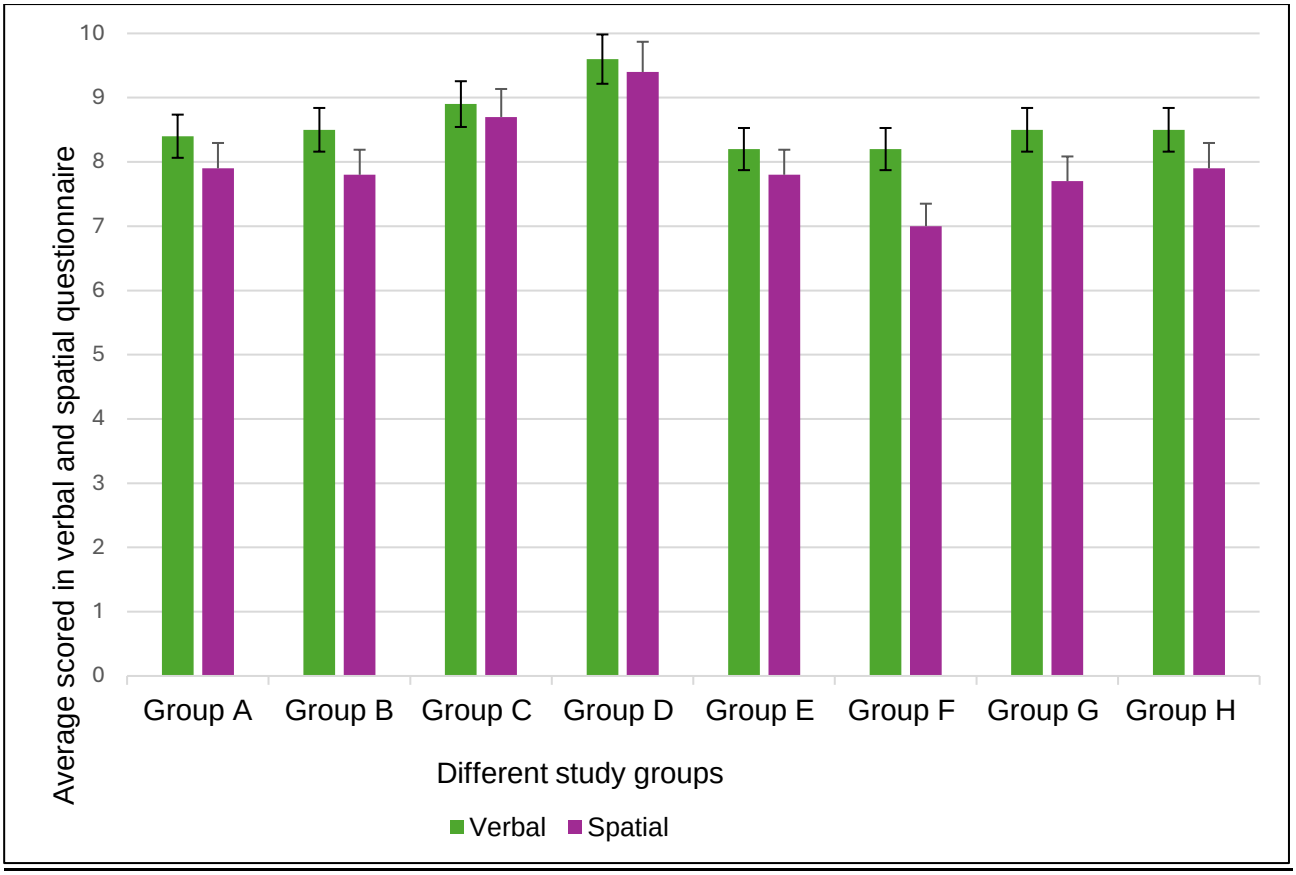


Figure 5.4: Histogram of verbal and spatial intelligence scores by linguistic background. This figure presents a histogram comparing the average scores obtained by different categories of second-year medical students in the verbal intelligence (green) and spatial intelligence (purple) sections of the questionnaire. The histogram provides insights into the relationship between linguistic background, cognitive abilities, and intelligence performance.

To determine the link between the anatomy examination performance and spatial and verbal intelligence, the students were categorised into three different groups based on their test scores for spatial and verbal intelligence: scores between 8 and 10, 5 and 7 and less than 4. According to the histogram shown in Figure 5.5, there appears to be a relationship between the verbal-spatial scores and anatomy examination performance. Using a Kruskall-Wallis test, a H (critical value) of 5.56 and p=0.018 was calculated for the formative examination results of students with spatial intelligence less than 4. Thus, there was statistical significance for the above group but there were no significant differences between any other categories

of students for either summative or formative examinations (Appendix 2 Chapter 5, document 7).

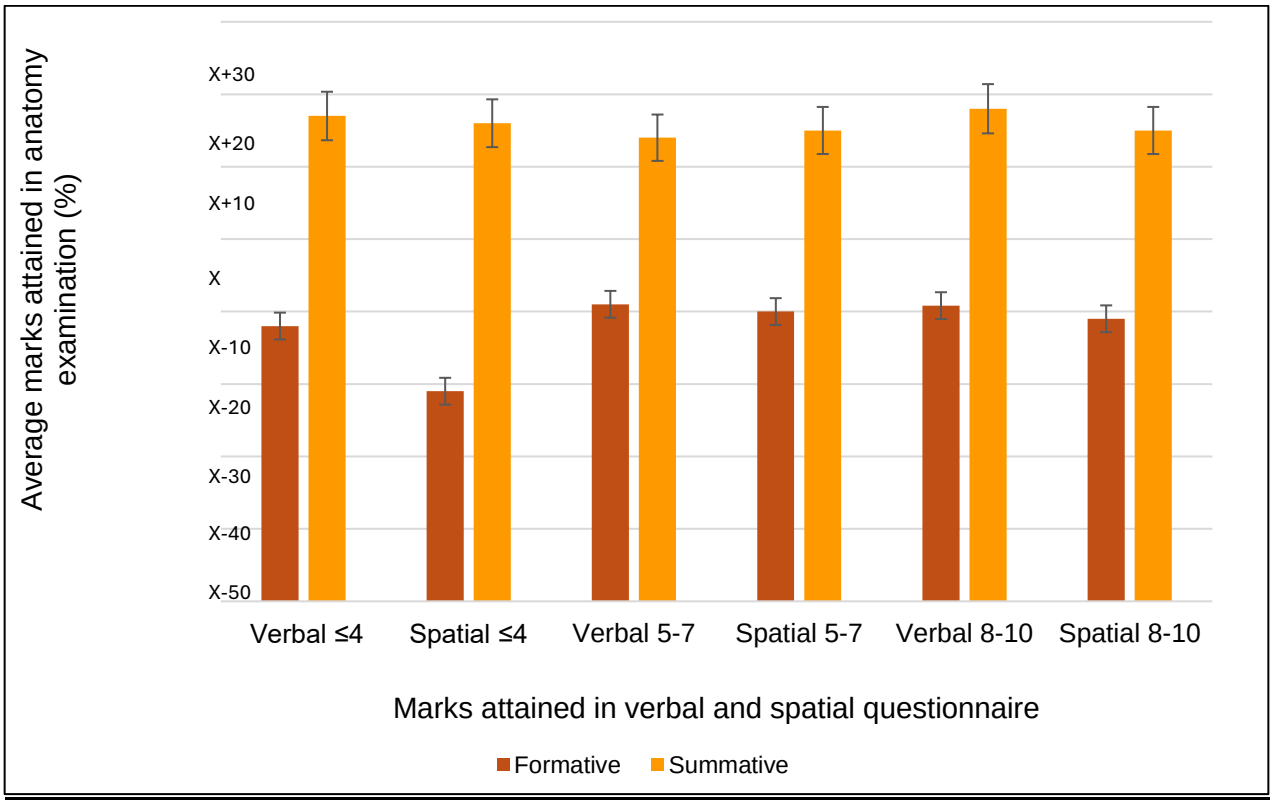


Figure 5.5: Histogram comparing verbal and spatial intelligence categories with anatomy examination performance. This histogram compares the performance of distinct verbal and spatial intelligence categories with their anatomy examination scores (Brown – formative marks, Orange – summative marks). The graph includes error bars representing standard deviations. Note that, to maintain confidentiality, the percentage marks are shown as a concealed value (i.e., x) plus or minus 10 to 50%.

In order to ascertain whether there are statistically significant differences for examination performances of groups of students with different linguistic skills, Whitney-Mann U tests were undertaken. In particular, I wished to establish whether the multilingual students with the highest spatial and verbal intelligence (i.e., Group D students with English and non-European languages) performed significantly better in their anatomy examinations ($p=0.001$**,** $P < 0.001$) (Figure 5.6).

It was found that there was no statistically significant difference from other groups, either for their formative or their summative anatomy examinations (Appendix Chapter 5, document 2).

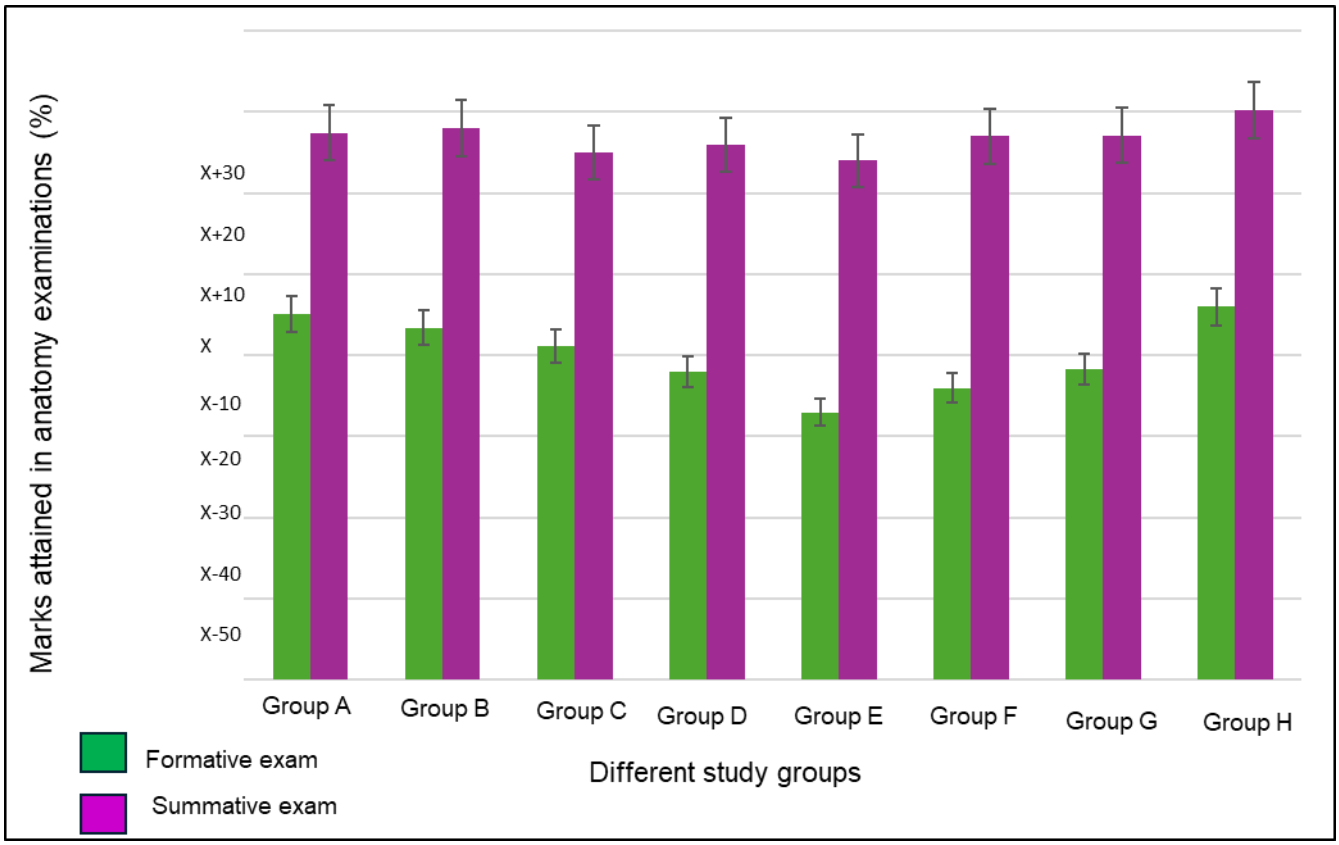


Figure 5.6: Histogram comparing group performance in anatomy examinations. This histogram compares the performance of various groups in their anatomy examinations (Green – formative marks, Purple – summative marks). The graph includes error bars representing standard deviations. Note that, to maintain confidentiality, the percentage marks are shown as a concealed value (i.e., x) plus or minus 10 to 50%.

5.4: Discussion

Monolingual students with high fluency and proficiency in English had lower spatial and verbal intelligence than multilinguals. International students with fluency in English and other non-European languages showed higher spatial and verbal intelligence than all other

groups. Students with low spatial intelligence performed poorly in anatomy spotter examinations that required spatial orientation.

5.4.1: Correlation between verbal-spatial intelligence and anatomy examination scores

That many medical students were assigned scores between 7 and 10 in our tests (59% of students with high spatial intelligence; 60% of students with high verbal intelligence) accords with reports that students with relatively high spatial abilities tend to gravitate towards, and excel in, scientific and technical fields such as the physical sciences, engineering, mathematics, and computer science (Wai *et al.,* 2009). According to Trickett and Trafton (2007), a student who has high visual-spatial ability is able to generate mental representations of intricate ideas and then mentally manipulate those representations, which is a skill that is needed for creative productivity and theory development in STEM subjects.

Although, there were students in the surveyed cohort who had low spatial and verbal intelligence scores (i.e., <4), across the class, and regardless of the spatial and verbal intelligence scores, little difference in examination performances were recorded. However, the students with spatial intelligence scores less than 4 performed poorer in the formative examinations that required spatial abilities. Regrettably, the use of multiple-choice questions in the summative examinations do not require visual-spatial abilities and indeed no differences in examination performances could be discerned for students with different spatial intelligence scores. Furthermore, no differences could also be discerned for multiple choice examination performance between students with different verbal intelligent scores. Whatever the multiple-choice questions are testing (primarily factual recognition), I conclude that these types of question do not differentiate between students with different spatial and verbal intelligence.

Keenan and Ben Awadh (2019) highlight the benefits of integrating 3D visualisation technologies in anatomy education, which aligns with the findings of this study on the importance of spatial abilities in academic performance. These technologies offer immersive and interactive experiences, allowing students to better visualise complex anatomical structures and their spatial relationships. Furthermore, Keenan and Powell (2020) stress the

importance of training students to navigate between 3D and 2D perspectives, which is a critical skill for understanding anatomy and interpreting diagnostic imaging. These insights reinforce the need for incorporating technology-driven strategies into anatomy education to support spatial learning.

5.4.2: Are males better at spatial tasks while females are better at verbal and memory tasks?

Despite there being some conflict in the literature, evidence regarding sex differences for spatial and verbal intelligences generally suggests that males perform better at spatial tasks while females perform better at verbal and memory tasks (e.g., Downing *et al.,* 2008; Zaidi, 2010). I found however that there were no significant sex differences in our data. This accords with the findings of Aluja-Fabregat *et al*. (2000) and Colom *et al*. *(*2006) who reported that, while males have a larger brain size, females have greater brain density. Thus, the sexual dimorphism allows the same number of neurons in male and female brains, despite the difference in size. According to Allen *et al*. (2002), in males and females the proportional size of regions relative to total volume of the hemisphere are similar. Thus, the representation of different centres in both the sexes are similar. This could explain why there are no sex difference in spatial and verbal intelligence. Alternatively, admission procedures and criteria for recruiting medical students could 'wash out' sex differences. It has been suggested that environmental factors, educational policies, learning preferences , geographical distribution and socio-economic factors play more important roles than sex in the development of intelligence (e.g., Miller and Halpern, 2014). These factors have yet to be assessed for medical students.

5.4.3: Relationship between personality traits and linguistic skills

Concerning personality traits, I previously reported that medical students who are multilingual classified themselves as being curious, organised, outgoing and friendly (Stephens and Moxham, 2018). This contrasted with monolingual students who considered themselves as

being cautious, easy going, reserved and detached. Several reports have linked the 'Openness' personality trait to multilingualism (Dewaele and Van Oudenhoven, 2009; Dewaele, 2010 a and b; Korzilius *et al.,* 2011; Dewaele and Stavans, 2012). 'Openness' is related to an ability to appreciate new ideas and to adapt to new cultures and societies (John and Srivastava, 1999). Thus, multilingual persons with 'Openness' are thought to be more skillful in conversation because they see the world from an interlocutor's point of view. They consequently would be expected to have higher verbal intelligence because of a strong understanding of vocabulary and language (Cook, 2002; Dewaele, 2007; Dewaele and Wei, 2012). Marchman *et al.,* (2010) reported that monolinguals perform better at verbal skills tests as they do not have to switch between languages and because their vocabulary in one language tends to be larger than their multilingual peers. However, our results do not support this view, the multilinguals performing better at both the verbal and spatial intelligence tests.

The questionnaire was written in Basic English with easy-to-understand statements and the spatial intelligence section of the questionnaire consisted of a series of images that analysed problem solving and spatial reasoning without relying upon, or being limited by, language skills. Assuming that all the participants had a sound understanding of the English language (a reasonable assumption given that all were second year medical students), interpreting the questionnaire should not have posed a challenge. The data also suggest that, regardless of their linguistic skills, all groups of students perform better at verbal compared to spatial intelligence questions. This finding might related to the fact that, being the first part of the questionnaire with questions that were straightforward to comprehend, the verbal intelligence questions could be more easily interpreted.

5.4.4: Impact of changes in educational policies on the development of verbal and spatial intelligence

The question should be posed: do students come to university with an education that has allowed them to develop properly their spatial and verbal intelligence? According to Machin

and Vignoles (2006), U.K. educational policy in the 1950s was such that most schools had specific core academic, vocational and business courses that were available to pupils. They stated that in 1990s:

"literacy and numeracy hours were introduced in the U.K. through a national standardised curriculum. This meant that the students had specific periods of time to spend developing reading, writing and maths abilities. This had greatly compromised the free selection of vocational courses that the student could choose from. With the change in curriculum, in order to stand out in the saturated job market, a student is expected to get involved in sports, volunteering and a host of extra-curricular activities".

These changes greatly undermined the amount of practical hours a student could choose, thus possibly affecting their spatial orientation skills and intelligence. Cognitive abilities, such as spatial intelligence and spatial visualisation, are not recognised currently at schools through traditional methods of assessment. This could have serious implications as students with relatively strong spatial abilities tended to gravitate towards, and excel in, science, technology, engineering and mathematics (STEM) disciplines (Wai *et al.,* 2009; Kell and Lubinski, 2013; Kell *et al.,* 2013).

5.4.5: Aptitude tests: how effective are they in medical admissions?

Several studies have demonstrated a clear link between spatial ability with career progress and with performance of complex, discipline-related tasks, even when taking into account other forms of intelligence (Benbow and Stanley, 1982; Hambrick *et al.,* 2012*).* According to Al-Rukban *et al.* (2010), Tektas *et al*. (2013), Husbands *et al*. (2014), and Petterson *et al.* (2016), the current selection methods in medical schools (such as academic records and interviews) are not robust and reliable enough to judge whether candidates are likely to be successful in medical training and as clinicians. Elam *et al.* (2002) reported that, where aptitude test scores are employed for medical admissions, they are one of the most influential factors determining decisions. Aptitude tests often include assessment of spatial and verbal intelligence. Eyal *et al.* (2001) and Wanzel *et al.* (2002) claim that admitting students with

poor spatial intelligence into medicine might affect their training, visuo-spatial ability being thought of as fundamental to the cognitive understanding of the three-dimensional environment that medical students face in their clinical careers. Furthermore, the ability to mentally visualise anatomical structures and relationships in three-dimensions plays an important part in the understanding of anatomy, in the development of surgical competencies and in the interpretations of medical imagery.

In Chapter 4, I reported that students with prior knowledge of Greek and Latin perform better in their anatomical examinations. This might be related to the fact that anatomical terminologies are derived from classical languages such as Greek and Latin and a sound understanding of these languages would help with knowledge recall and thus examination performance. That advantage seems to have faded when it comes to interpreting spatial and verbal intelligence questions. Understanding of these languages may not have influenced the brain in the same way as language acquisition. Hence, the advantages were not evident while solving spatial and verbal intelligence problems in the questionnaire.

5.4.6: Exploring the linguistic advantage of oriental languages

My findings indicate that the students who are fluent in English and other non- European languages perform better in both spatial and verbal intelligence. According to Sakamoto and Spiers (2014) and Rodic *et al*. (2015 a and b), children from Asian countries perform better at spatial intelligence tests as they have an increased spatial ability to interpret complex, visuo-spatially arranged, character-based, reading and writing systems. English language is based on letter-based scripts, where complexity is linear. For many Oriental languages, the complexity of the characters increases with the number of elements (such as strokes and sub-character components all set out into the same square configuration) (Tang *et al.,* 2006). Thus, when reading or writing Oriental languages, visuo-spatial processing and analysis are necessary. It is possible that continuous engagement in such processing leads to superior development of relevant brain networks, which in turn may lead to advantage in spatial intelligence (Tang *et al.,* 2006). Another reason the students at Western universities that

originate from Asian regions perform well might relate to their parents' stable socio-economic status, parental expectations, and access to educational resources at home and in communities (Goyette and Xie, 1999, Liu *et al*, 2021).

5.5: Limitations of the study

While my analysis suggests that multilingual medical students performed better at spatial and verbal intelligence tasks, our data was limited by the fact that there was no information on how these languages were acquired nor on the culture and history of the region in which those languages were acquired. I also do not have information relating to the socio-economic backgrounds of the students. Future studies could establish the psycholinguistic aspect of multilingualism by investigating the functional anatomy of the brain, perhaps by means of functional MRI. The medical student cohort at Cardiff University is essentially UK based, although multi-ethnic. It is hoped that studies similar to our own will be conducted at medical schools outside Europe and Western cultures.

5.6: Recommendations

It could be beneficial to introduce aptitude tests that assess spatial and verbal intelligence during medical interviews. That I recorded a difference in examination performance dependent upon spatial intelligence argues for this recommendation. Given that I believe that the medical students would also benefit from tutorials/lectures that help them understand Latin and Greek medical terminologies, I further recommend that such tutorials/lectures could coincide with the assessments of spatial and verbal intelligences and appreciation of the student's linguistic skills.

Chapter 6

The impact of personality traits on academic and professional outcomes in medical education: A comparative international, interdisciplinary study between UK and French students

Abstract

Non-cognitive functions, such as personality traits, may impact the success of medical students in their studies and professional careers. In this study, I explored how personality traits may influence linguistic skills and examination performance. Using the 'Big Five Inventory' (BFI) with 44 items, I compared medical students in the UK and France, as well as psychology and business students in France.

Results revealed that UK medical students, similar to French business and psychology students, exhibited less ‘O’ trait (openness) than French medical students ($p<0.01$). While French psychology students had higher 'C' trait (conscientiousness) than French medical students ($p<0.02$), no significant differences were found for UK medical students. UK medical students demonstrated less 'E' trait (extraversion) than French business students ($p<0.01$), and less 'A' trait (agreeableness) than French psychology and medical students ($p<0.04$). Both UK and French medical students had less ‘N’ trait (negative affectivity) than French psychology students ($p<0.05$).

These findings suggest a personality profile for UK and French medical students characterised by lower ‘N’ trait (negative affectivity) and 'E' trait (extraversion) compared to other French students, possibly indicating less 'C' trait (conscientiousness). The UK medical students showed a statistically significantly lower ‘O’ trait (openness) and less ‘A’ trait (agreeableness) when compared with some other students. Concerns arise about whether this profile aligns with desirable traits for the medical profession and about how the profession is perceived by the general public.

Examining the relationship between personality traits and anatomy examination performance in the UK Cardiff cohort, I found that, irrespective of personality, female medical students outperformed males. Female students with higher ‘N’ trait (negative affectivity) performed better ($p<0.01$). Other personality traits did not significantly influence examination performance.

Analysing linguistic skills, students with no knowledge of Greek and/or Latin showed higher 'C' trait (conscientiousness), while those with prior knowledge had higher 'N' trait. Monolinguistic students exhibited higher ‘N’ trait (negative affectivity) ($p<0.02$) compared to those with prior knowledge of Greek and/or Latin. Multilingual students fluent in English had

higher 'E' trait (extraversion), whereas international multilingual students had lower 'E' trait (extraversion).

In conclusion, the results do not provide clearcut differences except in relation to previous findings where students with prior knowledge of Greek and/or Latin were performing better in their assessments in comparison to students with no prior knowledge of Greek and/or Latin. Previously (See Chapter 4) it was conjectured that improved examination performance might be related either to Greek/Latin students being more *au fait* with anatomical and medical terminologies or to them having a more conscientiousness approach to their studies. Given that the Greek/Latin students have lower ‘C’ personality trait (conscientiousness), the earlier results indicate that their examination performance is more likely to be related to their ability to understand complex medical/anatomical terminologies.

6.1: Introduction

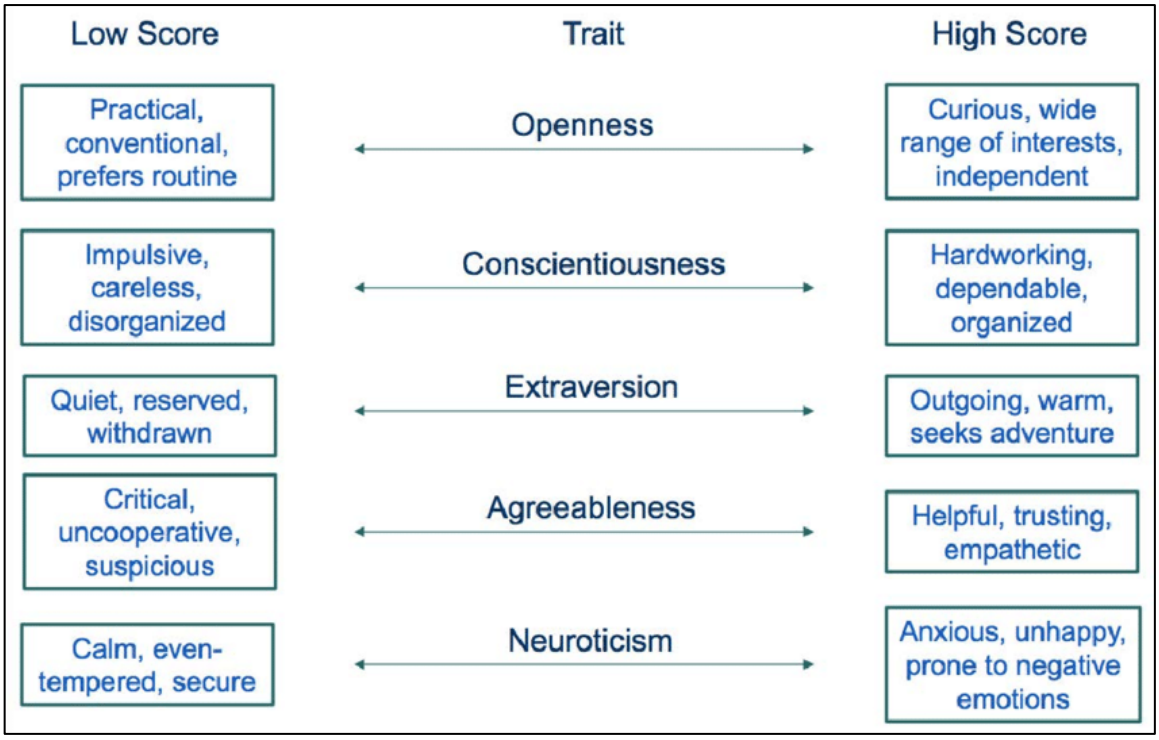
Motivation to learn is one of the most effective factors dictating student achievement (Rahman *et al.,* 2017). Without a profound interest in learning, all educational systems are set to fail. It is therefore important to understand what factors affect motivation in order to improve educational performance. Although sex, intelligence, self-appreciation and critical evaluation, study habits, age and state of maturation and social background have been extensively investigated in terms of academic achievement there is evidence that personality can also play a role in developing academic motivation and achievement (O'Connor and Paunonen, 2007; Busato *et al.,* 2000, Costa and McCare, 1992).

Admitting students to medical schools should involve consideration not just of basic academic achievement but also of their motivation for learning and on personality and behavioural factors (O'Connor and Paunonen, 2007). Powis (2015) has highlighted the fact that the selection of medical students remains a challenge and that there is presently no consistency of approach. Lourinho (2017) claims that future doctors should have a variety of specified skills and personal attributes, in addition being well qualified and competent technicians. This differs from the traditional approach that has generally relied upon academic achievement and Monroe *et al.* (2013) reported that there has been a paradigm shift in the selection processes alongside significant changes in medical curricula. However, it has been reported that selection relying heavily on academic achievement has resulted in low levels of dropout (Ferguson *et al., 2002,* McManus *et al.,* 2013, Puddley *et al.,* 2014). Conversely, it cannot be assumed that those with just high academic abilities become the most competent clinicians and Patterson *et al*. (2016) has reported that some personal characteristics (such as conscientiousness) need to be present from the beginning of a student's medical training. Additionally, Moxham *et al.* (2009) reported that anatomists required of their medical students many personality and behavioural characteristics in addition to academic achievements. Indeed, in recent years numerous selection tools have been developed that aim to assess non-academic characteristics among applicants for medicine that are already recognised as being academically well-qualified, including interviews (Lourinho *et al.,*2016), mini-multiple-interviews (MMI) or situational judgement tests (Patterson *et al.,* 2016) and personality assessments (Ferguson *et al.,* 2003). These studies highlight the evolving nature of the

medical admission process, indicating a move towards a more comprehensive and nuanced evaluation that goes beyond academic achievements to consider personal attributes and motivations. This shift reflects a recognition that successful medical practitioners require a combination of academic excellence and specific personal qualities to excel in their roles.

There is emerging consensus among psychologists studying personality that traits can be grouped under five, higher order categories: O (Openness), C (Conscientiousness), E (Extraversion), A (Agreeableness) and N (Neuroticism or negative affectivity) (Weisberg *et al.,* 2011). These traits, referred to as the 'Big Five' (Lean *et al.,* 2018), together with the characteristics, represent the normal range of individual differences. This makes the model suitable for studying traits and samples derived from the general population (Ferguson *et al.,* 2000; Fleeson and Gallagher, 2009). Focusing on the prototypical components of each Big Five domain, Oliver John and associates have devised the Big Five Inventory (BFI). The BFI most commonly employed consists of 44 brief items or statements that conserve research time and prevent respondent fatigue. Table 5.1 below shows the range for each of the Big five personality traits.

Table 6.1: Overview of the Big Five personality traits and their spectrum. This table presents a structured overview of the Big Five personality traits and their respective spectrum, as originally developed by John and Srivastava (1999). The Big Five model is widely recognised as a comprehensive framework for understanding individual differences in personality and has been applied extensively in medical education research to examine its relationship with academic performance, learning styles, and professional development.



Reported in Chapter 3 was the finding that medical students in the early stages of their course strongly believe that it is important to have some understanding of classical Greek and/or Latin. It was also shown that medical students who have had some tuition in classical Greek and/or Latin prior to entering medical school perform better at examinations in anatomy. It was conjectured that the reason for this could relate to better familiarity with medical terminologies or could be based upon personality differences. Furthermore, in Chapter 5 it was reported that students who were categorised as monolingual (with only skills in English) had lower spatial and verbal intelligence than those who were multilingual. Medical students who had fluency in English and non-European languages showed greater spatial and verbal intelligence than other groups. Again, personality may have a bearing on these differences. Collectively, these findings highlight the importance of recognising the multifaceted nature of student characteristics in the academic realm. Personality, intertwined with cultural perspectives, linguistic skills, and cognitive abilities, emerges as a dynamic factor influencing educational experiences and outcomes in assessments. As I delve deeper into understanding the intricate interplay between personality and academic performance, I open avenues for tailoring educational approaches and support systems that acknowledge and leverage the diverse strengths and needs of individual learners.

The personalities of medical students have previously been reported. In particular, Plaisant *et al.* (2014) reported differences between personalities of French medical students, psychology students and business students. By kind permission, investigations reported here use the data from this study to make comparisons with first year UK (Cardiff) medical students. Furthermore, using the 44-item itinerary BFI devised by Oliver John, an assessment was made of their personalities in relation to examination performance for anatomy and in relation to linguistic skills.

The following hypothesis were tested.

1. No personality differences between French and UK Medical Students, and Psychology Students:

This assumption assumes that nationality or cultural background (French versus UK) and academic discipline (medicine versus psychology, business studies) do not significantly influence personality traits. It may be grounded in the belief that personality traits are more universally distributed across these groups, and any differences observed can be attributed to individual variations rather than group affiliations.

2. Business students having lower ‘O’ Trait (Openness), ‘E’ Trait (Extraversion), and ‘A’ Trait (Agreeableness) but Higher ‘C’ Trait (Conscientiousness):

This hypothesis is based in the conventional expectations about individuals in business-related fields. The expectation of lower openness, extraversion, and agreeableness might align with the perception of business students as being more task-oriented, goal-focused, and perhaps less open to novel experiences. The anticipation of higher conscientiousness may reflect the emphasis on diligence often associated with business-related professions.

3. Students with prior knowledge of Greek and/or Latin having higher ‘C’ Trait (Conscientiousness) with a lower ‘E’ Trait (Extraversion) and a higher ‘N’ Trait (Negative Affectivity):

This hypothesis suggests that familiarity with classical languages is associated with specific personality traits. The expectation of higher conscientiousness could be tied to the assumption that learning classical languages demands discipline and attention to detail. The anticipation of lower extraversion and higher negative affectivity may be based on the

perception that individuals with linguistic expertise tend to be more introverted and possibly perfectionistic.

4. Multilingual students having higher ‘E’ Trait (Extraversion) and ‘A’ Trait (Agreeableness) compared to monolingual students, and monolingual students having higher ‘N’ trait (Negative Affectivity):

This hypothesis highlights the relationships linguistic abilities and personality traits. The expectation of higher extraversion and agreeableness in multilingual students could stem from the hypothesis that introduction to multiple languages enhances social and interpersonal skills. The anticipation of higher negative affectivity in monolingual students may be centred on the belief that limited language proficiency might be linked with higher stress or negative emotions.

It is acknowledged that the research undertaken in this part of the thesis is complex and complicated. Therefore, to aid the reader in navigating through the research, Figure 6.1 below provides a mind map that highlights some of the essential features, including findings and the implications of those findings.

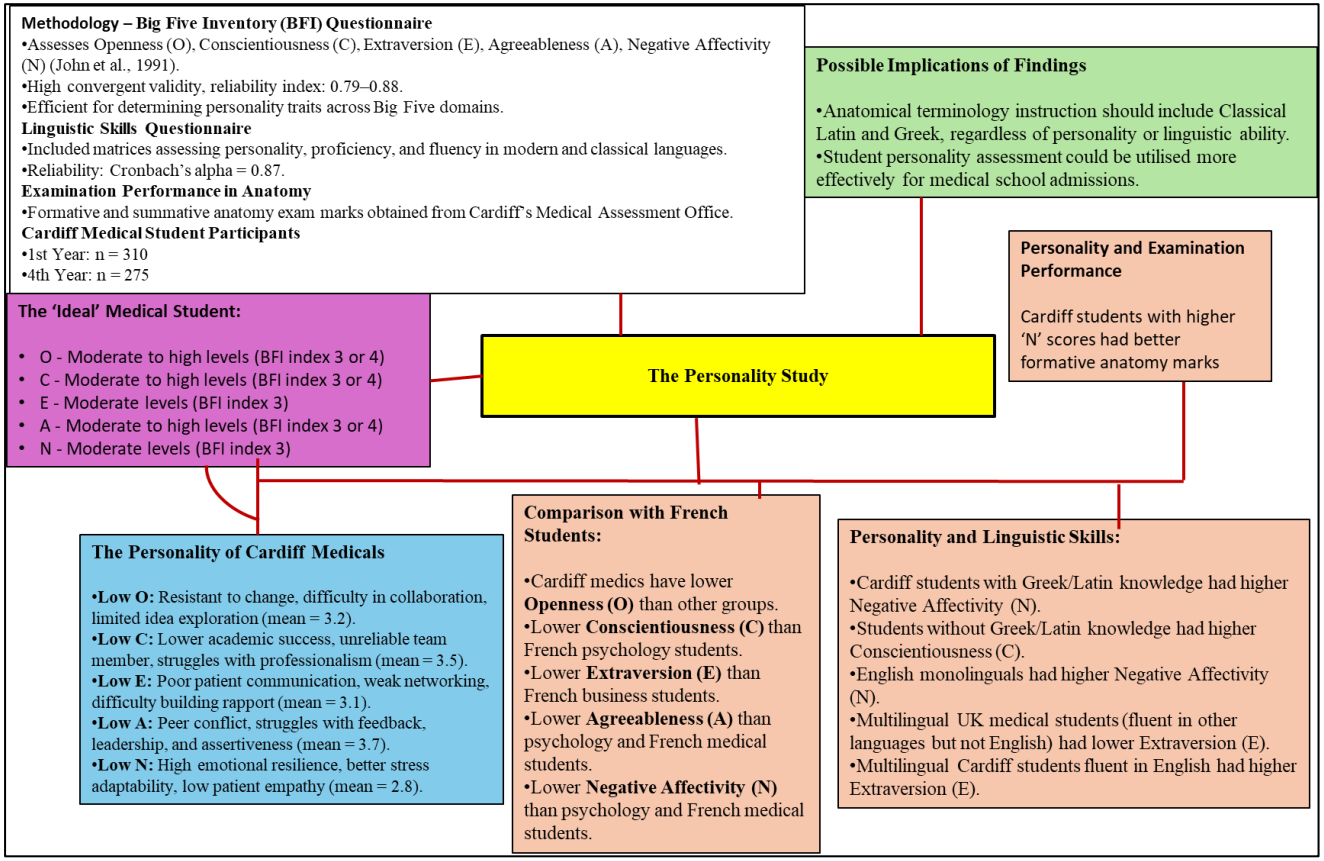


Figure 6.1: Mind map of key findings and recommendations from this chapter. This figure offers a structured representation of how different aspects of the study interconnect. The visual summary helps contextualise the impact of linguistic proficiency and personality traits among medical students.

6.2: Methods

Ethical approval for this part of the study was obtained from the Research Ethics Committee at the Cardiff School of Biosciences (Stephens 0115-2). The student participants were given an information sheet and a consent form that emphasised that their participation in the study was voluntary and anonymous. They were also informed that they could ask the principal investigator questions concerning the survey and that they could withdraw from the survey at any time.

This study engaged two cohorts of students: first and fourth-year medical students from Cardiff University in 2019. The fourth-year medical students were analysed to explore the broader dimensions of medical student personality in the UK and investigate potential connections between personality traits and performance in the anatomy components of their examinations. The fourth-year students were the same as those previously involved in the study of their knowledge of, and attitudes towards, classical languages (see Chapter 1). In this part of the investigation, these fourth-year students were the only cohort of students available, with ethical approval, to compare personality with examination performance. The formative and summative gross anatomy assessment marks for these medical students were collected by the principal investigator from the Medical Assessment Office at Cardiff. These data were anonymous but could be related to the responses of the survey by a unique code whose identity was known only to the Medical Assessment Office.

In order to understand the relationship between personality and linguistic skills, a first-year cohort of medical students at Cardiff University during 2019-20 academic year was chosen.

Both the fourth and first-year cohorts of students were supplied with a questionnaire that included the forty-four item ‘Big Five Inventory’ (BFI) developed by John *et al.* (1991) (Appendix 2 Chapter 6, document 1). In addition, the first-year medical students were given a language proficiency and fluency questionnaire in order to understand the relationship between personality and linguistic skills (Appendix 2 Chapter 6, document 2). The questionnaire for the fourth-year students were distributed following a lecture, while for the first-year students, it was given during an Anatomy practical session.

Using two student cohorts in this study has several advantages. It allows for investigating different stages of medical education, specifically the first and fourth-year groups, offering potential insights into how personality traits evolve across training. Additionally, it enables a comparison between newer and more advanced students, providing a nuanced understanding of the impact of education and experience on personality. Incorporating both first and fourth-year cohorts aims to explore potential links between personality traits and anatomy examination performance. This sheds light on whether specific characteristics predict academic success at different stages of medical education, crucial for tailoring effective support.

6.2.1: Questionnaires

6.2.1.1 The BFI questionnaire

Why was Big Five Inventory (BFI) chosen?

The BFI shows high convergent validity with other self-reporting scales (Gosling, 2003). Furthermore, John (1998) reported that the reliability index ranged from 0.79 to 0.88 and Soto and John (2017) suggested that the inventory has clarity and is efficient in determining personality traits by reasonably broad coverage of its Big Five domains. Indeed, they reported that these attributes pertain even though the inventory is brief. BFI has previously not featured extensively in the medical literature. Extensive studies have been undertaken by Moxham and Plaisant (2017) to understand the attitudes of medical students. The inventory can serve as a uniform, comprehensive and robust framework for describing the characteristics of medical students' personalities and for substantially advancing our understanding of whether these traits relate to academic success.

The questionnaire employed the forty-four items 'Big Five Inventory' (BFI) and was chosen because it is now the preferred instrument for evaluating personality (John and Srivastava (1999)). The BFI measures 'O' trait (openness), 'C' trait (conscientiousness), 'E' trait

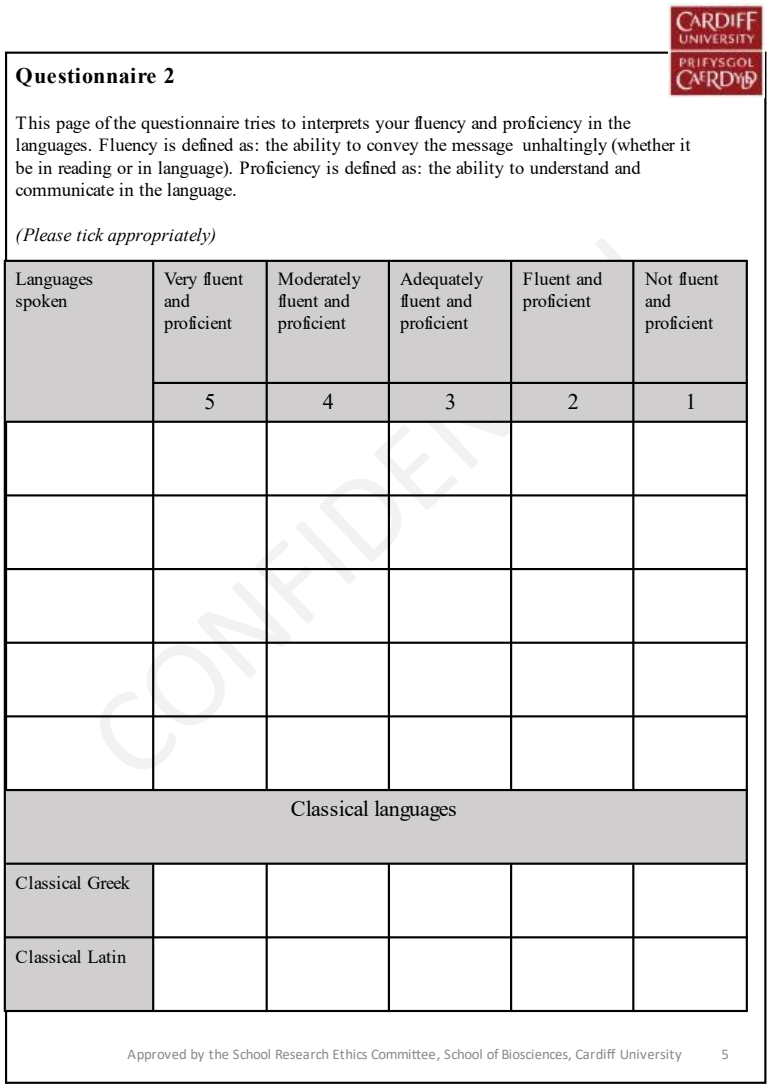
(extraversion), ‘A’ trait (agreeableness) and N’ trait (negative affectivity) as developed by John *et al.* (1991).

Previously, Plaisant *et al.* (2014) used the BFI to report on the personalities of French medical, psychology and business studies students. These data were kindly made available by the authors for the present study in order to compare our findings for the personalities of UK (Cardiff cohort) medical students with the French cohorts.

6.2.1.2: Linguistic skills questionnaire

This linguistic skills questionnaire was the same questionnaire employed for the study described in Chapter 4. It consists of a series of a Likert scale questions where the participant had to choose one appropriate option between languages spoken (very fluent and proficient (5) to not fluent nor proficient (1)) see Figure 6.2.

For statistical analyses, data were placed into Excel spreadsheets and evaluated using ANOVA tests, Chi-square tests, Levene’s test and Bonferroni’s post-hoc test. In order to assess the reliability and validity of the questionnaire, Cronbach’s alpha tests were employed on the raw data.



Questionnaire 2

This page of the questionnaire tries to interprets your fluency and proficiency in the languages. Fluency is defined as: the ability to convey the message unhaltingly (whether it be in reading or in language). Proficiency is defined as: the ability to understand and communicate in the language.

(Please tick appropriately)

Languages spoken	Very fluent and proficient	Moderately fluent and proficient	Adequately fluent and proficient	Fluent and proficient	Not fluent and proficient
	5	4	3	2	1
Classical languages					
Classical Greek					
Classical Latin					

Approved by the School Research Ethics Committee, School of Biosciences, Cardiff University 5

Figure 6.2: Linguistic skills questionnaire for assessing proficiency and fluency. This figure displays the linguistic skills questionnaire used to assess the proficiency and fluency of Cardiff University medical students in various languages. The questionnaire played a critical role in categorising students into different linguistic groups, allowing for a comparative analysis of how language proficiency relates to academic performance and cognitive abilities.

6.3: Results

6.3.1: Personality traits amongst Cardiff medical students

Of the 275 Fourth Year medical students at Cardiff, 215 students responded to the questionnaire (a response rate of 78%). Using the Cronbach's alpha tests to assess the reliability of the questionnaire, an alpha coefficient of 0.96 was calculated. Given that a coefficient between 0.6 and 1.0 is regarded as significant, the questionnaire used can be regarded as reliable and valid.

Figures 6.3-6.7 show the histogram for each personality trait.

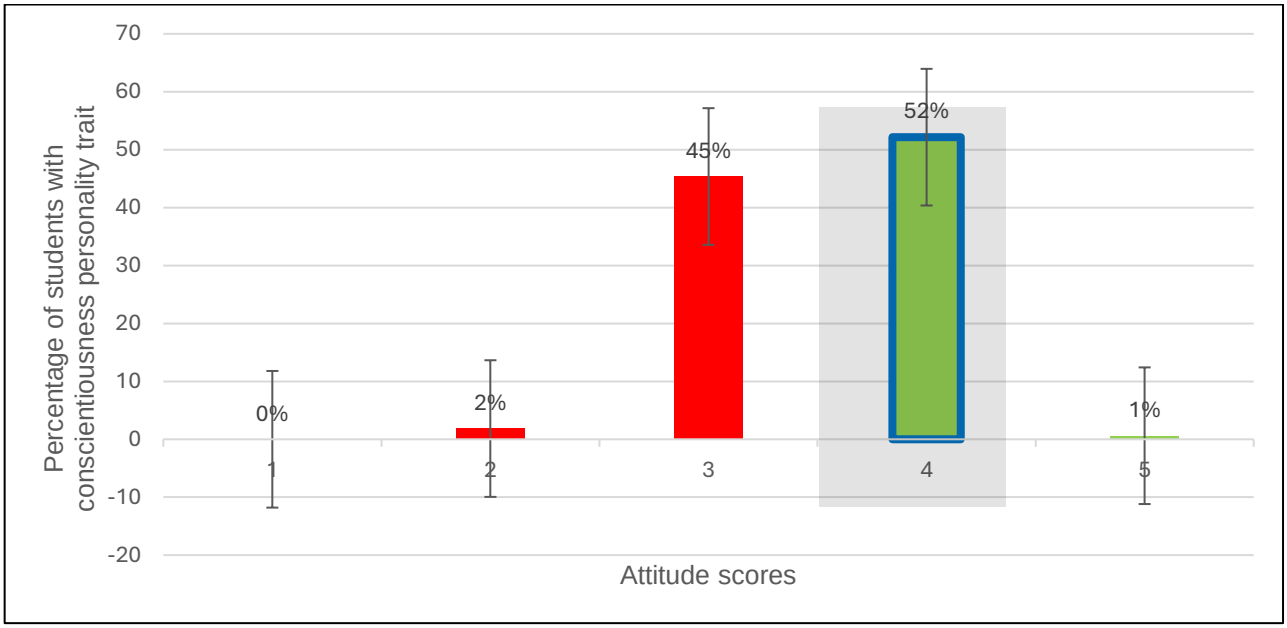


Figure 6.3: Histogram of 'C' trait' (conscientiousness) among Cardiff medical students. The histogram for 'C' trait' (conscientiousness) for the cohort of Cardiff medical students investigated shows, using a 'traffic light 'system, the attitude scale values that could be deemed most suitable (green), neutral (orange) or unsuitable (red) for a medical professional. The column that has a blue border within the grey box shows the required attitude level that was reported by the anatomists in the study by Moxham *et al*. (2018).

From the graph above, 52% of students (highlighted within the grey box) had higher levels of conscientiousness, corresponding with that deemed required by the anatomists in the study of Moxham *et al.* (2018). However, 45% of the cohort had only moderate levels of conscientiousness and 2% showed low levels.

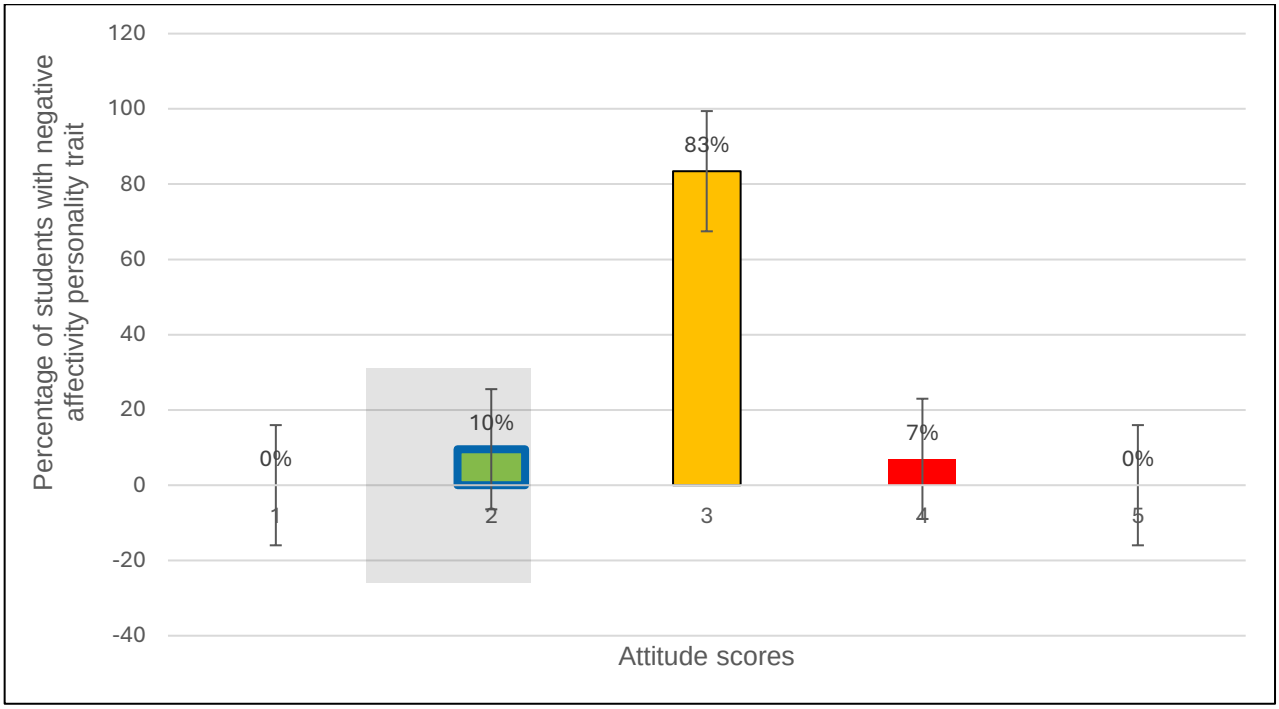


Figure 6.4: Histogram of N' trait' (Neuroticism) among Cardiff medical students. The histogram for 'N' trait' (Neuroticism) for the cohort of Cardiff medical students investigated shows, using a 'traffic light 'system, the attitude scale values that could be deemed most suitable (green), neutral (orange) or unsuitable (red) for a medical professional. The column that has a blue border within the grey box shows the required attitude level that was reported by the anatomists in the study by Moxham *et al.* (2018).

This study found that only 10% of students showed the emotional stability desired by the anatomists (highlighted within the grey box) shown in grey box), with 83% of students being neutral and 7% of students showing increased negative affectivity/neuroticism.

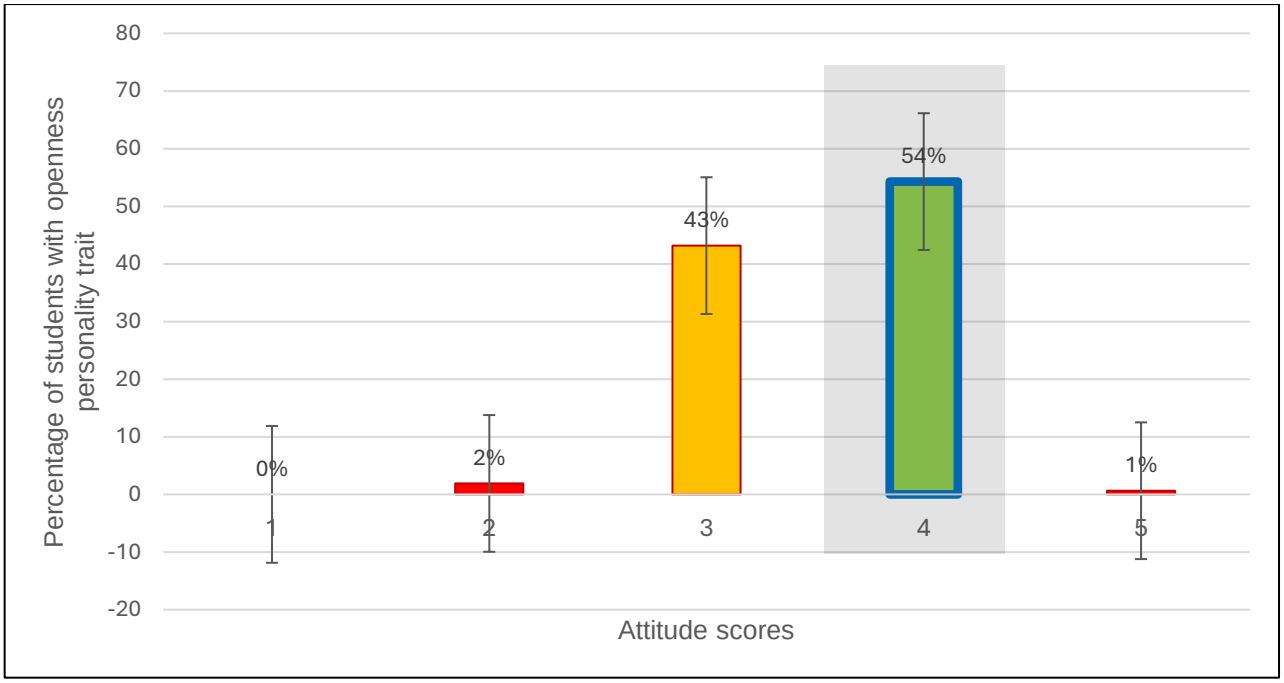


Figure 6.5: Histogram of 'O' trait' (Openness) among Cardiff medical students. The histogram for 'O' trait' (Openness) for the cohort of Cardiff medical students investigated shows, using a 'traffic light 'system, the attitude scale values that could be deemed most suitable (green), neutral (orange) or unsuitable (red) for a medical professional. The column that has a blue border within the grey box shows the required attitude level that was reported by the anatomists in the study by Moxham *et al.* (2018). In this study only 54% of medical students fitted that.

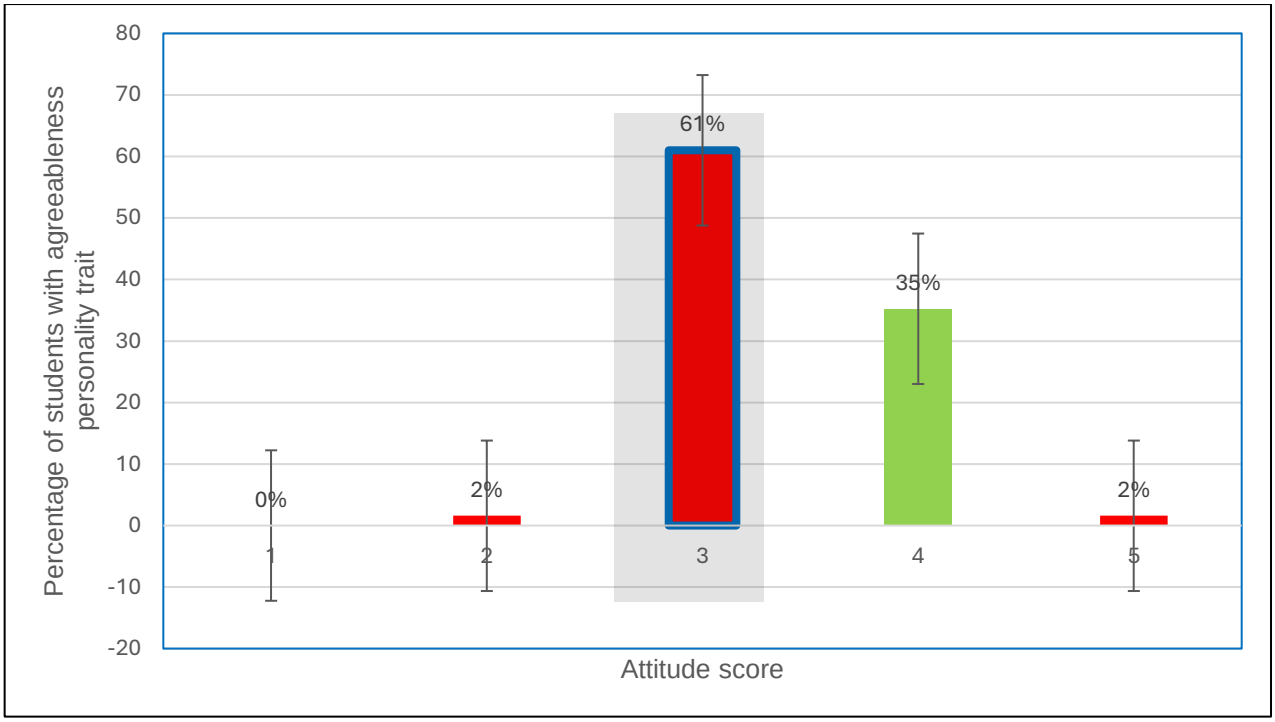


Figure 6.6: Histogram of 'A' trait' (Agreeableness) among Cardiff medical students. The histogram for 'A' trait' (Agreeableness) for the cohort of Cardiff medical students investigated shows, using a 'traffic light 'system, the attitude scale values that could be deemed most suitable (green), neutral (orange) or unsuitable (red) for a medical professional. The column that has a blue border within the grey box shows the required attitude level that was reported by the anatomists in the study by Moxham *et al.* (2018).

In line with the anatomists' views, the majority of the students in this study (61%) were neutral in terms of agreeableness with only 37% showing a positive agreeableness.

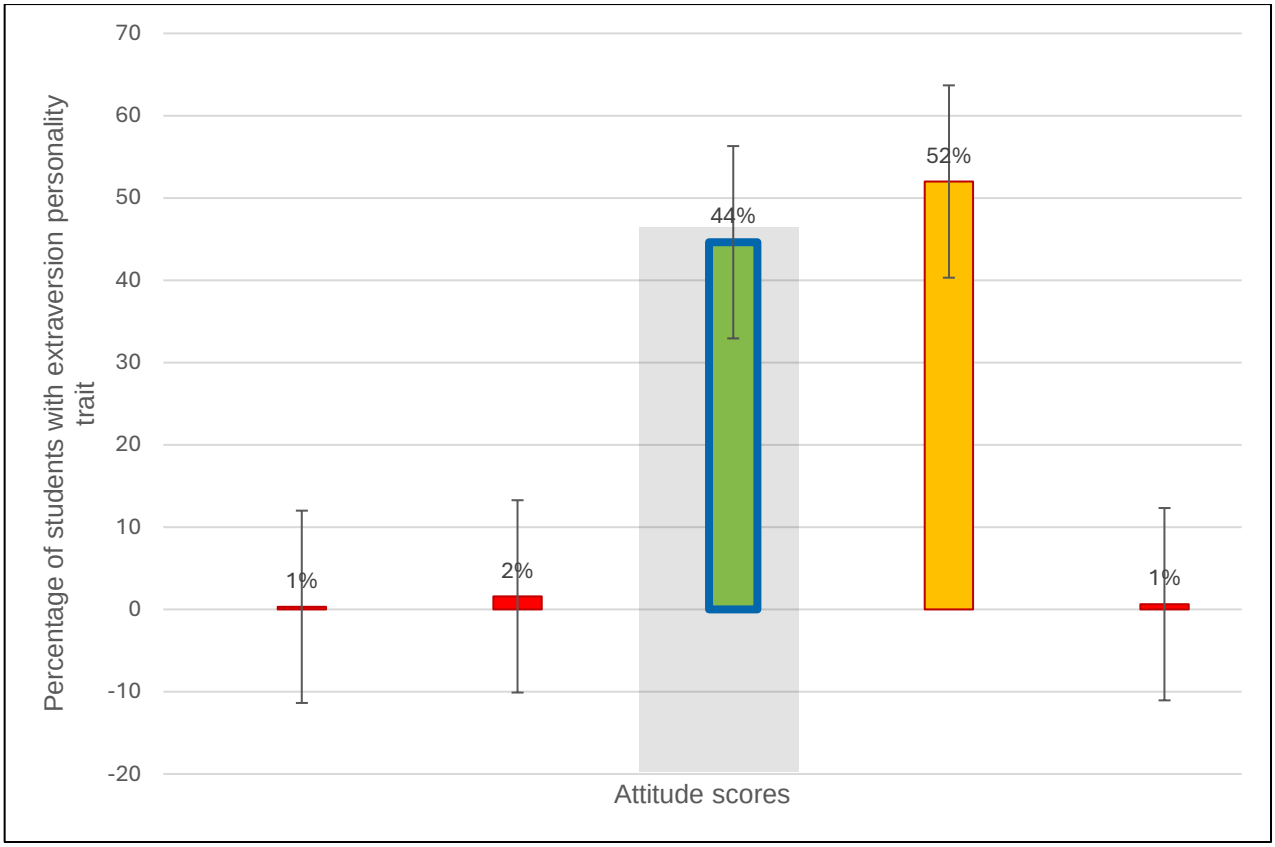


Figure 6.7: Histogram of 'E' trait' (Extraversion) among Cardiff medical students. The histogram for 'E' trait' (Extraversion) for the cohort of Cardiff medical students investigated shows, using a 'traffic light 'system, the attitude scale values that could be deemed most suitable (green), neutral (orange) or unsuitable (red) for a medical professional. The column that has a blue border within the grey box shows the required attitude level that was reported by the anatomists in the study by Moxham *et al.* (2018). In line with the requirements of medical students suggested by anatomists (Moxham *et al.,* 2018), 44% of the students in this study showed neutrality in the spectrum between introversion and extroversion.

6.3.2: The personality traits of the Cardiff medical students in comparison with French students

Comparing the Cardiff medical students with the French medical students at the Sorbonne (University of Paris, Descartes), no statistically significant differences were found for 'E' trait (extraversion), 'A' trait (agreeableness), 'C' trait (conscientiousness) and 'N' trait (negative

affectivity). Nevertheless, Cardiff medical students showed less ‘O’ trait (openness) ($p<0.04$). Compared with the French students of business studies at the University of Tour, Cardiff medical students showed no statistical differences for ‘A’ trait agreeableness, ‘C’ trait (conscientiousness) and ‘N’ trait (negative affectivity) but showed less ‘E’ trait (extraversion) and ‘O’ trait (openness) ($p<0.04$). Compared with French psychology students at the University of Tour, no statistical differences with Cardiff medical students were found for ‘E’ trait (extraversion) and ‘C’ trait (conscientiousness) but the Cardiff students showed less ‘A’ trait (agreeableness) ($p<0.04$), less ‘O’ trait (openness) ($p<0.04$) and showed ‘greater ‘N’ trait (negative affectivity) ($p<0.04$). Summary of these results are shown in Tables 6.2,6.3 and Figure 6.8.

In conclusion:

The analysis of personality traits across different student groups revealed distinct trends. French business students exhibited the highest levels of extraversion and the lowest negative affectivity, suggesting a strong social orientation and emotional stability. French psychology students were the most agreeable and conscientious, while also displaying the highest negative affectivity, indicating a combination of cooperative tendencies, discipline, and emotional sensitivity. French medical students scored the highest in openness and showed moderate agreeableness, reflecting a tendency towards intellectual curiosity and balanced social interactions. In contrast, UK medical students demonstrated the lowest openness, low agreeableness, low conscientiousness, low extraversion, and low negative affectivity, suggesting a more reserved and independent academic profile. These comparisons are further detailed in Appendix 2, Chapter 6, Documents 1, 2, and 3.

Table 6.2: Summary table showing different personality traits amongst French medical, business, psychology and Cardiff medical students that had statistical significance.

UK medical students	French medical students	French psychology students	French business students
Less 'N' trait (negative affectivity) than Psychology students Less 'A' trait (agreeableness) than Psychology students Least 'O' trait (openness) compared to other groups Less 'E' trait (extraversion)	More 'O' trait (openness) (Most open compared to other groups) More 'A' trait (agreeableness) than Psychology students Less 'N' trait (negative affectivity) than Psychology students Less C than Psychology students	More 'A' trait (agreeableness) and more 'O' trait (openness) and more 'N' trait (negative affectivity) than French medics	More 'E' trait (extraversion) and more 'O' trait (openness)

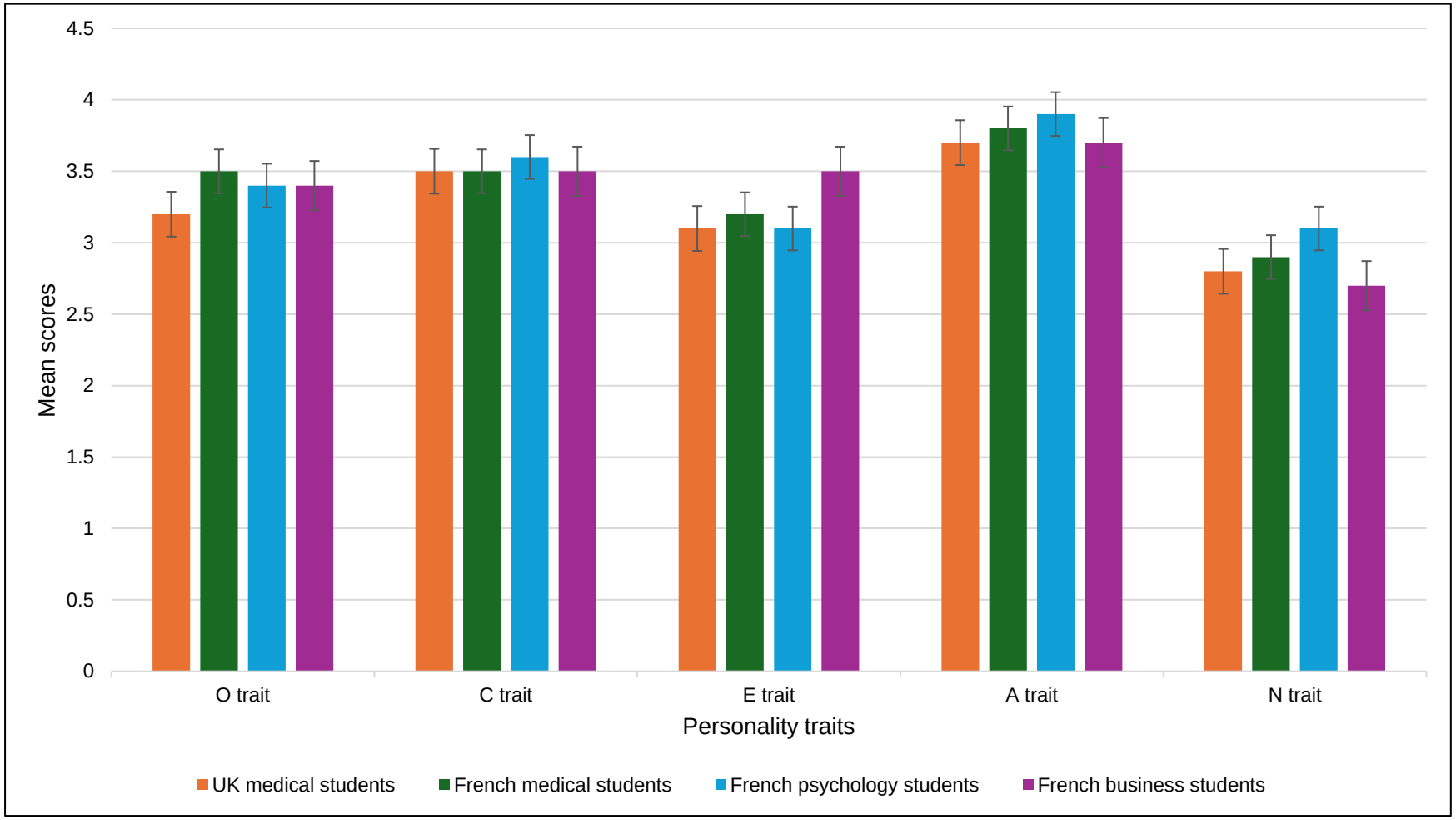


Figure 6.8: Comparative histogram of personality traits across student groups. This figure presents a comparative histogram illustrating the differences in personality traits among various groups of students, including UK medical students, French medical students, psychology students, and business students. The histogram provides a visual representation of how personality traits vary across disciplines and cultural backgrounds.

Table 6.3: Diagrammatic representation of statistical differences between UK and French student cohorts. This figure presents a diagrammatic comparison of UK and French student cohorts based on statistically significant differences in the data. A traffic light system is used to highlight positive differences (green boxes) and negative differences (red boxes). Blank grey boxes indicate that no statistically significant differences were detected.

Personality traits	UK Medical students	French Medical students	French Psychology students	French Business students
O (Openness)	Lowest level 3.2	Highest level 3.5	Greater 'O' than UK medical students 3.4	More 'O' than Psychology and UK medical students 3.4
C (Conscienti-ousness)	3.5	Less 'C' than Psychology students 3.5	More 'C' than French medical students 3.6	3.5
E (Extraversion)	3.1	3.2	3.1	Greater 'E' than all the other students 3.5
A (Agreeableness)	Less 'A' than Psychology and French Medical students 3.7	Greater 'A' than Psychology students 3.8	Less 'A' than French medics but greater 'A' than UK medical students 3.9	3.7
N (Negative affectivity)	Less 'N' than Psychology students. 2.8	Less 'N' than Psychology students 2.9	Greater 'N' than UK and French Medical students 3.1	2.7

6.3.3: Personality traits for the Fourth Year UK medical students (Cardiff cohort) in relation to examination performance

Across the whole cohort of those Fourth-Year medical students, no statical association was discerned between any of the personality domains and the results of formative or summative examinations (Appendix 3 Chapter 6, document 6). For sex differences, however, female students performed better than the males in the formative examinations (p=0.05). Furthermore, females with higher 'N' scores (Negative affectivity) had better formative marks (p=0.05) (Appendix 3 Chapter 6, document 4).

6.3.4: Student personality and linguistic skills

The merged personality and multilingualism questionnaire was distributed to 310 first year Cardiff medical students. 222 students responded to the questionnaire (response rate of 72%). The Cronbach alpha coefficient calculated was 1.02 (a coefficient between 0.65 and 1.0 showing that a questionnaire is reliable and valid). Appendix 3 Chapter 6, document 7. As the Cronbach's alpha value cannot exceed 1, an alternative split-half reliability test was conducted on the raw data, yielding a value of 0.8, which indicates high reliability. A reliability coefficient in the range of 0.7–0.8 is generally considered acceptable for most research contexts, such as surveys, educational tests, and exploratory studies. A value between 0.8–0.9 reflects high reliability, making it ideal for established and well-developed instruments.

Comparing the personalities of the UK medical students with their linguistic skills, students with prior knowledge of Greek and/or Latin (11% of the cohort) had significantly higher 'N' trait (negative affectivity). Students with no prior knowledge of Greek and/or Latin had significantly higher 'C' trait (conscientiousness) compared with the students with Greek and/or Latin. No other differences were discerned for 'E' trait (Extraversion), A trait (Agreeableness), and O trait (Openness) (Appendix 3 Chapter 6, document 8).

Statistical differences in personalities were discerned amongst the students without Greek and/or Latin. English monolingual students had significantly higher levels of ‘N’ trait (negative affectivity) than the rest of this cohort. Multilingual UK (Cardiff) medical students who were not fluent in English but with high fluency in other languages, had significantly lower ‘E’ trait (extraversion) than the rest of this cohort. Multilingual Cardiff students with high fluency in English had significantly higher levels of ‘E’ (extraversion) in comparison to the rest of the groups (Table 6.4).

The 'Big Five personality traits' have garnered increasing interest in their role in students' academic achievement (Fleeson and Gallagher, 2009). Particularly, researchers have explored their impact on secondary school students' academic success (Hayat *et al.,* 2020; Laidra, Pullmann, and Allik, 2007). Academic performance predictors extend beyond cognitive resources like general cognitive ability (Laidra *et al.,* 2007) to include non-cognitive factors, with personality being one such influential factor (MacCann *et al.,* 2019; Richardson *et al.,* 2012).

Table 6.4: This table presents a comparative analysis of personality traits among first-year medical students at Cardiff University, categorised based on their linguistic background. The data were collected using the Big Five Inventory (BFI), which assesses Openness (O), Conscientiousness (C), Extraversion (E), Agreeableness (A), and Neuroticism (N).

Groups	Comparative personality traits	
Group A - Greek/Latin tuition but no qualification (pre-GCSE) (n=12)	High N compared to C2	
Group B - Greek/Latin with tuition and GCSE qualification (n=20)	Performed better at formative and summative exams.	
Group C1 - Monolingual English with no Greek/Latin (n=21)	High N compared to all C	
Group C2 - Multilingual with high fluency in English with no Greek/Latin (n=75)	Multilingual - Higher E than AB and C combined	
Group C3- Fluent in English with moderate fluency in other languages with no Latin/Greek (n=13)		C is significantly higher in combined C than in C1
Group C4 - Not fluent in English with high fluency in other non- European languages with no Latin/Greek (n=81)	Low E than in C combined. High verbal and spatial intelligence. Performed better in anatomy exam (Spotters/formative exams)	

6.4: Discussion

Daminabo (2008) defines personality as the aggregation of characteristics distinguishing individuals and the stability of behaviour across diverse situations. Traits, as enduring dimensions of personality, differentiate people from one another (Colman, 2003; Daminabo, 2008). They represent stable characteristics across times and situations, contributing to an individual's uniqueness (Colman, 2003).

In university education, personality traits, such as conscientiousness, extraversion, and openness, can influence success (Payne, Youngcourt, and Beaubien, 2007). The 'Big Five' traits—extraversion, agreeableness, conscientiousness, negative affectivity, and openness—contribute to an individual's learning goal orientation and performance goals (Payne *et al.,* 2007).

The assessment of personality and traits involves various methods, including the Myers-Briggs personality test, Caliper profile, and personality factor questionnaire. The Big Five inventory, developed by Oliver John (1991), has become the most widely used test in psychology literature (Rimfield *et al.,* 2015; Gurven, 2013).

6.4.1: The role of conscientiousness in medical education and practice: Insights and implications

Moxham *et al*. (2018) reported on the personalities of medical students that anatomists deemed best suited for their education and training. The responding anatomists valued most highly the requirement for high levels of conscientiousness and emotional stability, followed by high levels of openness but with lower requirements for agreeableness and extraversion.

Regarding ‘C’ trait’ (conscientiousness) and referring to Figure 6.3, 52% of students had higher levels of conscientiousness, corresponding with that deemed required by the

anatomists in the study of Moxham *et al*. (2018). However, 45% of the cohort had only moderate levels of conscientiousness and 2% showed low levels. It is not possible from the current study to ascertain if the 45% or 2% performed any worse in their examinations compared to the 52% showing higher levels of conscientiousness (nor indeed whether the 1% performed any better). To ascertain any such relationship between conscientiousness and examination performance, a longitudinal or cross-sectional study that employs correlational or experimental methods could effectively examine the relationship between these variables. Furthermore, it would be instructive to investigate why 1% of the students were overly conscientiousness. In terms of competencies for the medical practice, it could be argued that lack of conscientiousness is not desirable, and neither is extreme conscientiousness because it might be associated with 'burnout' and loosing 'job satisfaction'. The effects of doctor personality traits on clinical performance have received some attention in the literature (Austin *et al.,* 2007, Hojat *et al.,* 2013, Costa *et al.,* 2014, Boerebach 2014 and Li *et al.,* 2017). The personalities of doctors need to be suited to a demanding career in medicine, and indeed might relate to careers in particular medical and surgical specialties. While being sufficiently responsive to patients, and having good communication skills, Duberstein *et al*. (2007) have reported that effective communication and treatment planning require high performing medical practitioners who are highly valued by patients to be conscientiousness and empathetic. There are many characteristics that come under conscientiousness, including dependability, self-disciplined and a preference to be planned rather than spontaneous behaviour (Roberts *et al.,* 2009). It is also perceived that high levels of conscientiousness correlate with better academic performance and students with high conscientiousness are more likely to be admitted into medical school. (Lievens *et al.,* 2009, Hakimi, Hejazi and Lavasani, 2011). Bergmann, Muth and Loerbroks, (2019) stated that high levels of conscientiousness are associated with higher stress levels during medical studies, owing to high expectations regarding academic performance. They surmised that students might spend their daytime almost exclusively on studying and prioritising academic demands above social relationships or leisure activities. The authors also conjected that, low conscientiousness may be associated with procrastination leading to postponing assessments and/or examination preparations.

Selection of medical students with high levels of conscientiousness does not mean that they will retain such levels further in their medical training or careers. Nor does it mean that even

if they retain high levels of conscientiousness, they will moderate their behaviour. Indeed, Gabbard (1985) stated in a literature review based on case studies published in the American Medical Journal (JAMA) that conscientiousness is related to an exaggerated sense of responsibility, which in turn is one aspect of compulsiveness in the personality of physicians. Thus, according to Gabbard, students' conscientiousness may partly explain subsequent compulsiveness once they are trained physicians. He hypothesised that well-modulated conscientiousness, and the wish to help protect against 'burnout syndrome', contributes towards heightened psychological resilience. Higher conscientiousness was associated with a high amount of patient contact and specialising in surgery and other internal medicine specialties. Lower conscientiousness was associated with specialising in psychiatry and hospital service specialties.

6.4.2: Emotional stability versus neuroticism in medical students: expectations and outcomes

Figure 6.4, shows that anatomists responding to the survey conducted by Moxham *et al.* (2018) required the students to show considerable emotional stability. This study found that only 10% of students showed the emotional stability desired by the anatomists, with 83% of students being neutral and 7% of students showing increased negative affectivity/neuroticism. As will be discussed later, a complicating factor in this with regards to neuroticism trait is that females with higher negative affectivity performed better in their anatomy examinations. No further information can be gleaned with respect to male peers with low negative affectivity.

Neuroticism is a common personality trait in medical professionals and it can be argued that it motivates one to work harder, maintain high standards, and achieve goals (Widiger *et al.,* 2017). The flipside is that neuroticism can make life more stressful than it needs to be and this could impact the team around them. It can be conjectured that an overly neurotic medical practitioner might cause tension and stress within a team and result in ineffective use of available resources, burnout, and poor patient outcomes. Peters and King (2012) suggested that some early warning signs of neuroticism include 'all or nothing thinking',

micromanagement of team members, failure to delegate, inability to forgive small errors, dissatisfaction with success, procrastination to avoid the possibility of making an error, and relentless striving for achievement without praising others. Studies from Germany have found that medical students with personality traits such as poor emotional stability or a high sense of dominance were associated with health problems such as anxiety and depression that ultimately could lead to early burnout and job dissatisfaction (Voltmer, Kieschke and Spahn, 2008, Chow *et al.,* 2018). Presumably high levels of neuroticism (in terms of anxiety and self-doubt) may contribute to the perception of stress and difficulties in coping with stress. Such individuals may feel unable to enjoy leisure time, because of the above-mentioned feelings of guilt. Should this view be substantiated? Then there is a clear discordance between what is desirable in terms of emotional stability of a fully trained medical practitioner and what personality characteristics are seen with students admitted to medical school. Perhaps, the requirement to perform academically well to gain admittance into medical school may favour those students who have high negative affectivity, who are competitive, and who feel the requirement to perform at the highest level.

6.4.3: Openness in medical students: Balancing ideals with professional requirements

With regards to the 'O' trait (openness) for the cohort of Cardiff medical students (Figure 6.5), contrary to the authors' expectations, the anatomists hoped for the medical students to exhibit moderate levels of openness. Indeed, in this study only 54% of medical students fitted that requirement. It could be argued that the 2% of students lacking openness do not fit in well with the medical profession where it might be expected that openness to new medical and surgical developments is a requirement. Then again, the 1% of students that are extremely ‘open’ may also not fit well with the profession as they may not be sufficiently discriminatory in their views and may be deficient in providing appropriate analysis and criticisms.

John and Srivastava (1999) have reported that individuals who are high in openness tend to be generally more creative, are more likely to pursue creative achievements, can engage in divergent thinking, and often take part in creative hobbies. Openness in general does make people less prone to mental health challenges (eg: anxiety and depression). As previously stated, ‘burn out’ may be associated with a high level of neuroticism/negative affectivity. As

it is conceivable that ‘burn out’ may be related to those who are insufficiently ‘open’, the data from the present investigation was subjected to correlation between neuroticism and openness.

Openness facilitates acceptance, flexibility and adequate adjustment to situational changes. Openness has been linked to academic ability and divergent thinking and is seen as becoming more beneficial, particularly in clinical education and in the applied settings of medicine than in academic achievement during medical education (Barrick, Mount and Judge, 2001, Hojat, Erdmann and Gonnella, 2013). Researchers use the expression “getting along” as a reflection of the “Openness to experience” personality trait, which seems to facilitate the optimal interpersonal interaction between a physician and a patient. Specialists with no clinical patient contact showed higher openness, which may refer to hospital-based or procedure-oriented specialists and/or basic applied laboratory researchers with minimal patient contact. Compared with other specialties, the job description of medical researchers, for example, may also allow and make it generally easier to show intellectual curiosity and divergent thinking, thus reflecting higher openness to experience (Soto and John, 2017). Higher openness was associated with working in the private sector, specialising in psychiatry, changing specialty, and not practising with patients. Lower openness was associated with a high amount of patient contact and specialising in general practice as well as ophthalmology and otorhinolaryngology. Low openness was associated with patient expectations, excess workload, and the specific demands of the specialty. In the present study, 55% of students showed openness at a level of 4 or 5. At this stage of their training these students might be expected to be idealistic whereas it is conceivable that later on in their training, and as they progress through their medical career, they could conceivably become more jaded and less open. Although difficult to organise, a future study might involve a longitudinal study of personality of medical students as they pass through training and careers.

6.4.4: Agreeableness in medical students: Expectations versus reality and its impact on professional dynamics

Regarding ‘A’ trait’ (agreeableness) for the cohort of Cardiff medical students (Figure 6.6), in contrast to the anticipated outcome, the anatomists did not require high levels of agreeableness as it might be expected that high levels of agreeableness are required to develop empathy in dealing with patients. In line with the anatomists’ views, the majority of the students in this study were neutral in terms of agreeableness with only 37% showing a positive agreeableness. It can also be argued that 2% on the disagreeable scale might not accord with general population’s view of the required attributes of medical practitioner. Furthermore, extreme agreeableness might not be beneficial since there might be times where it might be necessary. Although responses are inevitably speculative, it is not unreasonable to suggest that at least one of the reasons for students not showing high levels of openness might relate to the high academic requirements to medical school and a competitive attitude bread by the need at schools to achieve higher academic levels. The question however remains why anatomists did not require their medical students to be ‘’agreeable’’? Is it in the nature of the discipline?

In traditional methods of anatomy teaching, emphasis was laid on the knowledge attained. With the development of anatomical curriculum and integration of applied anatomy, more emphasis is based on additional skills such as teamwork, role play, dealing with mortality etc. Anatomists are becoming more acquainted with these moral responsibilities. It could be argued that these skills are requiring them to be less agreeable.

Agreeableness is defined as the tendency to be cooperative and not competitive. *Agreeableness* includes kindness, empathy, compassion, helpfulness, cooperativeness, sharing, and being friendly (JAMA, 2014). According to BMJ, (2002) these are “social lubricants.” Receptivity without judgment, the ability to pause, and lingering with experiences are qualities of many agreeable people. Thus, safe spaces for continued dialogue are open. People who are high in this factor do not argue or oppose criticism and premature judgment. This may be counterproductive as the individual may be pushed into taking wrong decisions by more dominating individuals within the team. As health care professionals are part of a

multi-disciplinary team, being ‘pushed over’ may be a dangerous personality trait to possess. According to JAMA (2014), higher agreeableness was associated with working in the private sector and specialising in general practice and occupational health. Lower agreeableness and neuroticism were associated with specialising in surgery.

6.4.5: Extraversion in medical students: Finding the balance for professional suitability

With regards to ‘E’ trait’ (extraversion) (Figure 6.7), in line with the requirements of medical students suggested by anatomists (Moxham *et al.,* 2018), 44% of the students in this study showed neutrality in the spectrum between introversion and extroversion. Clearly, extreme introversion and extreme extroversion might not be deemed suitable for members of medical profession in that extreme extraversion could be construed as belonging to someone who takes a flippant attitude that suggests lack of seriousness while extreme introversion might relate to timidity and lack of confidence. In this study, most students were midway along the extrovert/introvert spectrum (44%) while other students (52%) were just on the extrovert side of the spectrum. This might indicate a balanced trait that might be deemed a desirable characteristic of a medical practitioner given the demands of the medical profession.

6.4.6: Personality, learning, and outcomes in medical education

Finally, there are implications regarding learning approaches at medical school that relate to different personality traits. Zhang (2003) found that deep learning was greatest in extroverts who were also open to experience. On the other hand, strategic learning was greatest in highly conscientious individuals with low openness. Surface learning style was greater in introverts who were also low in openness (Figure 6.9). Medical practitioners having high satisfaction with their career in medicine were reported as having a deep approach, including a deep learning style when they applied for medical school. McManus, Keeling and Paice (2004) reported that satisfaction with medicine also related directly to the personality traits of high extraversion and low neuroticism. Furthermore, the deep approach to work correlated

with greater extraversion and more openness. Franco and Franco (2020) showed that agreeableness, openness, and extroversion were the most positive factors affecting students' communication abilities. Based on these statements, agreeableness, openness, and extroversion could be the basis for forming good doctor–patient relationships. In addition to empathy and clinical communication skills, emotional intelligence influenced by personality traits is another factor that can affect the doctor–patient relationship. An increased level of emotional intelligence was shown to positively influence doctor–patient relationships (Chew, Zain and Hassan 2013). In summary, personality traits, such as extroversion, openness, conscientiousness, agreeableness, and negative affectivity, play a significant role in shaping learning approaches, career satisfaction, communication abilities, and doctor–patient relationships among medical practitioners.

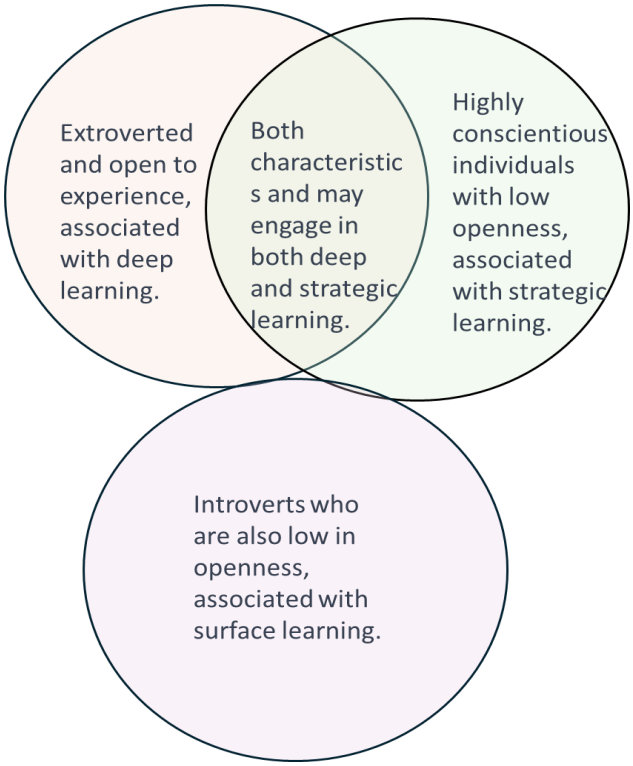


Figure 6.9: A self-drawn schematic diagram illustrating the relationships between personality traits and learning preferences. The diagram suggests that introverts are associated with surface learning and do not actively engage with deep and strategic learning. The connections in the diagram represent hypothesised tendencies rather than absolute categorizations, acknowledging that learning preferences can be influenced by various external factors, including motivation, teaching methods, and subject matter. This is my own

conclusion, based on personal observations and interpretations of existing psychological and educational theories.

Personality traits can affect medical students' lives and work. Among such, personality traits generally regarded as positive, such as conscientiousness, extroversion, openness, and agreeableness, play positive roles in the life and work of medical students. Liu *et al.* (2022) stated that students with these traits usually have better health outcomes and life performance, higher life satisfaction, better doctor–patient relationships with patients, and better academic performance than those with high levels of neuroticism. However, neuroticism is the only personality trait that positively impacts perceptions of disease risk. According to Kwon *et al.* (2016) students with high levels of agreeableness were more likely to take clinical medicine; more open students preferred surgical, emergency medicine, radiology, and laboratory medicine; and medical students who scored higher in extraversion and conscientiousness tended to choose general practice, internal medicine, obstetrics and gynaecology, paediatrics, and psychiatry. It is not unreasonable to conjecture that certain personality attributes fit with certain medical specialities. According to Milić *et al*. (2020), medical students who score higher on agreeableness and openness scales are more inclined to psychiatric specialties, while students with higher conscientiousness scores prefer anesthesiology and emergency medicine specialties. Heiligers (2012), AbouZaid *et al*. (2014) have suggested that sex significantly contributes to choice of medical specialties. From their data, they found that male medical students prefer specialties associated with technical and instrumental dexterity requirements, such as surgery. On the other hand, female students tended to focus on specialties with opportunities for relational aspects and more contact with patients.

It could be argued that personality traits can exhibit variation based on the specific situation or context. Individuals may display different facets of their personality in response to varying environments, stressors, or demands. The same individual may exhibit different facets of their personality in response to evolving life circumstances. McCrae and Costa (1994) suggested that, in the past, some researchers held the view that personality was 'fixed' during early

adulthood. Since 1994, cross-sectional and longitudinal studies of personality have forced a re-evaluation of this assumption (Mroczek and Spiro, 2003 and Srivastava, John, Gosling and, Potter, 2003). Roberts and Mroczek (2008) have shown furthermore that personality traits continue to change throughout adulthood, indeed often into old age. Such changes may be substantial and consequential. There is however a paucity of true cross-cultural longitudinal research. The field of personality development needs a greater understanding of the developmental experiences that occur during an individual's life span and life experiences, genes, and other constructs such as cognitive ability and life goals may all be important mechanisms.

In the present study I looked at the medical students at the early stages of their training and education often as they emerge from their schooling. Given that personality might change as these students progress through their training and careers, it is conceivable that, even though the students whose personality may not be considered desirable may change on being presented with the ethical requirements of the profession. Even if such students do not change their personalities, it would be hoped that they could change their behaviour. According to Bexelius *et al.* (2016), examples of clinical practitioners who are kind and considerate to patients while being less considerate to their colleagues and staff are well known.

6.4.7: Optimising personality in medical education

With such a wide spectrum of personality traits and other influencing factors—including economic status, clinical experience, family influence, and lifestyle—it is difficult to define an ideal personality profile for a medical student (Kwon and Park, 2015; Bexelius *et al*., 2016). While certain traits may appear advantageous in medical education and practice, their effects must be considered within an evidence-based framework rather than conjecture.

For instance, openness is often associated with intellectual curiosity and adaptability, which may be beneficial in medical training (Donnon *et al*., 2009; Ferguson *et al*., 2014). However, excessive openness might lead to acceptance of ideas without rigorous scientific scrutiny, potentially undermining evidence-based practice (McCrae and Costa, 1997). Similarly, conscientiousness is widely regarded as a predictor of academic success, particularly in medical education, where diligence and perseverance are required (Lievens *et al*., 2009). However, extremely high conscientiousness has been linked to maladaptive perfectionism and increased stress levels, potentially impairing clinical decision-making and adaptability (Stoeber and Otto, 2006; Doherty and Nugent, 2011).

In terms of extraversion, research suggests a balance is preferable, as both extreme introversion and extreme extraversion can impact patient interactions and professional perception (Borges *et al*., 2010). Agreeableness is generally associated with empathy and positive patient interactions, but excessive agreeableness may lead to difficulty in setting professional boundaries or challenging patient misconceptions, potentially affecting clinical judgment (Magalhães *et al*., 2012). Similarly, while a neutral position on neuroticism (or negative affectivity) is often assumed desirable, some studies suggest that mild neuroticism may enhance sensitivity to patient anxieties, fostering greater empathy (Hojat *et al.,* 2015). However, excessive neuroticism is linked to burnout and emotional exhaustion among medical students (Dyrbye *et al.,* 2006).

While these considerations provide a theoretical basis for understanding personality traits in medical education, further empirical research is needed to determine the optimal personality profile for medical professionals, particularly in different cultural and clinical contexts (Lievens and Sackett, 2012). Any claims regarding the "ideal" traits of a medical student should be grounded in robust longitudinal studies rather than speculation.

It is of course not possible to admit students to medical school on the basis of wishing for them to have the perfect personality profile. It might however be good practise to have some formal assessments of a medical student’s personality during the early stages of their medical education. Such information would enable a personal tutor (or equivalent professional) to advise the student as to those elements of their personality that are favourable to their clinical practise and those elements which they should be aware of that are less advantageous. Armed with such information the student might consider ameliorating those disadvantageous

elements through appropriate behaviour. It is not known whether such consultations currently exist in medical schools.

6.4.7.1: Critical analysis of personality trait data

The personality trait data collected in this study were critically compared to normative data from the general population. The results indicate that medical students largely exhibit moderate scores across all measured traits, aligning closely with population norms. This lack of variability raises questions about the utility of personality testing as a discriminative tool within a relatively homogeneous group. It also highlights potential limitations of the assessment instrument, including insufficient sensitivity or the influence of social desirability bias (De Vries and Born, 2013; McCrae and Costa, 2004). While personality assessments provide insights into general tendencies, their standalone use for differentiating individuals or predicting academic or professional outcomes may be limited (John and Srivastava, 1999; Furnham, 2008). Future studies should consider integrating multi-dimensional assessments, such as combining personality tests with cognitive or emotional intelligence measures, to provide a more comprehensive evaluation (Nunnally and Bernstein, 1994).

6.4.8: Comparative analysis of personality traits: Cardiff medical students versus. French students in diverse disciplines

6.4.8.1: Why do Cardiff participants have lower ‘A’ trait (agreeableness), ‘O’ trait (openness) ‘E’ trait (extraversion) and lower ‘N’ trait (negative affectivity) compared with French medical, psychology and business students?

In a mean value scale of 1 to 5, Cardiff participants on average scored 3.7 for ‘A’ trait (agreeableness) compared with a range (French 3.7-3.9). Although numerically this appears to be just a small difference, it is nevertheless statistically different and could be discerned as being disappointing should empathy be regarded as an essential characteristic of a

medical practitioner. Of course, a score of 3.7 on a scale of 1 to 5 demonstrates that the UK medical students are empathetic, but the surprising result is that they are less empathetic than the French psychology students. Medical training is inclined towards intellectual problem solving in order to come to the correct diagnosis and treatment planning. Teamwork influencing others and being empathetic to patients and their relatives requires 'agreeableness'. Consequently, achieving competence in clinical skills like trust, empathy, and cooperation may be enhanced by incorporating specific, evidence-based methods of interaction (e.g. agenda setting, conflict resolution, negotiation, and alliance making) into clinical education. Although there is no evidence in the literature to compare 'agreeableness' for medical students with the general population, a study by Chibnall (2009) concluded that, in the United States of America, medical students were less agreeable than other professionals, such as police officers.

The present investigation found that, compared to French psychology students, medical students at Cardiff University had less 'A' trait '(agreeableness)' (mean of 3.7 compared to 3.9) and slightly lower N' trait (negative affectivity) (mean of 2.8 compared to 3.1). Study by Plaisant *et al*, 2014 compared personality traits between the French psychology students and French medical students. It was also found that French medical students were less 'agreeable' and had lower 'negative affectivity' with additionally lower 'conscientiousness'. That both Cardiff and Paris medical students similarly differed from the psychology students might be associated with 'competitive drivers' amongst medical students and could reflect either the way in which the students are admitted to medical schools or to the nature of the training they receive. John (2009) reported that highly agreeable persons are trusting, straightforward, altruistic, cooperative, modest, and empathic, traits that appear to define (or at least facilitate) many of the clinical competencies. According to Moxham *et al.* (2018) anatomist in Europe and America did not require a high level of agreeableness for their medical students. This finding begs the question - Is it essential to have a high 'A' trait '(agreeableness)' to be a successful medical professional? According to Mullolah (2018), personality traits define the career path or specialisation that students choose. For example, medical students who preferred psychiatry as a specialty showed the highest score on agreeableness and openness. Borges (2002) reported that students who preferred to specialise in family medicine, public health and anaesthesiology were less extravert. Although there is presently no evidence to assess patient's reactions to medical practitioner

in terms on their degree of extraversion or introversion, it is not unreasonable to speculate that extremes along the spectrum of this personality trait would be undesirable. Furthermore, it would also not be unreasonable to suggest that a practitioner on the lower side of agreeableness would not appeal to patients. It is surprising that there is little evidence in the literature to assess what characteristics of the medical practitioner appeal to the general public and it could be argued that provided the practitioner, regardless of their personality or behaviour (not on the extremes), provides correct diagnosis and treatment plans then the practitioner would be regarded as competent and therefore satisfactory.

McCrae and colleagues (1989) reported that medical students with increased levels of openness preferred medical departments as opposed to surgical specialties, while those with overexpression of agreeability tended to choose clinical medicine as opposed to research. This may possibly be because of more patient contact and the interactive nature of the medical specialties compared to surgical departments. Moreover, the same study pointed out that students with increased levels of openness reported satisfaction and personal interest as the most important factors in choosing their specialty, while those with higher levels of conscientiousness stated that personal interest mostly guided their choices. Would Cardiff medical students having had low ‘E’ trait (extraversion)’ and ‘O’ trait‘ (openness)’ end up choosing a speciality with reduced job satisfaction resulting in faster burnout rates?

In a mean value scale of 1-5, Cardiff medical students scored an average of 3.2 for ‘O’ trait (openness). While they scored a mean of 3.1 for ‘E’ trait (extraversion). Again, there is no literature evidence to study and compare extraversion and openness within the general population.

Medical students at Cardiff University had lower ‘E’ trait (extraversion)’ (mean of 3.10) and ‘O’ trait ‘(openness)’ (mean of 3.20) when compared to French business students (mean of 3.51 and 3.48 respectively). Business students tend to have high extroversion, openness, and conscientiousness and these traits have a strong impact on entrepreneurial intentions (Liang *et al.,* 2015). Moreover, business students need to be creative. Personality traits such as conscientiousness, extraversion, and agreeableness positively and significantly impact creativity. Students with high openness are more creative (Karwowski and Lebuda 2016). Creativity has been found to be highly correlated with entrepreneurial intentions as highly

creative individuals can maintain a positive attitude and confidence in entrepreneurship (Entrialgo and Iglesias 2020). Suciu, (2021) reported that those medical students who displayed high 'E' trait (extraversion)' showed a positive corelation with 'O' trait (openness) but no with 'A' trait (agreeableness). Indeed, the 'A' trait was found to be negatively influenced by the 'E' trait (extraversion)'.

Cardiff medical students had the lower 'N' trait (negative affectivity) (mean of 2.88) compared to French psychology students (mean of 3.14). Although there is no data to substantial comparisons between medical and psychology students, relations between negative affectivity and its various forms such as anxiety is well documents amongst medical students around the world. Anxiety can be precipitated in situations such as when self-set lofty goals by these ambitious medical students are not met. Other factors like academic workload (Guthrie *et al*, 2005), consequent sleep deprivation (Wolf *et al,* 1988], financial burden and exposure to deaths of patients (Williams *et al,* 2005) have also been postulated to be possible reasons for medical students' high rate of anxiety and negative affectivity.

Studies have shown that satisfaction with academic achievements was found to have a substantial bearing on depression, anxiety, stress, and psychological well-being. Neuroticism is relatively common with undergraduate students due to their lower age compared to postgraduate students. Postgraduate students tend to deal better with anxiety and stress as increased age has a positive correlation with psychological well-being (Bayram and Bilgel, 2008). As the mean age of Cardiff medical students were between 18-21 years, it might play a role in this negative trait. However, Komarraju , (2009) conducted a study on 308 undergraduate students and reported a positive relationship between neuroticism and academic achievement. They concluded students enthusiastic to have high performance, might feel some level of achievement anxiety, which will motivate them to study. Similarly, Bratko, (2006) had previously posited existence of some level of anxiety and perfectionism in neurotic people might induce higher preparedness and thus academic performance in students, especially when they are not motivated.

Bidjerano and Yun Dai (2007) also reported the positive association between the neuroticism and extrinsic motivation and concluded that neurotic students in order to cope up with their anxiety related to failure intensify their efforts to prevent it. This is noticed in the formative

test results wherein, female students with higher ‘N’ trait (negative affectivity) performed better in the formative anatomy examinations.

Notwithstanding these benefits of some levels of neuroticism that can serve as a motivator in the competitive medical school environment, one cannot forget its evident drawbacks. Its negative effect as a strong predictor of stress and burnout among medical students and doctors is well-known (Yusoff, 2013, Mcmanus, 2004, Deary, 1996). In addition, a prevalence of poorer mental health has been shown among medical students when compared with other populations of the same age (Rotenstein , 2016). It is also important to highlight that a successful medical student won’t be necessarily a competent or a healthy/happy doctor (Patterson , 2016 and Smith, 2001). In some way, the fear of failure or of causing a bad impression can enhance medical academic achievement.

6.4.8.2: Why do students with prior knowledge of Greek and/or Latin have high ‘N’ trait (negative affectivity)?

From the earlier study in this thesis, the students with previous knowledge of Greek/Latin performed slightly better in anatomy examinations. This could be explained either by them having a better way of understanding anatomical/medical terminologies compared to their peers or it could be that these students with knowledge of Greek/Latin are more involved in their studies.

6.4.8.3: Why do multilingual students (not fluent in English but fluent in other languages) have low ‘E’ trait (extraversion)?

Medical education utilises a wide array of educational contexts, ranging from didactic lectures and small group teaching/discussions in the preclinical years to teamwork and one-on-one precepting in the clinical years. It could be argued that students with low ‘E’ trait might find certain teaching settings more challenging than students with higher ‘E’ trait. For example, As suggested by Wallace, (2013), teaching approaches that might be most challenging

include group discussions with more than a few learners, settings where forming quick relationships with team members is expected, and settings where ideas need to be offered quickly or assertively. The multilingual students who were fluent in non-European languages and had low 'E' trait (extraversion) were the international student community. According to El-Dib (2004), these international students, either because of their cultural or religious beliefs, may prefer to be identified as introverts as they represent a conservative society with strict religious beliefs. El-Dib also postulated that, in such a conservative society, females might not have the opportunities as much as males to socialise. One can hypothesise that their social networks are more related to their ethnic groups while the group fluent in English have greater networking as English is the *lingua franca*.

6.4.8.4: Why do monolingual students have higher 'N' trait (negative affectivity) compared to multilingual students?

While some multilingual students may have become so by diligent study, many become multilingual because the circumstances of their family, place of birth, or immigration history required that they acquired more than one language. In psychological terms, Ben-Zeev (1977), Bialystok (1986), Bialystok (1988) and Mezzacappa (2004) have reported that multilingual persons are good at multi-tasking, have a higher ability to solve linguistic problems and have high levels of concentration compared to monolinguals. They also reported that these qualities might help multilinguals socialise better and therefore it can be postulated that monolingual students tend to be more nervous and introverted in social setting. It could be further postulated that monolinguals might openly display linguistic insecurity and self-deprecation while in a social settings. Thus, it might be proposed that on the basis of these findings that monolingual medical students would have greater negative affectivity as they might be less adept in social settings.

6.4.8.5: Why do female medical students perform better at examinations?

Lievens *et al* (2002) reported that personality traits influence medical students' examination performance such that medical students with high extraversion and agreeableness score better academically. On the other hand, Furnham, Zhang, and Chamoro (2006) and Hakimi, (2011), found that extroverted people were more likely to be impetuous, impulsive at problem solving, talkative, distracted and externally motivated, and more prone to lower academic achievement. They claimed that students' interpersonal and intrapersonal skills accounted for this negative relationship; highly extroverted students being more likely to spend time on social and extra-curricular activities in comparison to introverted students. In the present study no clear relationship between examination performance and any personality traits. As an exception however, female students particularly with evidence of negative affectivity were seen to perform better in the anatomy component of their examination ($p=0.02$ for female and $p=0.08$ for males) ($p = 0.02$ for female students indicates a statistically significant difference ($P < 0.05$) and $p = 0.08$ for male students is not statistically significant, as it exceeds the conventional $P < 0.05$ threshold).

According to Jacobs (2002), Duckworth and Seligman (2006), Niederle and Vesterlund (2007) and Lundberg (2018), female students perform better in examinations than their male counterparts. Females were found to have more self-discipline, have fewer behavioural problems, be less overconfident, and show more developed attitudes towards learning. Females also consistently had higher levels of agreeableness and neuroticism and have an advantage in the neurocognitive ability of planning. Planning includes actions and thoughts for successful task completion, such as self-monitoring, self-correction, and verification of completion. Fear of failure may help them prepare for the examination better thus attaining better grades. Komarraju (2009) conducted a study on 308 undergraduate medical students and reported a positive relationship between neuroticism and academic achievement. They concluded students who were enthusiastic and who had obtained high performance scores felt some level of achievement anxiety, which motivated them to study. Furthermore, Bratko (2006) had previously posited existence of some level of anxiety and perfectionism in neurotic people might induce higher preparedness and thus academic performance in students, especially when they are motivated. Bidjerano and Yun Dai (2007) also reported that, in order to cope up with their anxiety related to failure, there is a positive association between the neuroticism and extrinsic motivation.

6.5: Conclusions

From this study, and using the BFI scales of 1-5, it can be concluded that Cardiff medical students are essentially ‘’neutral’’ for all personality traits (average values ranging from 2.8 for ‘N’ trait (negative affectivity) to 3.1 for ‘E’ trait (extraversion), 3.2 for ‘O’ trait (openness), 3.5 for ‘C’ trait (conscientiousness) and 3.7 for ‘A’ trait (agreeableness)). There is a similar personality profile for the French medical students, although statistically the Cardiff students show less ‘A’ trait (agreeableness), ‘O’ trait (openness) and ‘E’ trait (extraversion). As mentioned in the discussion there is little available evidence indicating how these personality traits at the early stages of medical school training subsequently change or how they affect clinical competence and career choices. Studies by Ammi *et al*. (2023) suggest that high scores for ‘C’ trait (conscientiousness) and ‘A’ trait (agreeableness) are related to doctors who show ‘’good and stable’’ mental health. In terms of the Cardiff medical students only 37% had high A, 52% had high C with just 30% having both high A plus high C. Thus, the students do not display the characteristics displayed by Ammi *et al.* (2023) that lead to ‘’good and stable’’ mental health. It will be instructive to ascertain whether those students who drop out from their medical course or those medical practitioners who abandon their careers lack the profiles described by Ammi *et al.* (2023). Moreover, if students personality were assessed while entering medical school, a case could be made for monitoring and/or advising those whose profiles may give rise to concern.

The willingness to help others is an important component of agreeableness and, according to a literature review within the British Medical Journal (2002), conscientiousness and good motivation to help their patients heighten psychological resilience and protect against burnout syndrome. It was further reported that individuals with high ‘O’ trait (openness) makes them creative, adaptable to new perspectives, and intellectually curious (to name just a few aspects), although only 37% of the Cardiff medical students scored 4 or 5 on the openness scale. The BMJ review also suggested that flexible mindsets, rather than mental rigidity, characterise the dimensions of openness and that having a combined low score for A’ trait (agreeableness), ‘O’ trait (openness) and ‘E’ trait (extraversion) may hinder the development of successful medical professionals. On the scales of 1-3, 14% of the Cardiff medical student cohort had low A plus O plus E. Whether these negative attributes predispose those medical

students to burnout and lack of interest in their work is presently unknowable. Personality assessment can aid the formulation of strategies for the best development of academic and clinical competencies, inform the process of selecting medical students, and could be beneficial for assessing whether certain personality traits best suit particular career options (such as surgery or medicine) (John and Srivastava, 1999; John , 2008, Plaisant , 2014). With such high stakes and given the critical workforce crisis in the UK's NHS, it is important to admit to medical school those students with ''suitable'' personality traits that predispose to future stable and satisfying career prospects. This might be aided by the introduction of personality assessments during interviews for medical school admissions.

In terms of the relationship between personality and linguistic skills and examination performance, that students with a previous education in Greek/and or Latin performed better at anatomy examinations (see Chapter 2) could be related to their having a significantly higher 'N' trait (negative affectivity), assuming if the view that such students are more anxious about their performance and more fearful of failure. This view could be contradicted by the fact that students monolingual in English and with no Greek/and or Latin experience prior to university also had significant 'N' trait (negative affectivity). Moreover, the other group of students that performed better at examinations were those who, although multilingual, were not highly proficient in English (international student cohort). For these students, 'N' trait (negative affectivity), 'C' trait (conscientiousness) and 'E' trait (extraversion) were not significantly different from the other students. It is more likely therefore that the higher examination performance for those students with Greek/and or Latin relates to their prior knowledge of Greek/and or Latin and not to their personality.

6.6: Limitations and future research

The main limitation of the study was that investigation of personality traits for medical (both UK and France), psychological, and business studies students was undertaken that was not longitudinal and therefore did not involve following students beyond their first year of study. Furthermore, this is a 'snapshot' of these first-year students and, as personality may change with time (Allemand *et al*, 2007 and Allemand *et al*, 2013), a longitudinal study may provide

data about the influence of personality on clinical performance, including well-being of medical personal and job satisfaction. Such information may influence the way patients are considered and treated.

It is also recommended that comparative studies across other countries over different continents be undertaken to understand the different cultural and traditional aspects that might influence personality development. Such studies will also potentially aid understanding worldwide of the admissions process to the medical curriculum. On the basis that the data presented here for UK and French medical students suggests personalities that reflect competitiveness, a more global approach might provide insights into different student's levels of competitiveness and ambitions. Moreover, it would be instructed to compare personalities of members of the medical profession as they choose their different career pathways.

The study of assessing medical student's personality with performance in anatomy assessments needs further investigations, particularly where comparisons can be made between anatomy examinations that are independent to those, as in the present study, that are integrated with a variety of other subjects.

In terms of relating personalities to linguistic skills, the present study concentrates on the extent to which the students are multilingual or monolingual. Future work might evolve students performing linguistic tests (perhaps also spatial test) together with personality assessments.

Despite these limitations, present study sets a benchmark upon which further work can be undertaken. Indeed, given the importance of how medical students, medical trainees and medical practitioners in advanced stages of their careers behave and display their attitudes towards patients it is remarkable that so few studies are available that involve personality assessment.

Chapter 7

Discussion

This thesis brings together studies involving first, second and final year medical students at Cardiff University. 940 students from the cohorts of academic years 2014-15 and 2018-19, were active participants in this study. Initially, investigations involved assessing the possibility that some knowledge of Greek and Latin classical languages improves understanding of human anatomy. I also investigated whether first-year medical students believed that knowledge of these classical languages was important for comprehending anatomical terminology. Subsequently, the relationship between examination performance, multilingualism, and verbal and spatial intelligence was assessed. Furthermore, by tracking the same cohort insights into the impact of non-cognitive factors, such as personality, on anatomy examinations was gained. To broaden the perspective, and to assess behaviour between students having diverse backgrounds, a comparative study was undertaken involving students from various disciplines (business studies, psychology, and medicine) enrolled at the Sorbonne (University of Paris, Descartes), the University of Tour (France) and at Cardiff Medical School.

This study offers the possibility of exploring the correlation between linguistic skills, personality, and examination performance, and emphasizes the need for more research into these relationships due to the challenge of a lack of existing literature for comparisons. The absence of related research however might provide an opportunity to set a benchmark for future studies. It is to be hoped that these investigations will encourage further research in this area, although problems may ensue because of the challenges inherent in contextualising findings and aligning methodologies.

7.1: Summary of research findings and mind map

The research analysed the relationships between linguistic proficiency, personality traits, cognitive abilities, and academic performance in medical students. It found that final-year students held negative attitudes towards classical Greek and Latin, whereas first-year students were more receptive. Despite attitudes, students with prior knowledge of these languages performed significantly better in anatomical examinations. Multilingual students exhibited higher spatial and verbal intelligence compared to monolinguals, but this advantage did not translate into higher anatomy examination scores. Female medical students performed better in verbal intelligence tasks but showed no significant advantage in spatial intelligence, and those with high negative affectivity excelled in formative anatomy

examinations. A direct correlation was observed between high spatial intelligence and better formative exam performance, whereas students with low spatial intelligence struggled with anatomy assessments requiring spatial reasoning. Personality traits also played a role, with multilingual medical students fluent in English exhibiting higher extraversion, while those with weaker English skills had lower extraversion. Monolingual students displayed higher negative affectivity compared to multilingual peers, and Cardiff medical students demonstrated lower openness compared to their French counterparts. Disciplinary differences were also noted, with business students expected to have lower openness, extraversion, and agreeableness, yet they exhibited the highest extraversion and openness compared to psychology and medical students. Medical students, in contrast, displayed higher conscientiousness but lower openness. These findings underline the complex factors influencing medical education outcomes, suggesting that linguistic background, cognitive abilities, and personality traits should be considered in medical admissions and curriculum development to enhance student learning and performance.

Table 7.1: Summary of hypotheses tested and their consistency with results. This table presents a summary of hypotheses tested throughout the thesis and indicates whether the results were consistent or inconsistent with each hypothesis. The table provides an overview of key research questions related to linguistic proficiency, cognitive abilities, personality traits, and academic performance in medical students.

Chapters	Hypothesis tested	Results	Conclusion Consistent/inconsistent
Chapter 3	Students throughout the medical curriculum have a negative attitude toward the importance of classical Greek and Latin	This hypothesis was backed by the final-year students but not agreed upon by the first-Year medical students.	Inconsistent
Chapter 4	Regardless of attitude, students in the early years of medical education perform better at both formative and summative anatomical examinations if they have prior knowledge of Greek and Latin.	Students with prior knowledge of Greek and Latin performed better in both formative and summative anatomical examinations	Consistent
Chapter 5	Medical students who are multilinguistic have higher spatial and verbal intelligence.	Students who are monolingual (fluent in English only) show less verbal and spatial intelligence compared to the multilingual groups.	Consistent
	There are sex differences in spatial and verbal intelligence, female medical students perform better verbally but not spatially	No significance	Inconsistent

	Medical students who are multilingual have higher spatial and verbal intelligence; they perform better at anatomy examinations.	Students who had fluency in English and non-European languages showed higher spatial and verbal intelligence than all other groups. However, there was no substantial improvement in their anatomy examination marks	Inconsistent
	Students with low spatial intelligence perform poorly at anatomy examinations	Students with spatial intelligence scores less than 4 performed poorer in the formative examinations that required spatial abilities. Higher spatial intelligence, better formative exam results. No impact of verbal intelligence on examination performance.	Consistent
Chapter 6	No personality differences would be discerned between French and UK medical students.	Comparing the Cardiff medical students with the French medical students, Cardiff medical students showed less Openness ‘O’ trait.	Inconsistent
	The expectation is that the business students will have lower ‘O’ trait (openness), ‘E’ trait (extraversion), and ‘A’ trait (agreeableness) but higher ‘C’ trait (conscientiousness).	Business students had the same levels of Conscientiousness ‘C’ trait as medical students.	Inconsistent
	The expectation is that the business students will have lower ‘E’ trait (extraversion)	Business students had the highest Extraversion ‘E’ trait.	Inconsistent

	The expectation is that the business students will have a lower ‘O’ trait (openness).	Business students were more open-minded than psychology students that are more open-minded than UK Medic.	Inconsistent
	Students with prior knowledge of Greek and/or Latin have a lower ‘E’ trait (extraversion).	No differences were discerned for Extraversion ‘E’ trait.	Inconsistent
	Students with prior knowledge of Greek and/or Latin have a higher level ‘C’ trait (conscientiousness) and higher ‘N’ trait (negative affectivity)	Students with prior knowledge of Greek and/or Latin have a higher level ‘C’ trait (conscientiousness) and higher Negative Affectivity ‘N’ trait.	Consistent
	Multilingual students will have a high ‘E’ trait (extraversion) compared to monolingual students.	Multilingual UK medical students who were not fluent in English but with high fluency in other languages, had significantly lower Extraversion ‘E’ traits than the rest of this cohort. Multilingual Cardiff students with high fluency in English had significantly higher levels of Extraversion ‘E’ trait in comparison to the rest of the groups	Partly consistent
	Multilingual students will have a high ‘A’ trait (agreeableness) compared to monolingual students.	No	Inconsistent

	Monolingual students will have a higher ‘N’ trait (negative affectivity).	English monolingual students had significantly higher levels of Negative affectivity ‘N’ trait than the rest of this cohort.	Consistent
	Female students perform better in anatomy examinations	Female students with high Negative affectivity ‘N’ trait performed better in formative examinations	Consistent

To help navigate the findings and understand the recommendations, I have put together a series of mind maps. These are shown below in Figures 7.1-7.3. Below is a brief narrative for each of the mindmaps.

Chapters 3 and 4 found that prior knowledge of Greek and Latin significantly improved anatomy exam performance, with first-year students valuing these languages more than final-year students, who were more sceptical about their relevance. This shift in attitude suggests that early exposure to classical languages may be beneficial, but reinforcement throughout medical education is necessary to sustain appreciation. The study also found that multilingual students showed higher spatial and verbal intelligence, though this did not directly enhance anatomy scores. Female students excelled in verbal tasks, while spatial intelligence was a key predictor of anatomy performance. To improve student engagement with classical Greek and Latin in medical education, early integration of classical terminology should be implemented, reinforcing its relevance in anatomy learning. Interactive methods, such as etymology-based workshops and digital tools, can enhance interest and retention. Educators should highlight the practical benefits of classical language knowledge in understanding medical terminology and improving exam performance. Aligning classical components within anatomy courses and providing longitudinal reinforcement throughout the curriculum will ensure sustained appreciation and effective application in medical training. This is shown in figure 7.1.

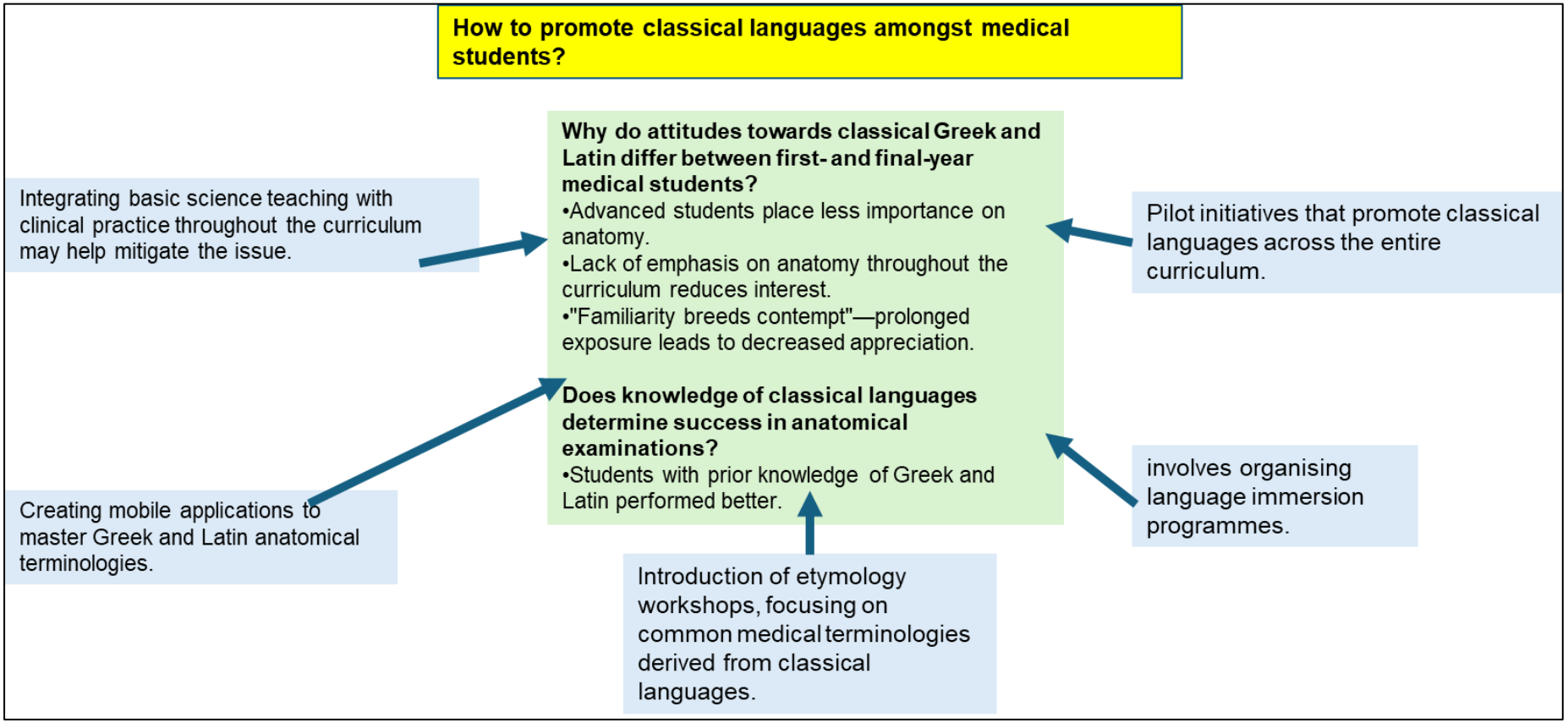


Figure 7.1: Mind map of key findings and recommendations from Chapters 3 and 4. The visual structure illustrates the interconnections between various factors, such as attitudes towards classical languages, prior knowledge, and examination performance, along with their implications for medical education. Green boxes represent key findings, while blue boxes represent recommendations.

Chapter 5 found that multilingual medical students exhibited higher spatial and verbal intelligence than their monolingual peers, particularly those fluent in both English and non-European languages, though this cognitive advantage did not translate into significantly higher anatomy examination scores. While female students performed better in verbal intelligence tasks, no significant sex differences were observed in spatial intelligence. Additionally, students with low spatial intelligence (scores below 4) struggled with formative anatomy examinations requiring spatial reasoning, whereas those with higher spatial intelligence performed better. Verbal intelligence had no impact on anatomy performance. Encouraging multilingualism through structured language-learning initiatives, such as language courses accessible to all students and summer language programmes, can enhance cognitive flexibility and communication skills. Medical schools should also promote the learning of additional languages, particularly those relevant to international medical practice, to foster linguistic proficiency and improve patient interactions. These are shown in figure 7.2.

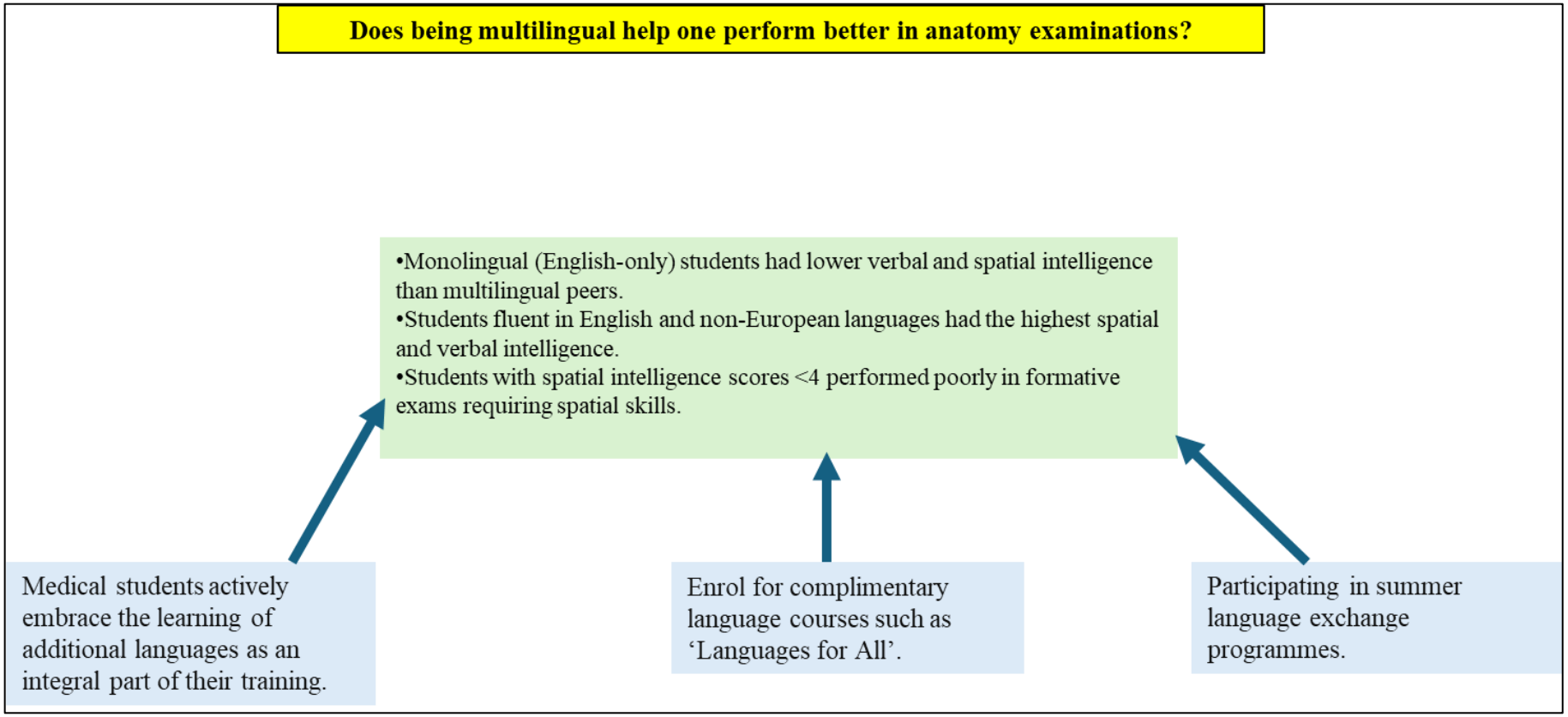


Figure 7.2: Mind map of key findings and recommendations from Chapter 5. This figure illustrates a mind map encapsulating the key findings and recommendations from Chapter 5. The visual representation highlights the interconnections between linguistic skills, verbal intelligence, and spatial intelligence, as well as their relationship with personality traits and academic performance. Green boxes indicate key findings, while blue boxes indicate recommendations. This structured overview provides insights into the implications of these cognitive factors for medical education.

Chapter 6 concluded that Cardiff medical students showed lower openness than their French counterparts. Business students had the highest extraversion and greater openness than psychology and UK medical students, despite similar conscientiousness to

medical students. Students with prior knowledge of Greek and Latin had higher conscientiousness and negative affectivity, while multilingual students fluent in English exhibited higher extraversion. Monolingual English-speaking students had the highest negative affectivity. Female students with high negative affectivity performed better in formative anatomy exams. Recommendations include integrating personality assessments in medical admissions, medical humanities projects to foster critical thinking, and networking events to improve adaptability and collaboration. Compulsory philosophy education in schools can enhance reasoning and openness, while resilience training and structured learning support should be provided for students with high negative affectivity and conscientiousness. These initiatives will help develop well-rounded, adaptable medical professionals. This is shown in figure 7.3.

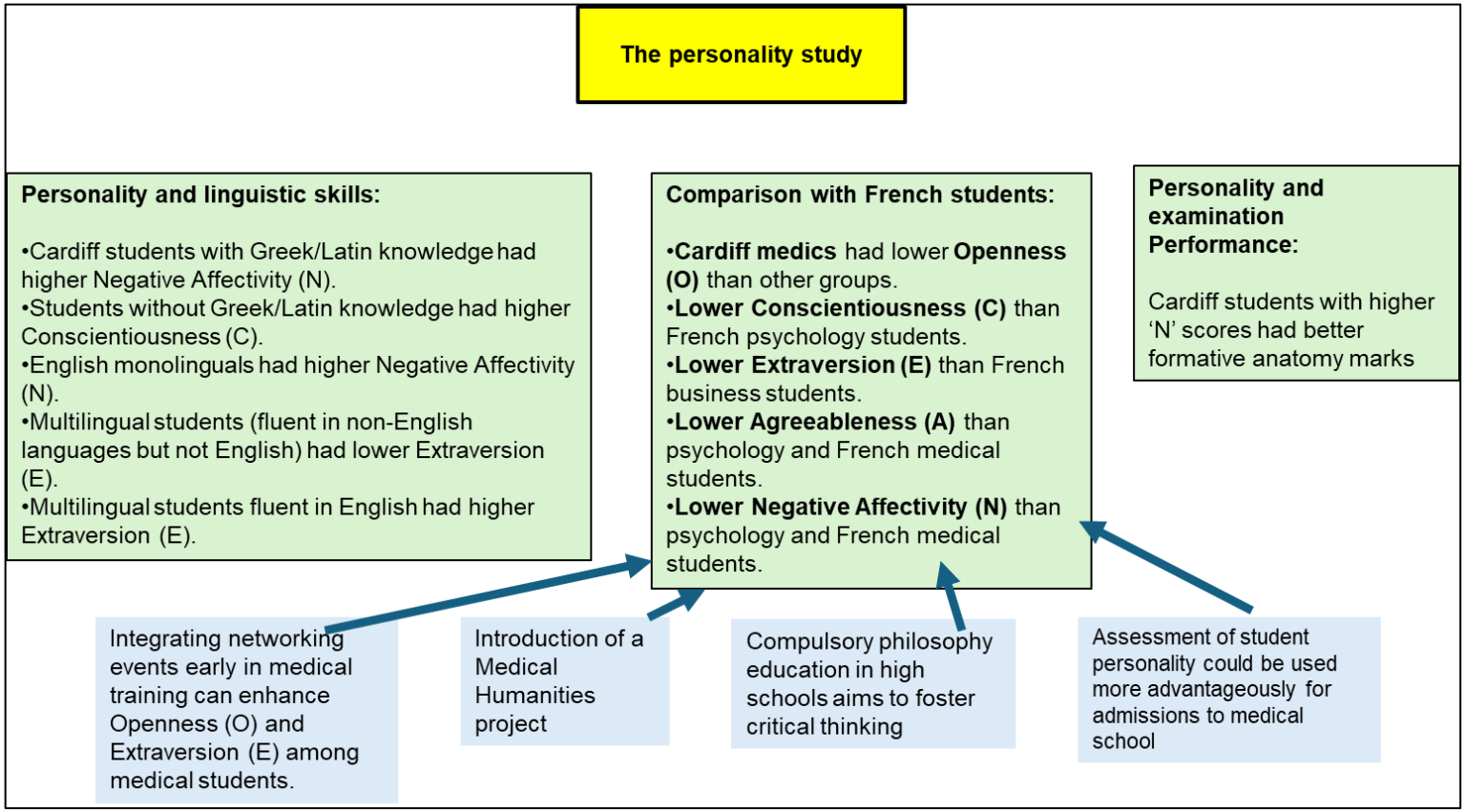


Figure 7.3: Mind map of key findings and recommendations from Chapter 6. This figure presents a mind map encapsulating the key findings and recommendations from Chapter 6, which explores the relationship between personality traits, linguistic skills, and academic performance in medical education. Green boxes represent key findings, while blue boxes represent recommendations. The visual structure highlights major themes and conclusions drawn from the study, along with potential implications for medical education, curriculum development, and student selection processes.

7.2: Promoting classical Greek and Latin amongst medical students

The research undertaken for this thesis revealed a marked contrast in attitudes toward classical Greek and Latin between first-year and final-year students, with 96% of the former expressing a positive attitude, while 83% of the latter held a negative perspective. This shift in attitude among final-year students poses potential challenges, particularly in the context of examination performance. Medical school examinations often demand a good understanding of terminology rooted in Greek and Latin, and these negative attitudes may result in insufficient examination preparation, consequently affecting academic success.

Berger-Estilita *et al*. (2020) highlight that for final-year students engaged in clinical rotations and patient interactions, a lack of proficiency in medical terminology would pose communication challenges, potentially affecting patient care and collaboration with colleagues. Certainly, in the past it has been important to talk to patient in simple English due to limited medical knowledge. Fage-Butler *et al*. (2016) note that patients may become more aware of medical terminology as they search the internet in order to obtain more knowledge of their medical condition. Therefore, increasingly it may become the case that doctor and patient will use more advanced terminology during their consultations. As per Lim *et al*. (2011) as these students progress into advanced clinical and academic settings, negative attitudes toward the foundational languages of medicine could impede effective teaching and communication, hindering the conveyance of intricate medical concepts. This, in turn, may erode confidence in clear communication, accurate diagnoses, and meaningful contributions to medical discussions.

According to Jóskowska and Grabarczyk (2013), a reluctance to engage in academic discussion owing to negative attitudes towards Greek and Latin may limit networking and collaboration opportunities during this crucial phase of a medical student's final year. Beyond individual impact, a negative attitude towards the significance of Greek and Latin in medicine may influence curriculum developers and educators, potentially leading to a devaluation of language studies in medical programmes. This could result in a curriculum that inadequately emphasises the linguistic foundations of medical terminology.

The potential repercussions extend to the professional identity and culture within the medical community. A negative attitude towards the linguistic roots of medical terminologies may contribute to a mindset that undervalues the importance of language in effective

communication and collaboration among healthcare professionals (Healy *et al*., 2022). Addressing these attitudes is crucial for fostering a comprehensive and well-rounded medical education that prepares students for successful careers in healthcare.

The issue of complacency among final-year students, particularly about their grasp of anatomical terminology and basic sciences, is a complex problem that touches upon several aspects of educational design, student motivation, and the structure of medical curricula.

Complacency may arise when students, nearing the completion of their course, feel confident in their acquired skills and knowledge to the extent that they overlook gaps in their foundational understanding (Cassam, 2017). This is particularly concerning in fields like medicine, where a deep understanding of basic sciences, including anatomy, is crucial for clinical practice.

The compartmentalisation of courses could be a contributing factor. Traditional curricula often segregate learning into distinct, isolated subjects without sufficient emphasis on the interdependence between them. According to Doja *et al*. (2016), this can lead to a fragmented understanding of concepts, where students might excel in memorising specific facts without grasping their relevance or application in a broader clinical context.

Integrating basic science teaching with clinical practice throughout the curriculum could help mitigate this problem. Integration encourages a more holistic understanding of medicine, where students can immediately see the relevance of basic sciences in clinical scenarios (Albert *et al.,* 2024). This approach can enhance retention of knowledge, foster deeper understanding, and importantly, maintain student engagement by demonstrating the practical applications of what they are learning. However, according to Dominguez *et al.* (2020), the success of integration also depends on faculty training, resources, and the willingness of institutions to adapt their curricula. It requires a shift within educational institutions towards a more interconnected approach to teaching and learning.

A minority, 5-7% of the UK school population, currently has access to classical languages such as Greek and Latin (Stephens and Moxham, 2018). Importantly, among the cohort of students in this study, 11% possessed prior knowledge of Greek and/or Latin and notably outperformed their peers in anatomical examinations. While this finding is particularly relevant

to students in the early stages of the medical curriculum, valuable lessons might be drawn from it but would need further investigation particularly as to whether the advantage continued throughout the reminder of clinical training.

Considering these results presented in this thesis, it may be worthwhile to pilot initiatives that promote classical languages across the entire curriculum. One potential avenue could be the introduction of etymology workshops, focusing on common medical terminologies derived from classical languages. These workshops could serve to enhance linguistic skills and deepen understanding. Another promising approach could involve organising language immersion programmes (these programmes use educational strategies to teach students in a second language across various subjects, promoting fluency through natural, contextual use) (Ortega, 2020). These programmes would expose students to anatomical/medical terminologies in Greek and Latin within simulated or actual clinical environments, providing hands-on experiences to reinforce their comprehension and application of terminology in practical settings. According to O'Connell (2020), collaboration with the classical language department presents an opportunity to enrich students' education. Joint initiatives can offer a more comprehensive understanding of the historical and cultural context of Greek and Latin, fostering a deeper appreciation for the linguistic roots of medical terminologies. This collaborative effort aligns with the goal of providing students with a well-rounded and culturally informed medical education.

Another frontier to explore would be creating smartphone/tablet applications to master Greek and Latin anatomical terminologies. These applications offer interactive learning, customisable to individual needs, with notifications prompting review of challenging terms. These applications can make learning enjoyable through gamification and track progress, aiding self-assessment (Mansouri *et al.,* 2020). This multifaceted approach enhances language acquisition in an engaging and personalised manner.

In summary, teachers have a crucial role in emphasising the significance of classical Greek and Latin in medical education, which underpins much of medical terminology and facilitates a deeper understanding of the concepts. By highlighting these languages' relevance, teachers can enhance students' learning, communication skills, and professional opportunities, while also improving patient care through clearer communication. Moreover, an appreciation for Greek and Latin helps preserve the rich heritage of medicine, fostering a sense of identity and continuity within the profession. By addressing and reversing negative

attitudes towards these foundational languages among students, teachers can encourage a more engaged and positive approach to learning, benefiting both their academic and future professional careers.

7.3: Linguistic skills amongst medical students

This study revealed a positive correlation between multilingualism and enhanced spatial intelligence, with a direct benefit to such students in anatomy examination performance. Those proficient in multiple languages demonstrated superior results in formative anatomy assessments, particularly in tasks involving prosections that demanded three-dimensional orientation. This advantage extends beyond medical training. It is not only a practical skill but also a crucial element in delivering patient-centred, culturally sensitive, and accessible healthcare. Nair *et al*. (2019) and Harrison *et al*. (2020) found that multilingual individuals exhibit heightened cultural competency, a valuable asset in the medical field where interactions with patients from diverse backgrounds are commonplace. As healthcare becomes increasingly globalised, the ability to communicate effectively across linguistic boundaries is crucial. Multilingualism empowers healthcare professionals to understand and navigate the cultural nuances that influence patients' health beliefs, practices, and preferences. This linguistic proficiency fosters stronger doctor-patient relationships, ultimately contributing to improved healthcare outcomes. Moreover, in the collaborative landscape of modern medicine, where professionals engage with colleagues and researchers worldwide, multilingualism plays a pivotal role. It facilitates seamless communication and collaboration, promoting the exchange of medical knowledge and advancements across borders.

Considering the aforementioned benefits of multilingualism, it might be suggested that medical students actively embrace the learning of additional languages as an integral part of their training. To provide an example within UK medical schools, Sheffield, Bath, Dundee, and London Universities offer complimentary language courses (Institution-Wide Language Programmes) presenting an opportunity for integration into the medical curriculum. Furthermore, Beaven *et al*. (2017) suggested participating in summer language exchange programmes that offer a structured platform for students to learn and practise new languages through meaningful interactions with native speakers. These initiatives contribute not only to

linguistic proficiency but also foster cultural understanding, enriching the educational experience for aspiring healthcare professionals.

7.4: The influence of medical student's personality traits on linguistic skills and examination performance

The comparative study reported in Chapter 6 reveals that Cardiff medical students exhibit lower levels of openness and extraversion than French students as reported by Plaisant *et al*. (2014). Although the numeric differences between the cohorts is small (for example on a scale of 1-5, Openness for Cardiff medical students=3.2 and Openness for French medical students=3.5) such differences are nevertheless considered by those studying the psychology of personality to be important with larger cohort where there are statistical differences.

As the selection process for entry into the Medical course at Cardiff prioritises academic excellence, this may attract individuals with higher conscientiousness but potentially lower openness and extraversion. Considering the observed openness among French business students, it prompts the question of whether we could draw lessons from their approach. Business programmes emphasise networking and social skills, fostering an environment of openness and extraversion by encouraging students to engage with events and professionals (Wolf and Ackerman (2005). In contrast, medical training introduces conferences and workshops later in their training. Potentially to enhance openness and extraversion among medical students, there might be value in integrating networking events into the early stages of medical training, providing opportunities for connections with professionals and peers.

In the research reported in Chapter 6, it was also found that French medical students exhibited the highest levels of openness, potentially attributed to cultural differences. French culture, renowned for its emphasis on intellectualism, curiosity, and an appreciation for the arts, may contribute to this receptivity to new ideas and experiences. As reported by United Nations Educational, Scientific and Cultural Organization (2007) and Norris (2020), in France compulsory philosophy education in high schools aims to foster critical thinking. This distinctive educational approach emphasises concepts such as freedom and morality, promoting intellectual autonomy, critical inquiry open mindedness, curiosity, and thought

itself. Philosophy's integral role in French culture may enhance societal openness and encourage a culture of thoughtful analysis and open-mindedness. In line with this, Roberts (2021) reported that the notion of integrating interdisciplinary courses, blending medical studies with humanities, arts, and social sciences, emerges. According to Kumagai (2017), such approaches could involve courses exploring medical ethics, history, or the social determinants of health. A parallel initiative has been initiated among first-year medical students at Cardiff through the introduction of a Medical Humanities project. This project encourages students to express their emotions about mortality and gratitude toward donors through various artistic mediums such as music, poems, and paintings. Evaluating the impact of such projects on personality traits, particularly openness, could provide valuable insights into the intersection of medical education and personal development (Mangione *et al*, 2018).

Given the extend of psychological and skill-based profiling of medical students within these studies, the question can be posed: Is there an ideal medical student? In my opinion, an ideal medical student should have experience studying Greek and Latin, possess a reasonable knowledge of languages other than English, and exhibit strong verbal and spatial skills. Additionally, they should possess personality traits characterised by moderate to high levels of openness, conscientiousness, and agreeableness, coupled with moderate levels of extraversion but with low levels of negative affectivity. This may seem to be Utopian situation and indeed at the present time a calculation shows that only 5% of the existing Cardiff medical student cohort fit such profile. Nevertheless, it can be argued that 5% is rather too low and the percentage should be higher.

According to DeYoung *et al.,* (2010), moderate to high levels of openness fosters creativity and a willingness to explore new ideas and perspectives. A balanced conscientiousness reflects organisational skills and flexibility, contributing to effective time management and goal-oriented diligence. Wilmot and Ones (2022) stated that moderate to high levels of agreeableness contribute to interpersonal harmony and effective collaboration. Moderate levels of extraversion enhance communication and teamwork, fostering positive working environments. According to Librán (2006), generally considered less desirable, moderate negative affectivity can heighten awareness of challenges, driving proactive problem-solving and careful decision-making for patient safety.

7.4.1: Exclusion of Learning Preference Theories and the Modality Appropriateness Model

The current study did not incorporate learning preference theories (such as VARK model) or the Modality Appropriateness Model, as these frameworks have been widely critiqued in contemporary educational research. Instead, this thesis focused on linguistic skills, multilingualism, and personality traits as key non-cognitive factors influencing medical education.

While learning preference theories suggest that individuals learn best when teaching is tailored to their preferred sensory modality (e.g., visual, auditory, kinaesthetic), extensive research has failed to find empirical support for this claim (Pashler *et al*., 2008; Brown, 2023). Studies have demonstrated that adapting instruction to match a student's preferred learning style does not lead to better learning outcomes compared to more generalised, multimodal instructional approaches (Riener and Willingham, 2010; Cuevas, 2015). Additionally, the persistence of learning preference theories in education has been described as a neuromyth that oversimplifies how individuals process information (Hall, 2016).

Given the lack of scientific validation and concerns about reinforcing self-limiting beliefs among students (Lodge, Hansen and Cottrell, 2016), this thesis did not employ learning preference models as a framework for understanding student success in medical education. Instead, it prioritised evidence-based factors, such as verbal and spatial intelligence, linguistic skills, and personality traits, which have demonstrated stronger predictive validity in academic performance (Ackerman, 2003; Ferguson *et al*., 2014).

The Modality Appropriateness Model (Welch and Warren, 1980) argues that certain tasks are better suited to particular sensory modalities (e.g., visual tasks should be taught visually, verbal tasks should be taught using text or audio). While this model offers a more task-centred approach than learning preferences, it still assumes that learning effectiveness is primarily determined by sensory modality. However, in anatomy education, research has demonstrated that 3D multimodal visualisation techniques provide better engagement and comprehension compared to traditional 2D representations, suggesting that rigid modality-matching approaches are inadequate (Keenan and Powell, 2020; Keenan and Ben Awadh, 2019). Integrated, multimodal approaches that engage multiple senses simultaneously have been found to be more effective than strict modality matching (Mayer and Fiorella, 2014),

particularly when students interact with dynamic, 3D learning environments (Ben Awadh, Clark, Clowry and Keenan, 2022).

Moreover, contextual factors such as prior knowledge, cognitive load, and attention play a significant role in how students process information (Sweller, Ayres and Kalyuga, 2011). The Cognitive Load Theory suggests that reducing extraneous cognitive load is more important than rigidly aligning instruction with a single modality (Kirschner, Sweller and Clark, 2006). This is particularly relevant in medical education, where 3D learning tools enhance spatial awareness and cross-sectional anatomical interpretation more effectively than simple modality-matching approaches (Ben Awadh *et al*., 2022). As a result, this thesis prioritised frameworks that consider cognitive and personality-based influences on learning rather than sensory modality alone.

Given these considerations, the current study focused on factors with stronger empirical support, such as verbal-spatial intelligence, multilingualism, and personality traits, rather than learning preference theories or the Modality Appropriateness Model. This approach aligns with modern educational research, which emphasises adaptive, evidence-based instructional strategies over outdated or unsupported models. Future research may explore how cognitive flexibility and multimodal learning interact with linguistic skills and personality traits in medical education to provide a more comprehensive understanding of student success.

7.5: Ethics and morality of personality testing in medical school admissions

The potential use of personality testing in medical school admissions raises significant ethical and moral questions. While personality traits such as conscientiousness and openness may correlate with academic success or professional competence (Roberts *et al*., 2007; Yusoff, 2019), the inclusion of these traits in admissions processes must be approached cautiously. One key concern is the potential for personality testing to unfairly advantage or disadvantage certain individuals based on factors such as culture, socioeconomic background, or sex (Furnham, 2008; Hofstede, 1986). For instance, variations in how individuals interpret and respond to personality test items across cultural contexts could lead to biased assessments, potentially excluding capable students (Duckworth and Yeager, 2015).

Furthermore, there is a risk that personality testing could perpetuate stereotypes or reinforce narrow definitions of what constitutes a "successful" medical student or clinician. Medical education should aim to promote a diverse and inclusive student body, recognising that a range of personality traits and perspectives contributes to better patient care and teamwork (Advance HE, 2021; Universities UK, 2020). Using personality testing as a gatekeeping tool could inadvertently exclude individuals with unconventional profiles who might otherwise excel in medical practice (LERU, 2019).

7.5.1: Equality, Diversity, and Inclusion in Higher Education

The findings of this study must be contextualised within the current Equality, Diversity, and Inclusion (EDI) framework in higher education, as guided by the principles of Universal Design for Learning (UDL). Increasingly, institutions are prioritising equitable access to education, particularly in competitive fields like medicine Admissions processes must align with these goals, ensuring that they do not disproportionately exclude individuals from underrepresented or marginalised groups. For example, personality traits such as extraversion or agreeableness may be favoured in traditional assessments but may not reflect the full spectrum of skills needed for medical practice. Overemphasising these traits in admissions criteria could unintentionally disadvantage introverted individuals or those from cultures where such traits are expressed differently (Hofstede, 1986; Yusoff, 2019).

Additionally, the study's reliance on personality traits as predictors of performance must consider potential biases in the data collection process itself. Self-reported personality profiles may reflect societal norms or pressures rather than students' authentic traits, thus raising concerns about the validity of the findings (Furnham, 2008). Such biases must be acknowledged when interpreting findings and considering their implications for EDI practices in higher education (Advance HE, 2021).

7.5.2: Ethical, moral, and equality, diversity, and inclusion implications

This research highlights key ethical, moral, and equality, diversity, and inclusion (EDI) implications in personality testing, language skills, and spatial ability/intelligence. Addressing these considerations ensures fair and inclusive applications in medical education.

7.5.2.1: Ethical considerations

Personality testing and cognitive assessments must safeguard privacy, consent, and fairness. These tools must be designed to respect participants' autonomy and ensure that individuals fully understand how their data will be used. Ensuring tests are culturally unbiased prevents disadvantaging specific groups, reducing the risk of discrimination and ensuring equitable treatment (Smith *et al*., 2020). In this thesis, ethical approval was obtained for all studies involving participants, ensuring informed consent and data confidentiality throughout the research process. For instance, the comparative analysis of personality traits between students from the UK and France adhered strictly to ethical guidelines, ensuring that cross-cultural differences were interpreted responsibly.

7.5.2.2: Moral considerations

Educational practices must promote equity by supporting students with diverse linguistic or cognitive backgrounds. Institutions have a responsibility to ensure that differences in prior opportunities, such as exposure to classical languages or spatial training, do not become barriers to success. Over-reliance on innate traits risks stigmatisation, but creating growth-focused environments can foster resilience and improve outcomes for all learners (Abouzeid *et al*., 2021). This thesis explicitly considered moral implications by comparing diverse student cohorts and highlighting disparities, such as differences in linguistic preparation. The findings underscore the moral responsibility of educators to offer targeted interventions to support students who may lack prior exposure to classical Greek and Latin or who face challenges in spatial reasoning.

7.5.2.3: EDI implications

Addressing language barriers and diversifying assessments ensures inclusive learning environments. Students from underrepresented groups or non-traditional backgrounds may face additional challenges in mastering complex terminologies, highlighting the need for tailored support systems. Diversifying admission and assessment practices helps to counter systemic inequities, creating a more inclusive educational framework (Yusoff *et al*., 2021). Within this thesis, specific attention was given to identifying factors that may disadvantage multilingual or underrepresented students, with recommendations to address these gaps. For example, findings revealed that multilingual students exhibited enhanced spatial and verbal intelligence, yet systemic barriers may still limit their academic performance if adequate support is not provided.

7.6: Training additional health care professionals: Major drive from the UK government

Wilson *et al.,* (2021) reported that as an increasing number of doctors choose to emigrate abroad, or leave the profession owing to burnout and dissatisfaction, the government faces mounting pressure to restore the normal functioning of the National Health Services (NHS). To safeguard the future of the NHS, it is imperative to both train and retain more doctors within the healthcare system. Recognising the need for diversity in the medical profession, initiatives have been designed to provide an alternative pathway into medicine, facilitating entry for individuals from diverse backgrounds.

To address the gap created by shortages of doctors, the UK government has recently launched fast-track apprentice training programmes, with the Medical Doctor Degree Apprenticeship programme serving as a notable example. This initiative, introduced by NHS England through Health Education England, provides the NHS with an opportunity to expand its future medical workforce and recruit from a broader pool of individuals within local communities. The apprenticeship programme not only addresses workforce shortages but also offers a new avenue for individuals to train as doctors, particularly those who, for various reasons, may be unable to pursue full-time university education. The Medical Doctor Degree Apprenticeship programmes raises concerns about anatomical education,

as apprentices may have limited exposure to cadaveric dissection and structured anatomy teaching compared to traditional medical students. Workplace-based learning may prioritise clinical tasks over systematic anatomical education, leading to gaps in spatial understanding crucial for surgery and radiology. Variability in training quality across NHS Trusts could further compromise anatomical competency, potentially impacting diagnostic accuracy and licensing exam performance. To address this, structured anatomy teaching, lab access, and standardised assessments must be integrated to ensure consistent anatomical proficiency.

Regardless of whether medical students are trained through university education or via an apprentice scheme, it is doubtful that the expectations of achieving the ideal attributes of moderate levels of openness, conscientiousness, extraversion, agreeableness, and negative affectivity can be feasibly met with percentages higher that the present 5% seen amongst the Cardiff cohort of medical students. Since with the existing university education programme few or a small percentage of students fit what might be considered to be the ideal profile. It is reasonable to ask whether such a profile would be obtained from the apprenticeship programme and whether the societal and political needs are going to outweigh the professional standards normally expected by the general public. Inevitably, societal and political considerations will trump the considerations of academic achievements, skills and personality requirements. However, if it were feasible to shape an ideal cohort, the admission process would need significant changes. Incorporating robust personality tests might provide insights into interpersonal skills and communication styles. However, as personality tends to change with time, circumstances, and life experiences (Roberts and Mroczek, 2008) and (Chopik and Kitayama, 2018), the validity of such personality tests to admit medical students is questionable. Admitted students might evolve during medical training, challenging the initial personality test's predictive value. As personality traits were studied in the fourth year, it's unclear if these traits are inherent or acquired during medical training. Lourinho *et al.,* (2017) noted that the demanding nature of medical school may influence personality traits, including agreeableness and negative affectivity.

7.7: Conclusion

Negative attitudes toward classical languages not only might hinder examination preparedness, patient care, and collaboration in clinical settings but also impede effective teaching and communication in advanced contexts, limiting networking opportunities within the medical community. Given the limited access to classical languages, it is recommended that a comprehensive approach is followed. For example, possible solutions include pilot programmes such as etymology workshops, language immersion, collaboration with classical language departments, and the use of mobile applications for language mastery. Embracing multilingualism may enhanced anatomical examination performance and improved cultural competency in healthcare. The integration of language courses and exchange programmes into the medical curriculum enriches students' educational experience. To address lower levels of openness amongst medical students, early integration of networking events and interdisciplinary courses is suggested, drawing inspiration from successful practices among French business students where they attend career fairs and conferences during the initial years of their curriculum. An ideal medical student should exhibit moderate levels of key personality traits—openness, conscientiousness, extraversion, agreeableness, and negative affectivity. To cultivate an optimal cohort, substantial changes may be necessary in the admission process, given sufficient political will. Introducing robust personality tests could offer valuable insights into interpersonal skills and communication styles.

Figure 7.6 gives a concise representation of all the findings and recommendations from the thesis. It also suggests how these findings can be implemented in designing admissions criteria

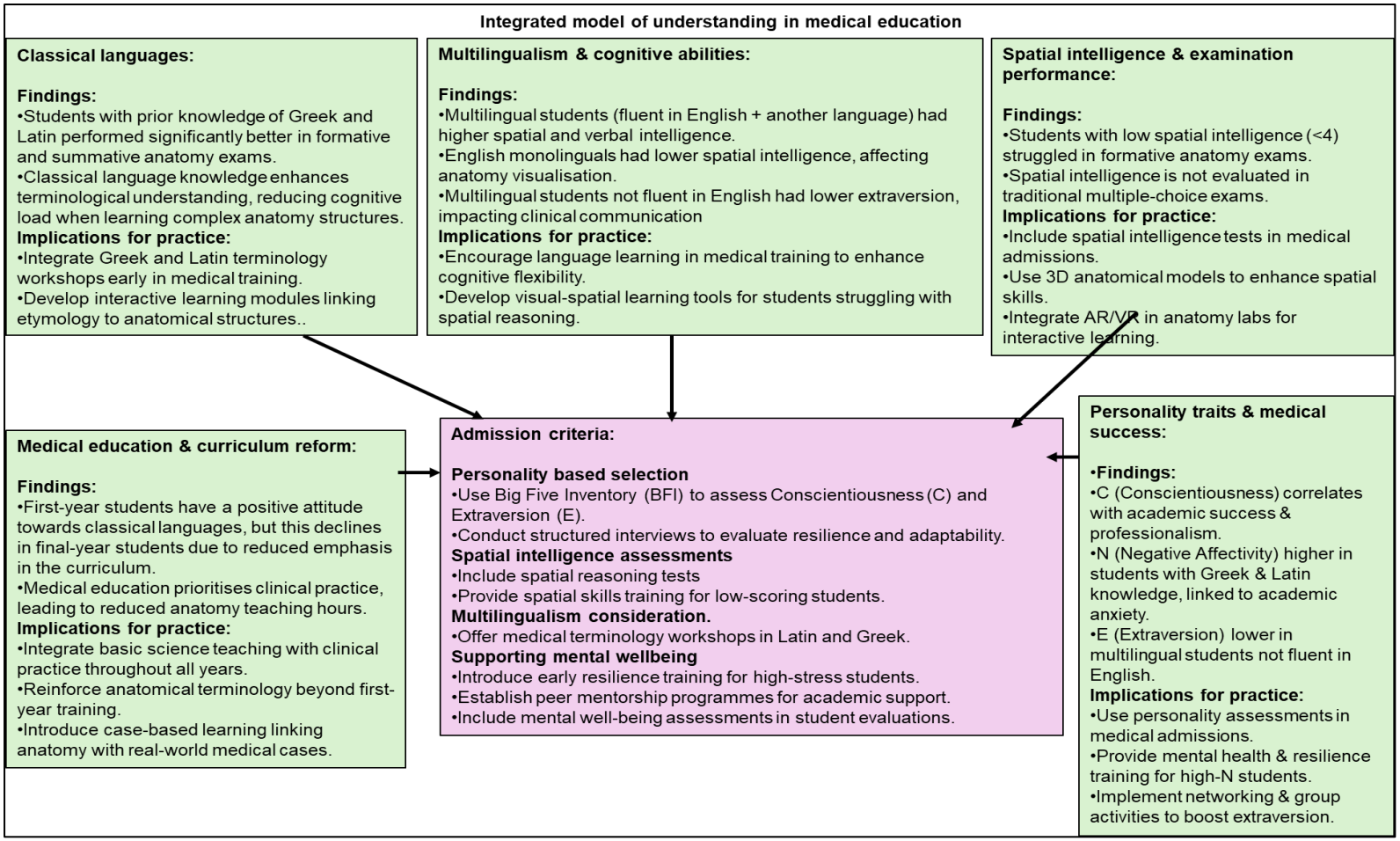


Figure 7.4 Illustrates an integrated admissions model that incorporates personality traits, spatial intelligence, multilingualism, and mental well-being into medical school selection. The model demonstrates how these factors influence academic success, anatomy learning, and professional competence, providing a framework for more holistic and evidence-based admissions criteria. Green boxes indicate the findings and implications for practice from Chapters 3–6, while the pink box suggests the overall implications for medical admissions criteria.

7.8: Limitations of the study

This study presents several limitations related to its design, methodology, data collection, and generalisability to wider contexts and student populations. Addressing these limitations is critical to ensure the findings are interpreted appropriately and to guide future research.

7.8.1: Study design

A key limitation is the reliance on a cross-sectional study design, which provides a snapshot of data at a single point in time. While the study identifies correlations between personality traits, spatial abilities, and anatomy performance, it cannot determine whether these traits directly influence performance or if external factors contribute to these trends. A longitudinal design, tracking students over time, would provide a stronger foundation for establishing causal relationships and observing changes in traits and performance as students progress through their education.

7.8.2: Questionnaire and testing instruments

The study relies on self-reported questionnaire data, which introduces potential biases that may affect the validity and reliability of the findings. Instruments such as the Big Five Inventory (BFI), though widely used, depend on participants' self-perception and can be influenced by social desirability or misinterpretation of questions. These biases may compromise the accuracy of the data, particularly for complex traits such as negative affectivity. Additionally, the thresholds for interpreting spatial intelligence and operationalising learning preferences may not fully align with current evidence-based practices, potentially reducing the precision of the results.

7.8.3: Data collected

The data were collected at a single point in time from a specific cohort of medical students at Cardiff University. This approach restricts the depth of insight into the dynamic relationships between personality traits, spatial intelligence, and academic performance. Cross-sectional data provide only a static view and cannot capture how these factors evolve over time or interact with external variables such as stress, teaching methods, or curriculum changes. Moreover, the absence of qualitative data limits the ability to explore participants' lived experiences, which could have added valuable context and depth to the numerical findings.

7.8.4: Translation and generalisability

The context-specific nature of the research limits the generalisability of its findings. The study's focus on Cardiff University students, with its unique educational environment and teaching methods, may not translate directly to other institutions, disciplines, or geographical regions. Furthermore, the relatively small sample size, particularly for subgroup analyses such as sex-based trends, reduces the robustness of the conclusions and increases the risk of type II errors, where meaningful effects might go undetected.

7.9: Recommendations

It might be believed that cognitive ability and personality tests could be useful in the admission process. However, this idea may seem idealistic because both universities and governments are unlikely to see such tests as an effective method for selecting medical students. Nonetheless, if such tests were implemented, they could serve a valuable purpose by allowing personal tutors to advise newly admitted students. These tutors could help students understand their skills and attributes that need development, highlighting both the advantages of their education and potential drawbacks. Personal tutors could be instrumental in interpreting the results of personality assessments, guiding students to comprehend what

their scores mean for their academic success. By focusing on strengths and areas for improvement, tutors can foster self-reflection and help students set personal goals.

7.9.1: Recommendations to enhance spatial abilities

To enhance spatial abilities among medical students, integrating advanced technologies such as 3D visualisation tools is strongly recommended. Keenan and Ben Awadh (2019) demonstrate how these tools can improve students' understanding of anatomical structures and spatial relationships. Additionally, Keenan and Powell (2020) emphasise the importance of promoting students' ability to transition between three-dimensional visualisations and two-dimensional representations, a critical skill for interpreting imaging and understanding anatomical layouts. Embedding these tools in the curriculum, alongside targeted spatial training programmes, can significantly enhance learning outcomes and better prepare students for clinical practice.

7.9.2: Recommendations for alternative methodologies

Future research should prioritise addressing the limitations and exploring the potential of alternative methodologies. Expanding the study to include diverse student cohorts across multiple institutions and cultural contexts would enhance the generalisability of the findings. This broader scope would allow researchers to investigate whether the observed trends, such as the sex-specific influence of personality traits, are consistent across different populations.

Longitudinal studies could further enrich the research by tracking changes in personality traits, spatial abilities, and academic performance over time. Such designs would enable researchers to examine the developmental trajectories of these traits and their long-term impact on medical education outcomes. This approach would also help identify causal relationships that are difficult to establish in cross-sectional designs.

Incorporating qualitative methods into future research is another critical step. Conducting interviews, focus groups, or thematic analyses would provide deeper insights into the mechanisms underlying the observed trends. For instance, exploring how students perceive

their spatial intelligence or how personality traits influence their coping strategies during anatomy examinations could shed light on the factors driving their performance.

Lastly, adopting a mixed-methods approach would allow researchers to balance the breadth of quantitative analysis with the depth of qualitative insights. This approach would be particularly valuable in medical education, where the interplay of cognitive, emotional, and behavioural factors often requires a detailed insight. By integrating these methods, future research could provide actionable recommendations for educators, such as tailoring teaching strategies or assessments to accommodate diverse personality profiles and abilities.

7.9.3: Recommendations for Ethical, Moral, and Equality, Diversity, and Inclusion implications

1. **Support systems**: Provide targeted support programmes to address gaps in prior learning. These could include supplementary language workshops, spatial reasoning training, and accessible learning resources tailored to individual needs. For multilingual students or those with limited prior exposure to classical languages, creating peer-support networks or mentorship schemes can enhance their learning experience.
2. **Monitoring and evaluation**: Implement robust systems for tracking student outcomes across demographic groups. Regularly review data to identify disparities in performance, retention, and satisfaction. Use these insights to inform policy changes, adapt teaching methods, and allocate resources effectively. Transparency in reporting outcomes also reinforces institutional accountability. The longitudinal data collected in this thesis illustrate the value of consistent monitoring in identifying trends and disparities.
3. **Curriculum design**: Integrate EDI considerations into the curriculum by including diverse perspectives and examples in teaching materials. Promote awareness of how cultural, linguistic, and personality differences influence learning and professional practice. By fostering an inclusive curriculum, students gain a broader understanding of diverse patient populations and healthcare contexts. The findings of this thesis,

particularly regarding the impact of linguistic skills on learning outcomes, support the inclusion of tailored resources and culturally sensitive teaching materials.

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Appendix 1

1. RESEARCH DEGREE THESIS

1. STATEMENTS AND DECLARATIONS FORM

1. PURPOSE

This form must be completed by all research degree candidates when submitting their thesis to their School PGR Office/equivalent (in person or by post), including at:

the initial examination stage when submitting a corrected thesis post-examination (following the completion of corrections and amendments), and at a formal resubmission.

If this is a first submission or a resubmission, candidates must also complete a Notice of Submission Form.

COMPLETING THE FORM

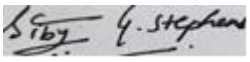
1. Please read, sign and date under each statement and declaration included overleaf. It is important that you read the statements and declarations carefully and that you fully understand each one before signing. If you have questions about any of the statements or declarations, you can speak to your School PGR Office.
2. Your signature may be in ink or electronic (a scanned image), but it **cannot be typed.**
3. The completed form should be provided to your School PGR office in hard copy or by email, along with the copies of your thesis.
4. The date you enter on the form should be the date your thesis is ready for submission: this should be before or on your thesis (re)submission deadline. If the University is closed on that day, you may submit your thesis and this form to the office, or arrange for their delivery, on the first day after the closure.

INSTRUCTION TO SCHOOL PGR OFFICE

This form should be retained and stored securely in the School Office. It does not need to be provided to the Registry, but a copy may be requested at any time in relation to the examination of the candidate.

SECTION 1: CANDIDATE'S DETAILS						
Full name	Shiby George Stephens.					
Student number	0708425					
School	Biosciences.					
Degree:	PhD					
Full title of thesis	The relationship between classical languages, linguistic skills, and personality traits and their impact on medical education and student performance					
This is a	first submission		corrected thesis	X	resubmission	☐

1.

SECTION 2: STATEMENTS AND DECLARATIONS TO BE SIGNED BY THE CANDIDATE			
STATEMENTS 1. This thesis is being submitted in partial fulfilment of the requirements for the degree of PhD 2. This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is it being submitted concurrently for any other degree or award (outside of any formal collaboration agreement between the University and a partner organisation). 3. I hereby give consent for my thesis, if accepted, to be available in the University's Open Access repository (or, where approved, to be available in the University's library and for inter-library loan), and for the title and summary to be made available to outside organisations, subject to the expiry of a University-approved bar on access if applicable.			
DECLARATION 1. This thesis is the result of my own independent work, except where otherwise stated, and the views expressed are my own. Other sources are acknowledged by explicit references. The thesis has not been edited by a third party beyond what is permitted by Cardiff University's Use of Third Party Editors by Research Degree Students Procedure.			
Signed *(handwritten or scanned image)*		Date	24/03/25

WORD COUNT: 43, 277

(excluding summary, acknowledgements, contents pages, appendices, tables, diagrams and Figures, references, bibliography, footnotes and endnotes).

NOTE

A new form must be completed at each submission stage (i.e. at the point of initial submission of the thesis for examination and after you have completed any corrections and amendments). If you are required to resubmit your thesis for further examination, you will also need to provide a new form with your resubmitted thesis.

RESEARCH DEGREE - NOTICE OF SUBMISSION FORM

PURPOSE: This form must be completed by all research degree candidates when submitting their thesis to their School PGR Office/equivalent. If the School is satisfied that the thesis should be accepted for examination, this form will be forwarded to Education Governance (PGR Quality and Operations Team). The information provided will be checked against the University's records (SIMS), and the date entered on this form will be recorded on SIMS as the date of thesis submission. Candidates resubmitting their thesis should also complete this form.
Note that there is a different Notice of Submission form for PhD by (Prior) Published Works.

NOTES FOR CANDIDATES

- Ensure that your thesis meets the University's requirements for presentation, including format and word limit.
- You must submit your thesis to your School, as instructed by your School's PGR Office.
- Ensure that you complete and submit the separate Research Degree Thesis Statements and Declarations Form with your thesis.
- If a submission fee is payable, please provide evidence of payment with this form. This applies if you are a staff candidate, if this is a late submission, or if you are resubmitting your thesis.
- If you require a temporary Bar on Access to your thesis, and you have not yet made an application, please do so as soon as possible using the appropriate form.

COMPLETING THE FORM

- Complete **section 1** and send it to your School PGR Office when you submit your thesis.
- By typing your name in the form you will have provided an electronic signature.
- The word count excludes the summary, acknowledgements, declarations, contents pages, appendices, tables, diagrams and figures, references, bibliography, footnotes and endnotes.
- The date you enter on the form should be the date your thesis is ready for submission: this should be before or on your thesis submission deadline, or you will be required to pay a late submission fee. If the University is closed on that day, you may send your thesis on the first day after the closure in case there are any technical issues for which you require support from University staff.

SECTION 1: CANDIDATE'S DETAILS				
Full name	Shiby George Stephens			
Student number	0708425			
School	Biosciences			
Degree	PhD			
Full title of thesis [*as presented for examination, using upper and lower cases as appropriate*]	The relationship between classical languages, linguistic skills, and personality traits and their impact on medical education and student performance			
Word count of thesis/critical commentary	43,277			
Is this a first submission or a resubmission?	First submission	☒	Resubmission	☐
SIGNATURE [*by typing your name here, you are providing your electronic signature*]	Shiby G. Stephens			
DATE	24/03/2024			

NOTES FOR PGR OFFICE

- Send the form to the candidate's supervisor for completion of section 2 and return to you, where it is your School's policy that their advice is sought regarding the submission, and where they need to confirm that research data are appropriately stored.
- Complete section 3 or pass to the Convenor for completion, in accordance with your School policy.

SECTION 2: SUPERVISOR'S STATEMENT (WHERE REQUIRED BY THE SCHOOL)			
I am aware that the School's decision to accept a thesis for examination rests with the Head of School/Convenor. I am also aware that a student may be permitted to submit their thesis against their supervisor's advice. Nevertheless, I am familiar with the thesis and am prepared to make a recommendation to the School regarding its acceptance for examination. I have considered the following: • the University's policy for submission, **including word limit and format** (e.g. the inclusion of paper(s), published or otherwise, is not permitted, except for DClinPsy); • whether the thesis is of a **sufficient quality and research integrity to warrant examination**; • whether, to the best of my knowledge, the thesis is compliant with any **conditions of sponsorship**, the University's policy on third-party editing, and with copyright legislation. **I can also confirm that the student is aware of their obligations in respect of their research data (the continued retention, storage and provision of access to their data, records and/or samples), and, where applicable, I confirm that appropriate provisions are in place**. (Where the School has an additional form that must be completed by the supervisor, I enclose that form, or have already sent it to the School Office.)			
On this basis, I make the following recommendation:			
The thesis should be accepted for examination	☒	The thesis should not be accepted for examination. Please provide reason below.	☐
SIGNATURE [*by typing your name here, you are providing your electronic signature*]	S. Rutherford		
NAME (if not typed above)	Stephen Rutherford		
DATE	10/06/2024		

SECTION 3: CONVENOR/SCHOOL PGR OFFICE STATEMENT		
I confirm the following: • the Convenor of the Examining Board is satisfied that there is a *prima facie* case for accepting the submission and referring the thesis for examination; • the title of the thesis reflects that on SIMS; • the candidate has submitted by their deadline on SIMS - OR - the thesis is accepted as a late submission, in which case fee payment is confirmed below; • where required, a submission and/or resubmission fee has been paid (please indicate below); for 2023/24, this is £411 for PhD and Professional Doctorates, and £343 for MPhil and MD; • the candidate has completed a Research Degree Thesis Statements and Declarations Form.		
A submission fee is payable for the following reason(s). (Note that more than one fee may be payable – e.g. for a late resubmission; for a late submission from a staff candidate)	**a staff candidature**	☐
	a resubmission	☐
	a late submission	☐
SIGNATURE [*by typing your name here, you are providing your electronic signature*]		
NAME (if not typed above)		
DATE	Click or tap to enter a date.	

Instruction to School PGR Office:

Please email this form to the PGR Quality and Operations Team in Education Governance: pgr@cardiff.ac.uk
(*Note that delay in forwarding the form can cause difficulties for students who wish to renew their ID cards, and can hold up internal and external reporting of submission rates*.)

Appendix 2:

Chapter 3

1. Attitudes towards Greek and Latin questionnaire	Attitudes towards Greek and Latin quest
2. Judge's score	Judge's score - Chapter 2.xlsx
3. Approved ethical approval Stephens 0115-2	Ethical approval Stephens 0115-2.pdf
4. Analysis and graphs for Greek and Latin among first and final year students	Greek and Latin analysis - Chapter 2.xl

Chapter 4

1. Language fluency and proficiency questionnaire	Language proficiency and fluency questionr
2. Examination results divided into groups	Exam results analyses per group - Chapter 3
3. T tests	t test results chapter 3.docx

Chapter 5

1. Verbal and spatial intelligence questionnaire	Verbal and spatial intelligence questionn
2. Complete spreadsheet	Complete spreadsheet - Chapter
3. Kruskall-Wallis test for males versus females	Kruskall Wallis male vs female - Chapter 4.
4. Mann-Whitney tests	Mann Whitney verbal Vs spatial - Chapter 4.
5. ANOVA and t-tests	ANOVA and t tests - Chapter 4.xlsx
6. Kruskall-Wallis sex and groups	Kruskall Wallis for gender and groups - (
7. Percentage of formative and summative marks	Marks calculation - Chapter 4.xlsx

Chapter 6

1. Personality/BFI questionnaire	Personality questionnaire.pptx
2. Personality and linguistic skills questionnaire	Personality and linguistic skills questic
3. Standard error and significance	Standard error and significance.xlsx
4. BFI UK and France	BFI UK and France.xlsx

5. Comparative personality traits	Comparative personality trait.xlsx
6. Formative and summative marks	Formative and summative marks.xls
7. Significance between groups and Cronbach alpha	Significance between personality
8. Personality and multilingualism comparison	Personality and multilingualism com