

DEVELOPMENT OF AN APTITUDE TEST THAT MEASURES LANGUAGE
AND VISUAL-SPATIAL ABILITIES TO IDENTIFY POTENTIAL ACADEMIC
VULNERABILITY OF STUDENTS IN ANATOMY.

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DECLARATION

“I, the undersigned, hereby declare that the work contained in this assignment is my original work and that it has not previously in its entirety or in part been submitted at any university for a degree.”

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SUMMARY

Students first entering the university, struggle not only with the culture, but more importantly with studying in a language that is not their first / home language. Students at Sefako Makgatho Health Sciences University (SMU) come from areas where they had little or no prior exposure to the ancient European languages, from which all medical terms are derived. It has been my experience that the students do not only have to understand the new Anatomy language, but they also require the ability to transfer what they learn in two dimensions from their prescribed textbooks, to what they see in the dissection hall. It is my belief that students in the Anatomy Department at SMU, struggle with both the English language and with visualising and orientation of anatomical structures in space. This could be a serious stumbling block when attempting to grasp Anatomy as a subject. It is therefore important to ascertain to which extent these two factors play a role in academic success, and whether it could lead to being academically vulnerable in Anatomy.

The aim of this study was three-fold. Firstly, to determine whether an internally developed aptitude test can be utilised to determine the language~ and visual-spatial abilities of Anatomy students and thus predict academic vulnerability. The second aim was to determine the validity and internal consistency of the aptitude test. Lastly, the study aimed to determine whether there was any correlation between the results of the aptitude test and the first test in Anatomy.

The aptitude test consisted of a section that tested language abilities (paragraph construction; sentence construction; comprehension; spelling, antonyms, synonyms and homophones; word relationships) and a section that tested visual-spatial skill (spatial ability; anatomical mental rotation; cause and effect).

The results indicate that the aptitude test had the ability to distinguish which language~ and visual-spatial abilities the students had difficulty in performing. Results indicated that students had trouble in writing a paragraph, as well as with the comprehension section of the test. Students did not seem to have difficulty in spelling of medically related words. Overall, the students performed better in the visual-spatial section of the test, than in the language section of the test. About thirty percent of students had difficulty in mentally rotating anatomical structures and in predicting the outcomes of nerve lesions and muscle attachments. The aptitude test had good content and predictive validity. The test also had a degree of internal consistency. No positive correlation could be made between the aptitude test and the first Anatomy test.

In conclusion, answering essay type questions might be difficult for students. They might also struggle with drawing inferences from theory text and from pictures. Students are not supposed to have trouble in transferring knowledge between theory and spot test. However, they struggle with this and more research is needed into this phenomenon. The discrimination and difficulty indices and internal consistency indicated that the test requires some adaptation before its use in future, to accurately predict academic vulnerability.

OPSOMMING

Studente wat die eerste keer universiteit toe gaan, sukkel nie net met die nuwe kultuur nie, maar belangriker as dit, sukkel hulle ook omdat hulle in 'n taal moet studeer wat nie hulle eerste / huistaal is nie. Studente by Sefako Makgatho Health Sciences University (SMU) kom van gebiede af waar hulle min tot geen blootstelling gehad het met antieke Europese tale, waarvan alle mediese terme afstam. Dit is my ervaring dat die studente nie net die nuwe Anatomiese taal moet verstaan nie, maar hulle moet ook die vermoë besit om wat hulle in twee dimensies in hulle voorgeskrewe handboeke sien, oor te kan dra na wat hulle in die disseksiesaal sien. Ek glo dat studente in die Anatomie Departement by SMU, sukkel met beide Engels en met die visualisering en oriëntering van anatomiese strukture in ruimte. Dit kan 'n ernstige struikelblok wees om Anatomie as vak te probeer bemeester. Dit is daarom belangrik om te bepaal tot watter mate die twee faktore 'n rol speel in akademiese sukses, en of dit daartoe kan lei dat 'n student akademies kwesbaar is in Anatomie.

Die doel van die studie was drieledig. Eerstens, om te bepaal of 'n interne ontwerpte aanlegtoets gebruik kan word om die taal- en visueel-ruimtelike vermoëns van 'n Anatomie student te bepaal en so die akademiese kwesbaarheid te voorspel. Die tweede doel was om die geldigheid en interne konsekwentheid van die aanlegtoets te bepaal. Ten laaste was die doel om te bepaal of daar enige korrelasie was tussen die resultate van die aanlegtoets en die eerste toets in Anatomie.

Die aanlegtoets het bestaan uit 'n afdeling wat taalvermoëns (paragraafkonstruksie; sinskonstruksie; begrip; spelling, antonieme, sinonieme en homofone; woord verhoudings) en 'n afdeling wat visueel-ruimtelike vaardighede (ruimtelike vaardigheid; anatomiese verstandelike rotasie; oorsaak en gevolg) bepaal.

Die resultate toon dat die aanlegtoets die vermoë besit om tussen taal- en visueel-ruimtelike vermoëns, veral die dele waarin die student gesukkel het, te kan onderskei. Resultate het ook aangetoon dat studente gesukkel het met die saamstel van 'n paragraaf, asook met die begripsdeel van die toets. Dit wou voorkom asof die studente nie sukkel met die spel van medies verwante woorde nie. In geheel het studente beter gevaar in die visueel-ruimtelike gedeelte van die toets as in die taalgedeelte van die toets. Dertig persent van studente het gesukkel in die anatomiese verstandelike rotasie afdeling van die toets. Dit was ook die geval in die voorspelling van die uitkoms van senuweeletsels en spieraanhegtings. Die aanlegtoets het goeie inhouds- en kriteriageldigheid gehad. Die toets het ook 'n mate van interne sekerheid gehad. Geen positiewe korrelasie kon gemaak word tussen die aanlegtoets en die eerste Anatomietoets nie.

Die volgende gevolgtrekking kan dus gemaak word: die beantwoording van lang-tipe vrae blyk moeilik te wees vir studente en hulle mag dalk sukkel om afleidings te maak vanaf teorie teks en van prentjies. Studente is nie veronderstel om moeilikheid te ondervind om kennis tussen teorie en praktiese toetse oor te dra nie, hoewel dit wel die geval is. Hierdie verskynsel verg verdere navorsing. Die diskriminasie- en moeilikheidsindekse, sowel as die interne sekerheid het aangedui dat die toets 'n aantal veranderinge benodig voordat dit weer in die toekoms gebruik kan word. Die aanlegtoets benodig dus veranderinge in die toekoms om sodoende akademiese kwesbaarheid akkuraat te voorspel.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

It is a known fact that students who enter university for the first time, struggle with the setting, the new culture and most importantly, studying in a language that is not their first / home language (Hossain et al., 2010). All the lectures at the Sefako Makgatho Health Sciences University (SMU), previously known as the University of Limpopo (Medunsa Campus), are conducted in English. Having taught at SMU for the past thirteen years, it has been my experience as lecturer, that the majority of students enrolled at SMU, do not speak English as their home-language or even second language. Teaching undergraduate students at SMU is becoming increasingly challenging due to the language barriers and cultural diversity of the students. No formal standardised student selection method, for example a test that measures the capabilities of the student, is being used with the selection process. It has been observed that students (medical, dental and allied health sciences) struggle when undergoing assessments. This is evident in the fact that the students do not understand basic English terminology e.g. instructions such as: Describe; Annotate; Make an annotated labelled line diagram; and other similar instructions used in assessments.

When students start Anatomy as a module, one of the biggest challenges they face is the ability to master the “new anatomical language”, which forms part of their continued and complex rite of passage from untrained individuals to health care and medical practitioners (Lucas et al., 1997). Being able to understand the specific meaning of terminology, fluent use and pronunciation of new terms may not be the most threatening adversities students imagine upon entry into medical education, yet it remains a major difficulty (Lucas et al., 1997). In medical education, most information is communicated verbally to large groups of students. Consequently, language comprehension and listening abilities are crucial for learning and necessitate both auditory perception and auditory working memory skills (Mann et al., 2013). Working memory is defined as “the system for the temporary maintenance and manipulation of information, necessary for performance of such complex cognitive activities as language comprehension, learning and reasoning” (Baddelay, 1992: 556). Medical students at SMU come from areas and cultures where they had little or no prior contact with Greek and Latin (ancient languages), from which medical terms are derived. This makes the task of learning a totally new language a serious stumbling block (Lucas et al., 1997). Furthermore, Lucas and co-workers (1997) demonstrated that language could be a critical obstacle to the success in gross anatomy. According to Nnodim (1994) it can be a more significant predictor of success than A-level grades (which has been documented previously).

It has been my experience that the students do not only have to understand the new Anatomy language, but they also require the ability to transfer what they learn in two dimensions from their prescribed textbooks to what they see in the dissection hall (three dimensional), and vice versa. Therefore, research done by Guillot and co-workers (2007) establishing the ability of medical students to be trained in learning functional Anatomy, is of the utmost importance. Guillot and colleagues (2007) therefore investigated the association between spatial intelligence and academic performance in Anatomy. According to Guillot and co-workers, functional anatomy teaching modules place emphasis on acquainting students to the study of the human musculoskeletal system, to examine movement and separate specific muscle groups. Students are taught

on how space is structured to describe anatomical structures: i) relating to anterior-posterior, vertical and lateral planes, on the one hand, and ii) with reference to horizontal, coronal and sagittal planes, on the other. Students are, therefore, commonly required to mentally rotate the skeleton in different planes and to view muscles, insertions and trajectories from static representation and, during muscle contraction, for dynamic representation of any angle. However, for the medical students to be successful in functional Anatomy, they require accurate “visualization of spatial reasoning” and the aptitude to utilise mental imagery associated with mental rotation (Guillot et al., 2007). According to Guillot and co-workers (2007), mental rotation is the capability to make a mental representation of two-and-three dimensional objects turning in space. Another study reported on by Guillot and co-workers (2007), investigated the possible relationship that might exist between high visual-spatial, mental imagery and mental rotation abilities and performance of students in their Anatomy examinations. A correlation was found between spatial abilities and performance, which suggested that students might be using different strategies including mental rotation while studying for Anatomy. Similar results were obtained by Garg and co-workers in studies they conducted in 2001. Vandenberg and Kuse (1978: 599) defined visual-spatial ability as “the ability to mentally manipulate objects in three dimensions”.

Guillot and co-workers (2007: 491) stated that:

“mental imagery refers to the ability to form vivid mental representations of an object or movement, by visualising as many details as possible, and to preserve spatial and temporal characteristics of actual movement”.

Guillot and co-workers (2007) further indicated that the association between mental rotation abilities and human Anatomy learning has received too little attention. This then means that the association between mental rotation abilities and human Anatomy remains a working postulation in anticipation of investigation (Guillot et al., 2007). This study is based on the postulation that if a student lacks the necessary mental rotation capabilities, as well as fundamental English skills, the student will also be challenged by Anatomy as a subject, which is the main area of focus of this study.

1.2 CONTEXT OF THE STUDY

The study was undertaken at SMU, which is a university that serves mainly the previously disadvantaged black population. A small number of white students and Indian students are selected for studies at SMU. All the students that participated in this study were black students, for which English is not their first language.

Three groups of students were used for the aptitude test, namely the first year Nursing, Speech- Language Pathology and Audiology (SLPA) and Radiography students. The majority of students registered for the courses were between 19 – 20 years old and their choice of study might have not been their first choice. Students are accepted into the degree courses on their secondary school marks, without an admission test to determine their abilities. At SMU, students can be accepted into the Nursing and SLPA courses without the school module Life Sciences being a prerequisite.

The aptitude test was developed to determine possible academic vulnerability early in the academic year to help course coordinators identify “at risk” students, and employ necessary interventions to assist these

students. The aptitude test was developed to determine whether English language abilities and the visual-spatial skills of Anatomy students could be used as effective indicators of academic vulnerability.

English abilities were chosen as a possible predictor of academic achievement because it has been the experience of the researcher that students who attend SMU have trouble with English as the medium of education. All lectures, laboratory work, assignments and prescribed textbooks are in English. Students have also exhibited difficulty in understanding basic English language used in Anatomy assessments where students are asked to describe a structure, make an annotated diagram or drawing, to name but a few. When students have to write essay-type answers to questions, most are unable to write an understandable paragraph on the topic at hand. Thus, students demonstrated great difficulty in the use of English and English related tasks.

Why would Anatomy students need visual-spatial abilities? Students need visual-spatial skills, as well as mental rotation abilities to be able to function properly in the dissection hall and to be able to relate different structures in the human body to each other. It has been the opinion of many of the Gross Anatomy lecturers in the Anatomy Department at SMU that the students experience difficulty with extracting structures from their cadaver and transferring what they have learned to the prosected specimens that they see during the practical tests. Some students struggle with orientating structures in different dimensions if it is not asked on a specific cadaver. If the organ chosen for the test is not in the same plane as the pictures in the atlas used for studying, most students cannot identify the item chosen to be identified. Thus, most students find it difficult relating what they see and learn from cadavers and atlases, to what they encounter during their practical tests.

1.3 PROBLEM STATEMENT

Over the past thirteen years at least, a decrease in performance of students studying Anatomy has been observed at SMU, as well as the institutions previously known as Medical School of Southern Africa (Medunsa) and University of Limpopo, Medunsa campus. This has been evident by the marks on record, obtained by the different groups of students studying Anatomy. No obvious cause is known for the decline in student performance, as the curricula for the different courses have remained fundamentally unchanged over this time. However, on a yearly basis, lecturers in the Anatomy Department (SMU) voice the problem they experience with the students' lack of basic English vocabulary. Personal communication with a lecturer involved in the assessment of the National Benchmark Test, supports the fact that the students struggle with English upon entry into university (P. Golparaj, personal communication, 2011).

The selection process of medical students at SMU could contribute to the fact that some students are struggling and failing. No standardised selection method, for example, a selection test which determines the skill set of the selected students, is used. The students are selected on their secondary school marks only, thus there is no way of knowing whether the selected students have the necessary skill set to be successful as health sciences students.

Another possible shortfall of the different anatomical curricula presented to medical, dental and allied health sciences students, is that academically vulnerable students are only identified later in the academic year, after several assessments. This is usually when the half year mark is calculated. Experience has taught me

that students with a half year mark of below 30 percent rarely pass the year with their first attempt. No additional interventions will help these students as they do not have the foundation of knowledge needed in Anatomy to pass. Furthermore, it has been observed by the researcher, that the students, who struggle with Anatomy, also struggle with Physiology and vice versa. At SMU, a student is required to repeat the year of study should they fail either Anatomy or Physiology, since they cannot advance to the next year without having passed all modules.

Informal discussions with lecturers in the Anatomy Department at SMU revealed that academically vulnerable students could possibly be identified by means of a specifically developed aptitude test. This aptitude test should have the ability to determine the capability of the student to manage study material that they will encounter during their Anatomy and Physiology courses. It is essential to keep in mind that students, who have entered universities since the year 2000, are more technologically advanced and respond better to material presented in a way that is related to computers or the internet (Roberts, Newman and Schwartzstein, 2012). This is one of the main reasons why the aptitude test used in the Anatomy Department of SMU is not a paper based test, but designed in a computer program (Toolbook), in order to resonate well with the generation of the students entering university.

Finally and most importantly, it is hoped that the results of this aptitude test will provide the department with an opportunity to distinguish, earlier in the academic year, between academically vulnerable and capable students.

1.4 RESEARCH QUESTION

The primary research question this study attempted to answer was:

Which linguistic and visual-spatial deficits could be identified for first year Nursing, Language Pathology and Audiology (SLPA) and Radiography students, with a specific aptitude test in order to determine academic vulnerability of students at SMU studying the module Anatomy?

Secondary research questions that were investigated:

1. What is the validity (content and predictive) and internal consistency of the aptitude test used to determine academic vulnerability of the selected first year Anatomy students at SMU?
2. How do the results obtained from the aptitude test (academic vulnerability) correlate with results obtained in the first Anatomy test?

1.5 PURPOSE OF THE STUDY

1.5.1 Aim and objectives of the study

The aim of the study was to determine whether an internally developed aptitude test could be utilised to determine the language and visual-spatial abilities of all selected first year Anatomy students, and thus predict academic vulnerability of the Anatomy students at SMU.

This study aimed to achieve the following objectives:

1. Determine whether the aptitude test can measure linguistic and visual-spatial abilities of selected first year Anatomy students, in order to indicate student academic vulnerability.
2. Determine the validity (content and predictive) and internal consistency of the aptitude test.
3. Determine whether there was a correlation between the results obtained in the aptitude test and the first Anatomy test.

1.6 THESIS STATEMENT

In the light of the above, this study aims to determine academic vulnerability of selected first year students studying Anatomy at SMU. This will be determined at the hand of a computer-based aptitude test that will measure English and visual-spatial abilities of students studying the module: Anatomy.

1.7 DELINEATION OF STUDY

1.7.1 Study population

Any medical, dentistry, as well as allied health sciences student who was not available on the specific day and time the aptitude test was taken, was excluded from the sample. Only the Nursing, SLPA, as well as Radiography students could be included in the sample population due to time constraints in the timetables of the other groups of students. Students who did not consent to partake in the study were excluded. No students outside the Anatomy Department were allowed to write the aptitude test.

1.7.2 Skills that were assessed

Although there might be numerous factors influencing student performance and success in Anatomy, only two were included in the study. English language abilities and visual-spatial skills were assessed seeing that these two skills are factors that greatly influence the learning experience of Anatomy students in Anatomy as subject.

1.7.3 Data collection methods

This study made use of a computer-based aptitude test in the Riddel test program only. No additional paper-based test was given to the students who consented to take part in the study. Both short questions and one essay question were included in the test for English ability. This was done to provide a variety of categories of questions to be asked. Only short-type questions were used to determine visual-spatial capabilities. The different categories that were included in the test were the following: 1.) Paragraph construction; 2.) Sentence construction; 3.) Comprehension of paragraphs and diagrams; 4.) Spelling, use of pre-and suffix and synonyms; 5.) Word relationships; 6.) Spatial ability; 7.) Anatomical mental rotation; 8.) Cause and effect determination; 9.) Data interpretation and 10.) Concentration. As per guidelines from the ethics committee, data interpretation and concentration did not form part of the evaluation of the students to determine academic vulnerability as it does not play a role in English or visual-spatial abilities.

1.7.4 Data analysis methods

The content and predictive validity of the test was determined by establishing whether the different components of the test did indeed measure what they were supposed to measure. Furthermore, could it indicate academic vulnerability? No other type of validity was determined as these two categories of validity are closely related to psychometric tests. No statistical significance was determined between the three

groups of students who constituted the study population. The study set out to determine which English and visual-spatial deficits could be identified with the test. The study applied a descriptive quantitative study design with frequency descriptions of the different categories tested in the aptitude test.

1.8 STRENGTH AND LIMITATIONS

A limitation of the study can be considered the recent development of this measuring instrument (aptitude test). Fortunately, the aptitude test has been piloted previously. Small modifications in the content of the test were made for the test to be applicable to the target population.

It is important to state that the institution where the study was conducted started as a new institution known as Sefako Makgatho Health Sciences University. As with the start of any new institution, it also experienced some problems in the smooth organization of everyday operations, which made conducting of the aptitude test with all the initially envisioned groups very difficult. It was envisioned that the medical, dental and all allied health students take the aptitude test. With the limited resources available, only the first year Nursing, SLPA and Radiography students could take the test. Thus, the sample size was much smaller than initially envisioned; only 131 undertook the study in the end. The test consisted of a number of smaller tests (six sub-units for English and three sub-units for visual-spatial ability), and because of the time limit that was set at two hours (length of time that was made available on the time-table by the different course coordinators of the different groups of students), all students that participated did not complete all the sections of the aptitude test. Because only students from the first year Nursing, SLPA and Radiography courses could participate in the study, there is a degree of selection bias in the study.

Reproducibility of the test was high in terms of inter-rater and intra-rater reliability, since the test was computer-based and graded by the computer program. The long question was marked, and classification of students into the different categories was performed by the principal researcher, which could lead to a degree of categorical bias.

1.9 DEFINITIONS

1.9.1 Difficulty index - The percentage of students answering an item correctly, indicates the difficulty level of the item. If a greater percentage of students answer the question correctly, the question is seen as being easier in relation to another question. Optimally, an item will encourage a widespread distribution of scores if its difficulty index is approximately 50%, which indicates that there is an even distribution of easy and difficult questions. A difficulty index of between 20-80% is regarded as optimal.

1.9.2 Discrimination index - The discrimination index is a statistic which indicates the extent to which a question has discriminated between the high scorers and low scorers in the test. This index is represented as a fraction, varying between -1 and 1. Optimally, an item should have a positive discrimination index of at least 0.2, which indicates that high scorers have a higher probability of answering correctly and low scorers have a lower probability of answering correctly. Questions with negative indices should be analysed to determine whether the question was flawed in any way. A discrimination index of between 0.2 and 0.8 is regarded as optimal.

1.9.3 Content validity addresses the match between test questions and the content or subject area they are intended to assess (Validity evidence, 2015).

1.9.4 Criterion-related validity – Predictive validity looks at the relationship between a test score and an outcome. For example, SAT™ scores are used to determine whether a student will be successful in university. First-year grade mark average becomes the criterion for success. Looking at the relationship between test scores and the criterion, can indicate how valid the test is for determining success in college. The criterion can be any measure of success for the behaviour of interest. In the case of a placement test, the criterion might be grades in the course (Validity evidence, 2015). Criterion validity can be divided into construct validity and predictive validity. Predictive validity is the extent to which a score on a scale or test predicts scores on some criterion measure. This study made use of predictive validity as manner in which criterion-related validity was determined.

The measure that will be used to ensure criterion validity is the intersection between the difficulty and discrimination indices. For the difficulty index, any value between 20% and 80% was seen as valid and reliable. For the discrimination index, any value between 0.2 and 0.8 was seen as valid and reliable. These two criteria (20-80% and 0.2-0.8) are continuously used by the Anatomy Department for determining validity and reliability of all assessments that are undertaken on the Riddel test program. The Riddel test program divides the students into four groups, of which there is a clear distinction between the really good students and the poor students. The discrimination and difficulty indices do tell you more about the test and the questions in the test, but the Riddel program has the ability to distinguish between the good students and the weak students. Thus, the assumption is that if a student falls in the good group of students, then they are supposed to do well in the rest of their assessments. This also holds true for the weak students.

1.9.5 Internal consistency Internal consistency (reliability) is a measure of reliability used to evaluate the degree to which different test items that probe the same construct, produce similar results (Test reliability, 2006).

1.9.6 A correlation coefficient is a number between -1 and 1 which measures the degree to which two variables are linearly related. If there is a perfect linear relationship with a positive slope between the two variables, the correlation coefficient would have a value of 1; if there is positive correlation, whenever one variable has a high (low) value, so does the other. If there is a perfect linear relationship with a negative slope between the two variables, the correlation coefficient would have a value of -1; if there is negative correlation, whenever one variable has a high (low) value; the other has a low (high) value. A correlation coefficient of 0 means that there is no linear relationship between the variables (Pearson's correlation, 2015).

1.10 ENVISAGED CONTRIBUTION OF THE STUDY

Currently, SMU only makes use of the secondary school marks obtained by the students, as admission criteria when applying to study any health science course, or as a subsequent predictor of student success. There is no formal test that is undertaken by the students to determine their ability to succeed when studying medicine or related health sciences courses. It has also been established that students who do not speak English as a home / first language, experience difficulty in studying in English. Furthermore, it has also been

postulated that English plays a significant role in achieving success in Anatomy, as it is the medium in which classes are presented. The prescribed books are also in English.

The need for students to exhibit visual-spatial abilities, with a degree of mental rotation, in order to understand Anatomy, has been debated and established. Introducing an aptitude test that measures both English abilities and visual-spatial skills could possibly identify students who will struggle with Anatomy (academically vulnerable) early in the year. This could enable the Anatomy Department to establish a possible intervention program for these academically vulnerable students.

1.11 ENVISIONED APPLICABILITY OF THE STUDY

1.11.1 Need to perform the study

Having been a lecturer in the Anatomy Department at SMU, it has been my experience that students at SMU struggle with English and visual-spatial skills. My concern for this matter has also been voiced by other lecturers in the Anatomy Department who experience the same shortfalls with students in their courses. After studying literature on linguistic abilities and visual-spatial skills, it is my belief that research is needed on how English language abilities and visual-spatial skills affect the performance of students in Anatomy at SMU.

1.11.2 Development of aptitude test

Several universities use an entrance examination for first-time entering students to gauge their abilities before they commence with their relative courses. At SMU, the secondary school marks of the students are used as parameter for entrance into a specific course, or as an indicator of academic success. Therefore, I envisaged that it might be of value to develop an aptitude test that could be utilised by different course coordinators to determine, early in the year, whether a specific student would struggle with Anatomy due to their English language ability and visual-spatial skills. This aptitude test was developed in the Riddel program, which was developed in the department by Dr Ackermann. Most of the different course coordinators use the Riddel program for all their assessments in Anatomy. The aptitude test could be set in such a manner that it will suit the infrastructure of the department, as well as the specific type of student that is selected to study at SMU. Thus, the aptitude test was developed to suit the needs of the SMU community. If the test proves to be a success in determining student academic performance, it might then be used at a later stage as a selection tool for students at SMU.

1.12 BRIEF CHAPTER OVERVIEW

I developed a previously piloted aptitude test which was presented to 131 students that form part of the Nursing, SLPA and Radiography groups of students. The aim of this aptitude test was to determine whether this internally developed computer-based test can be used to indicate shortfalls in the English language abilities and visual-spatial skills of these allied health sciences students.

The second chapter of this thesis deals with the seminal research that highlights the importance of English language abilities and visual-spatial skills in Gross Anatomy. The literature chapter also includes a theoretical framework that examines the importance of linguistic abilities and visual-spatial skills in an Anatomy module. Furthermore, the term “academic success” is unpacked and the influence of English in Anatomy classes, as well as the importance of mental rotation abilities is described.

The third chapter discusses the methodology used in the aptitude test. This study used the Riddel program written in Open Script which is the programming language of Toolbook. This chapter examines the study design and the research instrument used. Furthermore, it describes which student groups form part of the study sample, how the sample was chosen and the setting of the study. The different methods used to analyse the data are also described, together with the limitations and the ethical implications of the study.

Chapters four and five deal with the results of the study according to the research questions stated in section 1.4 of this thesis. Chapter four deals with the first research question by examining each component of the test to determine how the students performed in each sub-section of the aptitude test. Chapter five deals with the second and third research questions, which examine the validity and reliability of the aptitude test. It also examines whether there is any positive correlation between the aptitude test and the first Anatomy test.

The last chapter contains a brief overview of the purpose of the study. It also provides a summary of the findings, together with conclusions drawn from the results. It lastly describes the contributions made by the study and the research planned in the future.

1.13 CONCLUSION

This chapter related the possible impact of English and visual-spatial abilities of students in the Anatomy department at SMU, as seen in literature. As researcher, I attempted to establish the importance of English ability and visual-spatial skills of students, which could possibly be linked to academic vulnerability of students. One of the main reasons for undertaking such an aptitude test is to identify the academically vulnerable students in Anatomy early in the year, so that an intervention program can be put in place for the academically vulnerable students.

The aptitude test consisted of a number of subsections that either tested English language ability or visual-spatial skill. The aptitude test was tested for validity and reliability according to four indices namely difficulty index, discrimination index, criterion and construct validity, and internal consistency. The aptitude test was also compared to the first Anatomy test with the assistance of the Pearson's correlation coefficient.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter focusses on the literature that relates to how linguistic abilities and visual-spatial abilities influence performance of students registered for an Anatomy course related to health sciences education at SMU. The aim of this literature review is to highlight the importance of linguistic abilities and visual-spatial skills in any Anatomy module so that academically vulnerable students might be identified with the help of a specifically formulated aptitude test. This literature review will also attempt to distinguish between what is seen as academic success and academic vulnerability of students. It is important to have a way in which the abilities of the students can be determined so that academically vulnerable students can be identified earlier in the year, rather than later.

Firstly, seminal research on the effect of linguistic abilities on Anatomy will be discussed, including that of Chur-Hansen et al., (2007), Gross (1987), Hayes and co-workers (1994), Hossain et al., (2010), Lucas and co-workers (1997), Mann et al., (2013), Vermunt and Verloop (1999), Vygotsky (1962) and Ypinazar and Margolis (2004). Thereafter, seminal research on the effect of visual-spatial skill on Anatomy will be considered, including Anastakis et al., (2002), Cohen and Hagerty (2007), Garg and co-workers (2001), Guillot et al., (2007), Hagerty and co-workers (2004, 2005, 2007, 2009), Höffler (2010), Lufler et al., (2012), Nguyen and co-workers (2012), Rochford (1985), Vandenberg and Kuse (1978) and Wanzel and co-workers (2002, 2003). These sources were chosen for the review as most of them are substantially cross-referenced and have proved to be influential in the field of assessment testing. Furthermore, this chapter also includes a description of the importance of having a tool to predict the academic success or vulnerability of a student. A measure is needed for universities to be able to distinguish between potentially academically successful and potentially academically vulnerable students. The review further describes the specific role of English and visual-spatial abilities in any Anatomy module. Therefore, the literature review begins with investigating the wider scope of intelligence and how intelligence determines linguistic abilities. The review then focusses on the predictors of academic success and what could be an accurate predictor of success. The literature review ends by looking at the effect of English and then visual-spatial abilities in any Anatomy course. The question then arises whether a new aptitude test can be developed to determine academic success or vulnerability of Anatomy students at SMU.

The idea of using an aptitude test to determine the abilities of first time entering students is not new in general. A theoretical framework is included to explain the background and importance of linguistic abilities and visual-spatial skills in Anatomy. This is necessary to develop a sound understanding of how these two factors work separately and in unison when studying Anatomy.

2.2 THEORETICAL FRAMEWORK

Anatomy is a subject with its own terminology, vernacular use and pronunciation of words. These factors increase the difficulty of English as language of instruction and learning (Lucas et al., 1997). It is important to note, that if Anatomy is presented in English, which is not the first language of the student, they might have trouble with the new terminology as they are not taught in their mother language. Their prescribed text

books will also be in English, which will be a problem if it is not their mother language. Sapir (1929) and Whorf (1941) (both cited in Gross (1987)) were early theorists who hypothesized that language essentially governs thought. According to Gross (1987: 179): "This was based on the logic that: language enables us to form concepts; we think by using concepts, therefore any limitation in language will limit our ability to think". Whorf hypothesises that diverse traditional languages organise their reality in a different way. He asks the question of how language might affect cognitive processes (Whorf in Bruner 1967). This could mean that different ethnic groups have different connotations for the same descriptions in English, which renders cultural diversity in classes even more important to keep in mind.

Piaget (1952), however, argues that language echoes, and is reliant upon the level of intellectual growth at any given moment. Vygotsky (1962) takes the middle path between Piaget and Whorf. Vygotsky argues that language and thought are two separate processes, but that they have to come together at some point in the developmental processes for effective learning to take place (Taylor and Hamdy, 2013).

There is a golden thread that connects all three theories of language by Whorf, Piaget and Vygotsky. If there is a deficiency in English ability of the student, as is the case for most students at SMU, they subsequently have difficulty with the subject as a whole because they are taught in English and their text books are in English. English is important for discourse and communicating one's thoughts in group discussions and in the dissection hall. When students had to provide a simple definition for terminology related to cognitive learning activities as defined by Vermunt and Verloop (1999), they had great difficulty, or were incapable of performing the task. If students then have to proceed and apply these cognitive processes, including thinking in a "foreign language" (Anatomy) to build their concepts and knowledge, it becomes an almost insurmountable task.

Intelligence can be defined in other ways. Gardner (1993: xiv) classified eight intelligences and defines an intelligence as "the ability to solve problems, or to create products, that are valued within one or more cultural settings". According to Gardner (1993) all people possess these intelligences, in that some of them feature more prominently in some people than in others. Gardner's eight intelligences are: verbal-linguistic, musical, logical-mathematical, spatial, bodily-kinaesthetic and naturalist intelligence, as well as two personal intelligences: one directed towards other persons (interpersonal), and one directed towards oneself (intrapersonal) (Gravett, 2004).

According to Gardner (1993) most people are strong in two or three types of intelligence, weak in two or three and average in the others. Statistically, it is only the rare individual who is equally strong in all types or who has only one very dominant type of intelligence. According to Reese (1998), people with verbal-linguistic intelligence are sensitive to the meanings of words and the subtle shades of meaning between words. These people are also masters of syntax, semantics, and phonology and they enjoy word play, puns and rhymes. Individuals with visual/spatial intelligence have the capacity to accurately perceive the visual world, to perform transformations and modifications upon their initial perceptions, and to re-create aspects of their visual experience (Reese, 1998).

Furthermore, if the neuro-anatomy of learning is taken into account, and the existing neuronal networks now become important for learning, it is evident that these students will encounter a challenge. Previous experience and learning in secondary school probably occurred in their mother tongue, so their neuronal

networks and knowledge base in that specific language are very strong. For new learning to take place at university, new neuronal connections need to be forged, but the medium of instruction is now English. These new connections need to be integrated into existing networks, which were forged in a different language, so the student has difficulty with the language and understanding, and the process is thus more distressing.

According to Gravett (2004: 32): "Prior knowledge is always the beginning of new knowledge. One cannot understand something if it is not connected in some way to something one already knows". Learning material that learners encounter as meaningful and noteworthy is coded at a deeper level and retained in an organised structure, so that the person can recollect the information more freely. According to Robertson (1999), most people depend more on verbal than visual-spatial memory. Developing the ability of using visual imagery during deliberate learning could play a part in better storage of information for later retrieval. Furthermore, memory is also enhanced by actively linking the new material to one's prevailing knowledge structures (Robertson, 1999).

All medical professions depend on a detailed understanding of Anatomy, which involves such spatial concepts as the shape of anatomical structures (e.g. the lungs), where they are located relative to each other (e.g. the subclavian vein lies atop the lungs), and how they are connected (e.g. the subclavian vein is a tributary of the brachiocephalic vein). When conducting medical procedures, the internal structures of the body are not directly visible, thus medical professionals have to rely on their mental spatial representations of these structures and awareness of human variability (Hagerty et al., 2007).

Spatial cognition is essential to understanding medical images, including those produced by CT, MRI, X-ray and ultrasound. These medical images are fundamentally two-dimensional representations of three-dimensional objects (Hagerty et al., 2007). In interpreting medical images, specialists have to understand the three-dimensional structure of the anatomy of a specific patient on the basis of a two-dimensional view given in the image and their knowledge of anatomy. Interpretation of medical images, therefore, relies centrally on spatial representations and processes (Hagerty et al., 2007). Surgery, in particular, strongly depends on the internal representations and transformations of spatial information. The surgeon must develop a mental model of internal three-dimensional anatomy based on surface views of cross sections from X-ray, CT, MRI, or ultrasound images.

A relationship has been demonstrated between visualization ability and functional anatomy (anatomy where the function is studied together with the structure), task performance (Guillot et al., 2007), cross-sectional anatomy test performance (Cohen and Hagerty, 2007; Hagerty et al., 2009) and surgical performance (Anastakis et al., 2002; Wanzel et al., 2002). A strong spatial component in the manner that anatomical knowledge is mentally represented, has been suggested by findings such as these. It also suggests that individuals with lower visualization abilities will find it more difficult acquiring, representing and manipulating spatial mental representations of anatomy (Nguyen et al., 2012).

With the introduction of minimally invasive techniques, the surgeon must rely on a video image of the internal anatomy showing anatomical structures from unusual angles never seen in anatomy textbooks, and must use instruments constrained by a fulcrum at their passage through the skin. Consequently, the performance

of surgical tasks requires a broad range of spatial processes in order to plan, navigate, and reason using complex representations of space (Hagerty et al., 2007). Spatial ability has also been related to clinical performance. Wanzel and co-workers (2003) suggested that through experience, surgical performance increases, regardless of individual spatial ability (or manual dexterity), making the case that inherent spatial ability becomes less important as experience takes over.

Seeing that both visual-spatial abilities and linguistic intelligence is important in successfully studying Anatomy, the necessary definitions of academic success and academic vulnerability will be provided. Reasons will also be provided as to why an aptitude test, specifically developed for the SMU community, could be a reliable predictor of student success.

2.3 PREDICTORS OF ACADEMIC SUCCESS

Webster's Ninth New Collegiate Dictionary provides the definition for success as a "degree or measure of succeeding" or a "favourable or desired outcome" (Mish et al., 1983: 1178). It would therefore mean that a student will have success if they accomplish their aim or objective which would be to pass Anatomy. Furthermore, if they then succeed, it would then mean that they pass Anatomy. In this study, the term "student/students" will refer to students at SMU studying Anatomy. Thus, with reference to student success, it would refer to the ability of students studying Anatomy to obtain the desired outcome, which is to succeed in Anatomy. Ultimately, success is reflected by physician competence. However, defining competence is a challenging undertaking, as many cognitive and non-cognitive factors impact on this aspect of success. For this reason individual medical faculties usually develop unique admission measures incorporating more than one domain (Shaban and McLean, 2011). Furthermore, academic vulnerability refers to Anatomy students who are at risk of failing their Anatomy module.

"Academic" in academic vulnerability would refer to the factors that would impact on the success of passing or failing modules of an academic nature. This could mean students struggle with being able to understand what is read, understanding terminology of a subject, coping with the stresses of the curriculum. "Vulnerability" would refer to the inability of the student to pass assessments to promote to the next year of study, meaning the student might be academically challenged or disadvantaged. Secondary school grades, which are used at SMU as part of the selection criteria and possible predictor of success in medical school, cannot really be relied upon, largely because of the inconsistency in secondary school education (Shaban and McLean, 2011). Identifying academically vulnerable students is increasingly imperative in the context of broadening access to answer the demand of higher numbers of student intake (Shaban and McLean, 2011).

Medical faculties are faced with the dilemma of which selection criteria to use that would best predict student "success". It is also important for medical schools to know predictors of academic failure and success, as institutions are trying to assure high completion rates and acquire support mechanisms for students with poor performance (Kruzicevic et al., 2012). It could be possible to detect early warning signs of academic failure by studying factors associated with academic failure and success among medical students, (Kruzicevic et al., 2012). Regardless of the growing use of non-academic factors in the selection process, such as attitude and empathy, pre-admission academic achievement remains a vital consideration. However, the evidence is contradictory in terms of value of academic criteria, such as the secondary school

grade. This relates largely to the variability in secondary school education, which is seen as a measure of academic success at medical school (Shaban and McLean, 2011).

The United States of America, as well as Canada, use the Medical College Admission Test (MCAT) for the screening and selection of medical students (Donnon et al., 2007). Although MCAT scores are used far and wide, and significant research has been completed on its predictive validity, results on particular subset domains (moderator variables, participant characteristics and medical school performance) remain uncertain (Donnon et al., 2007). SMU currently does not have any formal testing method that forms part of the selection process. There is also no test available that has been specifically designed for the students with the socio-cultural background as those attending SMU. This further emphasises the importance of developing an aptitude test, specifically for the Anatomy students at SMU, which will initially be used to determine academic vulnerability of students. Should the aptitude test prove to be valid and reliable after piloting of this new version of the test, it could possibly be further adapted to the needs of the SMU community and then applied later for the student selection process at SMU.

To be able to establish the proper predictors of success in an Anatomy course, the two variables that have been identified in the Anatomy department of SMU need to be considered. These two variables include linguistic ability and visual-spatial skills. The question therefore arises how English as language would influence Anatomy performance.

2.4 USE OF ENGLISH IN ANATOMY

As already stated, Anatomy is a subject with its own terminology, lingua franca and articulation of words which increases the difficulty of English as the language of instruction and learning (Lucas et al., 1997). A study by Lucas and colleagues (1997) on Hong Kong medical students, found that students who were taught at secondary school in their mother tongue were greatly disadvantaged when they attended university in English. Medical schools, Anatomy education and Anatomy books are mainly available in English. The students from Hong Kong were given the same Anatomy test, one in their mother tongue and one in English. The students performed better when the Anatomy test was completed in their mother tongue (Lucas et al., 1997), which would mean there is a difference between the language of study and the language of assessment. It could be worthwhile to undertake a study which examines in which language most of the students and SMU study. Do they use English to study (which would then also be the language of assessments which is important), or do they translate everything to their mother language and then do assessments in English? If there is a deficiency in English ability, as is the case with most students at SMU, it is hypothesised that they will also have difficulty with the subject (Anatomy) as a whole. A sound theoretical and practical understanding of English is therefore essential.

The ability to use correct grammar, spelling and basic literacy skills is essential in medicine (Chur-Hansen et al., 2007). As in many parts of the world, students are disadvantaged in terms of the English language, which is also true for South Australia. At the University of Adelaide in South Australia, students are not assessed for potential difficulties with regard to their English language skills, although they have already been accepted to the course. Many of the students are quite disadvantaged due to a lack of an assortment of proficiencies in English for tertiary education (Chur-Hansen et al., 2007). Ypinazar and Margolis (2004)

discussed the linguistic boundaries of first year medical students in the Arabian Gulf. They observed that social anthropology can be considered as a strategic mix of language with culture and that both culture and social systems are conceptualised in language. This would suggest that students studying medicine in English, their second language, could be subjected to conflict between the contents of the courses and context of their everyday lives.

Along the same vein, Hayes and colleagues (1994 cited in Hossain et al., 2010: 32) state the following about non-English speaking pre-clinical medical students in Australia: "Lack of minimum level of competence in English seriously jeopardises the ability of students to listen to, participate in and understand classes, to read textbooks, to sit for written, oral or practical examinations and prepare assignments".

Various other studies (Lacina, 2002; Ridley, 2004) have identified language barriers as negative factors for student academic achievements. A direct correlation has been reported by Salamonson and co-workers (2009) amongst first-year nursing students. This correlation was made between low English test scores and low academic grades for students for whom English is a second language.

Except for linguistic ability that has been indicated to play a significant role in Anatomy performance, another factor that can influence academic success in Anatomy is visual-spatial ability. It is therefore necessary to study the effect of visual-spatial ability on academic success in Anatomy.

2.5 VISUAL-SPATIAL ABILITIES IN ANATOMY

Spatial ability has been found to be a good predictor of academic success in learning anatomy and examination performance (Garg et al., 2001). Visual-spatial ability has been defined as the ability to mentally manipulate objects in three dimensions (Vandenberg and Kuse, 1978). Mental imagery refers to the capability to form vivid mental pictures of an object or a movement, by seeing as many details as possible in one's mind's eye, and then store spatial and temporal features of actual movement (Guillot et al., 2007). Medical students need spatial abilities early in their education during the study of gross Anatomy (Lufler et al., 2012).

Even though Anatomy can be taught in a variety of ways, the spatial ability of the student plays a crucial role when using different learning resources such as atlases, illustrating structures in numerous positions and making use of different angles (Garg et al., 2001). An essential part of medical education and the study of gross anatomy, is the ability to learn spatially complex relationships (Garg et al., 2001). Rochford (1985) conducted a four-year long study at the University of Cape Town, examining the spatial learning disabilities and underachievement among university Anatomy students. He concluded that spatial learning disabilities varied from student to student, but may involve an inability to envision a given section through an object. Underachieving could also include an incapability to distinguish the obvious changes in the shape of an object when rotated in three dimensions.

Furthermore, underachieving could include an inability to keep in mind the relative positions of the structures of a given body rotating in space, a failure to mentally synthesize the orthogonal sections of a given object to form an image of the whole. Rochford (1985) also found that each year, about a third of the new Anatomy students at the University of Cape Town began their course with unmistakably measurable spatial deficits,

and that these deficits occurred among high-, medium- and low- achievers in Anatomy. Although most of these students gained anatomical spatial skills over a period of 2-8 months, about 7-10% of students did not.

Research has shown that the inherent spatial abilities of students in the medical course play a critical role in their ability to learn anatomical spatial relationships (Lufler et al., 2012; Garg et al., 2001). Guillot and co-workers (2007) found significant correlations between visual-spatial abilities and results on a test composed of rotated anatomical structures. A relationship was shown between the visual-spatial ability and a student's ability to identify anatomical structures when shown rotated in 3D space in these studies. Spatial relation ability, assessed with the mental rotation test, has been indicated as being involved in the construction of an internal description of a 3D structure, in specific processes or tasks such as understanding relationships between the bones and the skin (Garg et al, 2001), understanding names and locations of structures in cross-section views (Luursema et al., 2008), and in mentally turning a structure in order to find a matched viewpoint (Guillot et al., 2007). Conversely spatial visualization ability, measured with the group embedded figures test, seemed to be involved more specifically with the identification and the visual disembedding of a structure from a multifaceted 3D environment (Guillot et al., 2007).

Studies done on geometrical exercises, mathematics and veterinary education suggest that educators could use knowledge of students' visual-spatial abilities to select pedagogical approaches that may help students adjust their approach to learning. Early recognition of students who possess weak visual-spatial abilities coupled with appropriately targeted academic interventions, may lead to greater success in medical gross anatomy and in other aspects of their medical training (Lufler et al., 2012). Essentially, students with high spatial abilities perform better (Yang et al., 2003; Höffler, 2010), whereas students with low spatial abilities make more errors (Hagerty, 2004; Hagerty and Waller, 2005).

2.7 CONCLUSION

Literature shows that English abilities, as well as visual-spatial skills play a crucial role in the ability of a student to be academically successful in Anatomy. Students, who have to study in English and not their own language, struggle with new modules in English, especially Anatomy. Anatomy has its own anatomical terminology and its own way of describing the subject. Students struggle with this anatomical language because it is in English (derived in part from Latin and Greek), and not their mother language. Also, for learning to take place, existing frames of reference are needed to build the new knowledge. For students who only know English as a secondary language it becomes a very difficult task to now form meaningful connections between work that is already known, and new information (Anatomy).

Furthermore, literature has shown that if a student struggles with English as language, chances are good that the student will also struggle with Anatomy. It is therefore important to determine the English linguistic abilities of students to be able to distinguish whether a student will be successful in Anatomy.

Moreover, visual-spatial abilities have been shown to play a critical role in the performance of any health care student in an Anatomy course. If students do not have the ability to manipulate any 3D structure in space, they will have trouble identifying structures in their cadaver, as well as experiencing difficulty during prosected specimen practicals.

However, there is no clear indication in literature that an aptitude test can clearly indicate future academic success of students. There is, therefore, a gap in the current knowledge of what should be used as a possible indicator of academic success and vulnerability of students at university. This study therefore aims to determine whether an internally developed aptitude test could possibly be utilised to indicate the possible vulnerability students face in Anatomy, if they struggle with English and visual-spatial ability. There has until now been no means of testing at SMU to determine the ability of students. It would therefore be advantageous to develop a method that course coordinators could use to determine whether the students will struggle in Anatomy if the two variables, English ability and visual-spatial skill are taken into account.

The following chapter will examine the study design, sample population used and also the methodology employed to develop the aptitude test. Research instruments utilised in the aptitude test will also be described. Finally, the chapter will reflect on the data analysis tools utilised to determine the validity and internal consistency of the aptitude test, and to determine whether a positive correlation could be achieved between the aptitude test and the first Anatomy test that the students wrote.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

The purpose of this study was to determine whether a test developed in the Anatomy department at SMU could be used to determine which English ability and visual-spatial skill deficits could be identified which could possibly play a role in academic vulnerability. This research attempted to determine the validity of the results by making use of content and predictive validity. Lastly, the test attempted to establish whether there is a possible correlation between the results obtained in the aptitude test and the first Anatomy test of the study population.

This chapter will focus on the research design, followed by the sample population, sample setting and sample selection. The research instrument that was used in the study (Riddel program) will then be discussed, ending with the ethical considerations for this study.

3.2 RESEARCH DESIGN

The research followed a quantitative research approach with two different components: one component to determine ability (a psychometric research design), and the other to establish a possible correlation between two units – a correlation-based research design (Ringsted et al., 2011).

Psychometric studies fall into the group of explorative studies with the purpose of modelling by seeking to recognize and describe components of phenomena and their interactions. Modelling is achieved by distinguishing, defining and evaluating fundamental attributes and systems of behaviours, phenomena, interventions, measurements and measurement instruments, amongst others. Explorative studies are not only performed for the purpose of modelling, but also as a precursor for planning experimental studies and delineating appropriate interferences and outcomes (Ringsted et al., 2011). Psychometric studies are intended for authenticating the validity and reliability of measurement instruments. Psychometry is the discipline pertaining to psychological testing, and to any quantitative analysis of an individual's psychological traits or attitudes or mental processes (Stedman's Medical Dictionary). An aptitude test is an occupation-oriented intelligence test used to evaluate a person's abilities, talents and skills, particularly valuable in vocational counselling (Stedman's Medical Dictionary).

When researchers aspire to investigate whether there is an association between the variables in their study, but an experimental or quasi-experimental study design cannot be used, they utilise correlational studies (Tavakol and Sandars, 2014). In correlational studies, researchers debate the relationship between variables in theories or paradigms, for example: "What is the association between student ability and their score on the UK Clinical Aptitude Test (UKCAT)?" (Tavakol and Sandars, 2014: 754). By approximating the correlation concerning student marks and UKCAT scores, researchers can examine the correlation between student aptitude and UKCAT tests (Tavakol and Sandars, 2014). In this study, a measuring instrument (Riddel program), which has been previously piloted, was tested and used to determine the language abilities and visual-spatial skills of Anatomy students. The results from this aptitude test, with regard to academic vulnerability, were then used to determine whether there is a possible correlation to their performance in

Anatomy. Confounding variables in this study included the time of day the test was undertaken, fatigue level of the students, temperature in the computer labs where the tests was written and the age of the students.

3.3 METHODS

3.3.1 Sample population

All medical, dentistry and allied health sciences students within the Department of Anatomy were invited to write the first-time entry computerised aptitude test, but due to time constraints, only the first year Nursing, SLPA and Radiography students completed the aptitude test. At the beginning of the introduction week (one week before the test was scheduled), it was explained to all students involved in the study that the research is aimed at determining academic vulnerability early in the year. This will enable course coordinators to establish the necessary interventions to help these students. Students were also provided with a half-hour period during which the participants could ask the researcher any questions deemed important. The test took place the week after the introduction week. The time and place where the study was to occur were communicated with the students when the introduction of the study took place. Furthermore, students were also informed that undertaking the test was completely voluntary and students were provided with a consent form to sign should they decide to partake in the study.

Students who consented had to submit their signed consent forms as entry requirement for the test. It was also explained to the students that signing the consent form provides consent to the researcher to inform the individual course coordinators of candidates who are deemed to be possibly academically vulnerable students. Awareness of the presence of possibly vulnerable students in the group may encourage the lecturer to change the manner in which lectures are presented to the group, as well as helping lecturers to observe those who have been indicated as possibly vulnerable. Part-time Anatomy lecturers assisted the students during the two hour period when the test was undertaken and the researcher was not involved in the administration of the test. The part-time Anatomy lecturers were all trained on the Riddel program and were familiar with all aspects of the program.

3.3.2 Study setting

The aptitude test was undertaken by first year Nursing, SLPA and Radiography students within the Anatomy department at SMU. Students within the same course wrote at the same time, making use of the different computer facilities on campus, depending on the number of students in each group. The test was completed within a two-hour timeframe. Students who completed the test before the two hours were over, were allowed to leave the venue. The test was scheduled for 08:00 to control for the time of day that the test is undertaken, as well as the fatigue level of the students. Students were also allowed a five minute rest period half-way through the test to prevent them from becoming excessively tired during the test. Complete silence was maintained in the computer laboratories to enable the students to concentrate. Air-conditioning systems in the laboratories allowed the temperature to be regulated at comfortable levels. It is important to control these confounding variables as much as possible so that these factors do not play a role in the results obtained for the study.

3.3.3 Sample selection

All first year Nursing, SLPA and Radiography students who had agreed to take part in the study, by signing the consent form (Appendix 1), were included in the sample population. To ensure that bias was minimised, all students registered for first year Nursing, SLPA and Radiography, were recruited for the study. The students form part of different courses, and the aim of the study was to determine possible academic vulnerability. Therefore, no student from any of these courses was intentionally excluded as it would be unfair and unethical towards those who were being excluded.

Inclusion criteria: All consenting first year Nursing, SLPA and Radiography students who had access to the test on the specific day and time for when the test had been scheduled, were included in the sample population. First year students older than 19 years were noted on the information page collected, to distinguish other variables that could also influence academic vulnerability. Students older than 19 years were not excluded. Their results were analysed while keeping in mind that they were older than the rest of the class, which was also mentioned to the course coordinator.

Exclusion criteria: Any first year Nursing, SLPA and Radiography student who was not available on the specific day and time the aptitude test was undertaken, was excluded from the sample. Also, those students who did not consent to partake in the study were excluded. Students who repeated the course were excluded from the study, even if they consented to partake in the study, as they were already seen as academically vulnerable for having failed Anatomy the previous year.

3.3.4 Sample size

The following equation was used to determine sample size:

$$\text{Sample size} = \frac{(Z)^2 \times \text{std. dev.} \times (1 - \text{std. dev.})}{(\text{margin of error})^2}$$

Z value – confidence level of 90% = 1645; margin of error = 0.04; std. dev. = 0.2

= 120 participants

Thus the 131 students included in the study will be adequate to make informed conclusions about the results.

3.4 RESEARCH INSTRUMENTS

A computer-based test that was developed as a computer-based assessment program (Riddel) was adapted to test the aptitude of the Anatomy students after their introduction week in the Anatomy Department. This program is also used by the Anatomy Department for most of the courses for their theory block assessments.

Riddel is a program that can be used for official tests on a network or assignments offline. It is a replacement for a paper test. Riddel simulates the paper test process. The lecturer controls the whole testing process by setting up the test, loading the test on the network, retrieving the marks, marking written questions, evaluates the test and releases the marks.

Features of the program:

- Provides feedback from users that are using the program offline.

- Runs on a network where it links up with a data base to which all the information of the test is send to when it is used for summative or formative assessment. The information can be statistically analysed.
- The test is compiled on a computer onto which the editing version of the program was installed. Learners can access, but not edit, the program after a reader program was installed on their computers.
- The test is compiled, offline, like a presentation. The names and numbers of the users are incorporated in the test. This test file can then be used in 3 ways:
 - It can be used, offline, as an assignment where the test presents the user with a unique “completion code” when a set percentage is scored. This code can then be used as proof that the test has been completed successfully. If the percentage, normally 80%, is not achieved the user has to redo the test until the required percentage is achieved. A number of assignments can also be put in sequence. The completion code of the first assignment is then required to open the second assignment and so on.
 - Instead of the completion code the program can, after completion, provide the user with a mark and a code which can be converted into a percentage.
 - Riddel can also be used on a network. The test is loaded onto a server as a read only file. Users log in, in the computer lab, click an icon on the desktop to open the test. Depending on the setup the test will show the users their marks at the end of the test or not.

Riddel writes all the responses of the users back to the server from where it is retrieved with an extractor file.

The following statistics are done on the marks:

- % correct for each question.
- Difficulty index
- Discrimination index
- Questions that were answered incorrectly by the better learners
- Questions that were answered correctly by the weaker learners
- Averages
- Highest mark
- Lowest mark
- Time for the test
- Time spend on each page
- Occurrence of each answer
- The program also draws a graph of the distribution of marks.

This internally developed, and previously piloted aptitude test was adapted to form an aptitude test to measure the English abilities and visual-spatial skills of the Anatomy students to finally determine academic vulnerability. All the lecturing staff in the Anatomy Department provided questions which they though relevant to the purpose of the aptitude test. Questions that tested the two skills – English ability and visual-spatial skill were included. The lecturers, upon doing some research, decided which type of questions should be included in a section to ultimately determine English ability and visual-spatial skill.

The pilot test was rolled out to 55 dentistry students as their curriculum is very similar to that of medicine. Furthermore, this group is smaller than the medical group of students, which increases the ease and the speed with which the results could be analysed. 26 of the 55 students passed the aptitude test. The highest mark obtained for the test was 64% and the lowest mark was 26%. Because of the results obtained with the aptitude test pilot, important changes were needed in the aptitude test. The test was divided into different sections for the linguistic ability (six subsections) and visual-spatial ability section (three subsections) after it was found that the performance of students for a specific section could not be determined. The previous piloted study, at the University of Limpopo, did not contain any questions pertaining to linguistic abilities and had no verified visual-spatial questions, only “Match” and “Compare”-type questions of different views of Anatomy specimens. This test could not clearly predict academic vulnerability which necessitated that modifications be made to the test. The test also included tables and graphs supplied by the Physiology department, which has now been replaced by adapted graphical questions (data interpretation) set by Newton and Bristoll (2009). The current aptitude test includes English questions with the same format as questions obtained from the practice test Psychometric Success (psychometric-success.com), which was adapted to suit the possible community that would write the test at SMU. These English categories of questions also compare with questions tested by Hossain and co-workers in 2010 (Gwee, 2009; Hossain et al., 2010), as well as Chur-Hansen and Vernon-Roberts (2000).

The results of the tests were transcribed to a data collection sheet on a local server and stored as percentages, after which the examiner had to extract the results from the server with a specifically developed test extractor. The content of the test (type of question; number of pages in the test; number of questions per page; should a picture for the question be included) can be changed to the requirements of the examiner, which makes this program unique to SMU. The percentages were used on the grading scales to determine academic vulnerability in English and visual-spatial abilities. The Riddel program provides a percentage for the performance of each student for each component of the test that was recorded on the data collection sheet. All the tests for the English and visual-spatial ability were totalled (percentages) separately and the average for each component determined separately. The only component of the test that the researcher had to score according to a Likert scale, was the long question which required the student to write a paragraph.

English and visual-spatial questions were adapted from practice tests available on the web-page, “Psychometric Success”, assembled by Paul Newton and Helen Bristoll (Newton and Bristoll, 2009). Pictures obtained from several anatomy atlases, displaying the same anatomical structure (for example the heart, forearm, kidney) but from different angles, were included in the test, in order to evaluate whether the students could identify the same structure from different angles. “Psychometric Success” is a website that offers a number of free downloadable practice aptitude tests with answers, to any person who has to undergo any form of aptitude testing, be it for entry into university or when applying for a new job. These tests, set by two experts in the field of aptitude testing, are available for practice purposes at psychometric-success.com and are used by various institutions for testing of candidates as a new employee. A number of electronic books (e-books) can also be purchased from “Psychometric Success” to practice for different aptitudes needed for different situations.

The test was structured according to the categories of questions and evaluative scales in studies conducted by Hossain and co-workers in 2010 (Gwee, 2009; Hossain et al., 2010), as well as Chur-Hansen and

Vernon-Roberts (2000). Multiple choice questions and a single long question were used to assess the English knowledge and abilities of the students. The parameters used by the previously mentioned authors were also used by Holbrook and Bourke (1989) and Cobbin et al., (1992) (both cited in Hossain et al., 2010) in their “English Skill Assessment Test” (ESA).

The following areas specific to the English language, which is used in Anatomy, was tested:

- **Reading comprehension** – Understanding main ideas; Understanding direct statements; Making conclusions
- **Vocabulary** – Identifying a synonym; Understanding the use of prefix and suffix
- **Spelling** – Applying the knowledge of homophones in spelling; identifying the correct spelling of words commonly used in the field of medicine
- **Other areas** – Changing tenses; Understanding phrases; Understanding the meaning of a group of words and selecting, from a given list, a word that corresponds to the words in the group

Student performance was determined on an arbitrary grading scale as used by Hossain and co-workers (2010), which categorises the level of difficulty students had with “English used in Anatomy” (as indicated by their performance).

- **Grade 0** – No difficulty in executing the tasks at all; 80.01% and above correct responses
- **Grade I** – Can execute most of the tasks with very little difficulty; 60.01 – 80% correct responses
- **Grade II** – Some difficulty, to adequate ability in executing the tasks; 40.01 – 60% correct responses
- **Grade III** – Can execute some of the tasks, but with great difficulty; 20.01 – 40% correct responses
- **Grade IV** – Cannot perform the tasks at all; up to 20% correct responses.

The long question included in the test required students to describe the process of blood flow through the pulmonary and circulatory systems, using a provided diagram, in their own words. This paragraph was then used to determine fluency in written expression. The following parameters, which were used by Chur-Hassen and colleagues (2007), were used to assess the text:

- Does the student understand what is exhibited in the picture (comprehension and analysis)? Can this information be converted into a written paragraph to correctly relay the information expressed in the diagram (synthesis)?
- Use of appropriate vocabulary and terminology (integration and paraphrasing).
- Does the student demonstrate the ability to use correct spelling, punctuation and capitalization?
- Is the paragraph fluent (coherence of sentences)? Does it clearly communicate the sequence of events that take place in the diagram?
- Overall impression: all things considered, can the student effectively explain the concept, through a comprehensive paragraph, to another person?

In terms of the long question as described above, the students were then graded for each category listed above by means of a Likert scale, where 1 indicates poor ability, 3 indicates adequate ability and 5 indicates excellent ability.

Success in the visual-spatial section of the test is expressed on a similar Likert-scale (Grade 0 to Grade IV related to percentages obtained in the tests) as used in the evaluation of the short questions for the English

component. This should effectively determine the ability of the student to complete the exercise, according to a grade scale of difficulty.

Table 1 below illustrates the questions that were included in the test:

Table 1: Questions included in aptitude test

Question type	Origin	Reason for inclusion in test	Validity and reliability
Sentence construction	Developed by researcher	Students must be able to construct sentences when writing reports in later years of study	Determined during the study itself
Comprehension	Developed by researcher	Students must be able to understand what they read in their textbooks, either from text or from pictures	
Spelling	Developed by researcher	Students must be able to spell words related to the health sciences. Examples: severely, Medicine, easily, likely, sufficient etc.	
Prefix and suffix	Developed by researcher	Students must be able to understand specific pre- and suffixes related to the health science	
Synonyms	Adapted from "Psychometric Success"	Students must know the correct synonyms used during their secondary school years	
Verbal ability with regards to drawing Inferences from word relationships	Adapted from "Psychometric Success"	This is a higher function of English ability. Students must be able to draw inferences and build relationships between words in a group	
Homophones	Developed by researcher	Students must be able to choose the correct homophone in a sentence to construct verbally correct sentences	
Spatial ability	Adapted from "Psychometric Success"	Students must have the ability to turn objects in space (to determine whether students will have difficulty with this action during dissection and practical tests)	
Anatomical mental rotation	Developed by researcher	By looking at different pictures of the same structure, from different angles, the student must be able to identify the same structures on both pictures	
Cause and effect	Developed by researcher	Student must be able to predict the outcome of a movement or a nerve being severed (this will indicate whether a student can determine origin and insertion of muscles by just learning the action of the muscles)	

The time a student took to complete the test was not considered as a factor of academic vulnerability.

3.5 DATA ANALYSIS

The following indices are automatically determined by the aptitude test program as soon as the results are transcribed to the server and extracted by the examiner:

Difficulty index - The percentage of students answering an item correctly indicates the difficulty level of the item. The more students answer a question correctly, the easier the question. Optimally, an item will encourage a widespread distribution of scores if its difficulty index is approximately 0.5, which indicates that there is an even distribution of easy and difficult questions.

Discrimination index - The discrimination index is a statistic which indicates the extent to which a question has discriminated between the high scorers and low scorers in the test. This index is represented as a fraction, varying between -1 to 1. Optimally, an item should have a positive discrimination index of at least 0.2, which indicates that high scorers have a higher probability of answering correctly and low scorers have a lower probability of answering correctly. Questions with negative indices should be analysed to determine whether the question was flawed in any way.

By utilising the discrimination and difficulty indices the Riddel program makes it possible to distinguish between the really good, the average and the poor students. Thus, the Riddel program with the two indices indicate the students that perform well, and it is believed that if a student performs well in one assessment, they are supposed to perform well in most of their assessments. These two indices within the Riddel program therefore have a degree of predicting what might happen in future.

To determine the content validity of the test, a description will be provided of the questions that were contained in both sections of the test. A statistician was consulted to perform basic descriptive statistics, including frequency counts and percentage calculations. Furthermore, Cronbach's alpha test and correlation analysis was performed (Appendix 2).

To determine the internal consistency of the aptitude test, **Cronbach's alpha-test** was used to determine whether the different subsections within the English and visual-spatial sections of the test deliver the same results. English was not compared to visual-spatial ability. Predicted reliability (α), is calculated as:

$$\alpha = \frac{RK}{[1 + (K - 1)R]}$$

Where R is the mean of the inter-item correlations and K is the number of items considered.

Pearson and Spearman correlation analysis was used to determine the linear relationship between academic vulnerability (independent variable) and the results obtained in the first Anatomy block test (dependant variable). Academic vulnerability and the Anatomy block test mark were expressed as the percentages obtained for the tests. Possible academic vulnerability was only postulated if a positive correlation was made between the averages of the English and visual-spatial tests and the first Anatomy block test.

3.6 LIMITATIONS

It is important to state that the institution where the study was conducted is a new institution known as the Sefako Makgatho Health Sciences University. As with the start of any institution, the institution also experienced some challenges in the smooth organization of everyday operations, which made conducting of

the aptitude test with all the initially envisioned groups very difficult. It was envisioned that the medical, dental and all allied health students undertake the aptitude test. Circumstances rendered it impossible and consequently only the first year Nursing, SLPA and Radiography students could undertake the test. Thus, the sample size was much smaller than initially planned. The test consisted of a number of smaller tests (six sub-units for English and three sub-units for visual-spatial ability). Because of the time limit that was set at two hours (length of time that was made available on the timetable by the different course coordinators of the different groups of students), not all students who participated completed all the sections of the aptitude test. Thus, an individual student might have an incomplete aptitude test for the two hour duration of the test. Because only students from the first year Nursing, SLPA and Radiography courses could participate in the study, there is a degree of selection bias in the study.

3.7 ETHICAL CONSIDERATIONS

Authorisation to conduct the study within the Anatomy Department was obtained from the departmental head. The protocol was submitted to the Stellenbosch Health Research Ethics Committee (HREC) (S15/04/084), as well as the Sefako Makgatho University Research Ethics Committee (SMUREC) for ethics clearance.

Informed consent forms and information leaflets (Appendix 1) were distributed to the students with the commencement of the introduction week during an explanation of the study. After the introduction to the study session, the consent form was signed by only those students consenting to partake in the study. All students were assured that all results and all answers would be confidential. This study did not foresee that the students would endure any risk or discomfort by partaking in this study, since participants would not be exposed to any dangerous substances or situations. The study was conducted according to the International Declaration of Helsinki and other applicable international ethical codes for research on human subjects.

The students completed the aptitude test by using their assigned student number and not their name and surname, to increase the security and anonymity of the test. This was necessary to be able to identify the “at risk” students and to be able to correlate the results of the aptitude test with the results of the first Anatomy test. If any of the data should be used in a publication, any personal identifier would be removed so that none of the data could be linked to a single student. Each student was provided with a unique completion code at the end of the test which was used as an identifier from then on. No student numbers were used after obtaining the unique codes in the test. A password protected file linked the unique codes to the specific students. No person other than the principle researcher had access to the password protected file with the unique codes and the student numbers. Only the principle researcher knew which code referred to which specific student.

Each student was supplied with an information leaflet regarding the need for completion of the aptitude test (Appendix 1) during the introduction to the study session at the beginning of the introduction week. None of the obtained or recorded personal information, such as student numbers, will be used in future publications or presentation of results. All personal information will remain confidential at all times, and will be filed in the departmental safe for safekeeping, for 10 years. No academically vulnerable student will be “labelled” as

such, and will also not be treated any differently from any other student registered for the Anatomy course, apart from receiving appropriate and necessary interventions when necessary.

3.8 CONCLUSION

This chapter focussed on the sample population, setting and research instrument used.

The next chapter will reveal the results obtained after the tests were completed. The results will be presented in such a format that will link them to the three objectives of the study, which are to:

1. Determine whether the aptitude test could measure linguistic and visual-spatial abilities of selected first year Anatomy students, in order to indicate student academic vulnerability.
2. Determine the validity (content and predictive) and internal consistency of the aptitude test.
3. Determine whether there is a correlation between the results obtained in the aptitude test and the first Anatomy test.

The following chapter will also discuss the results obtained for the three groups of Anatomy students who participated in the aptitude testing. It will investigate whether the aptitude test could indicate academic vulnerability by means of the two variables: English language abilities and visual-spatial skills. A description will also be provided on how the difficulty and discrimination indices were used during the analysis of the results. Lastly, results will be discussed regarding a possible correlation between the results obtained in the aptitude test and the performance of the students during their first Anatomy test.

CHAPTER 4: FINDINGS OF THE LINGUISTIC AND VISUAL-SPATIAL ABILITIES OF STUDENTS

4.1 INTRODUCTION

This research project made use of a quantitative research approach with two different components: one component to determine ability (a psychometric research design), the other to establish a possible correlation between two units – a correlative research based design (Ringsted et al., 2011). The psychometric aspect of the study made use of a computer program (Riddel) developed by Dr Ackermann (developed and used since 2009) of the Anatomy Department. This Riddel program is utilised for most of the assessments of several departments at SMU. This Riddel program was then further applied to develop this psychometric test, with the addition of some material from Psychometricsuccess.com, to develop an aptitude test that could possibly determine the English language abilities and visual-spatial skills of the Anatomy students within the Anatomy department at SMU.

This chapter focuses on the research results obtained for the first research question of this study. It will attempt to identify the linguistic and visual-spatial deficits that can be identified with the aptitude test to predict possible academic vulnerability by studying the results obtained for each individual component of the test. After this, the next chapter will focus on the validity and internal consistency of the aptitude test, as well as how the results obtained in the aptitude test correlate with the first Anatomy test marks of the students who did the assessment.

One hundred and thirty-one (131) students took part in the aptitude test, but not all the students completed all the sections of the test. Because only the number of students that completed the test is used in the calculations, it does not affect the outcome of the results. Therefore, the number of students that completed the linguistic ability section of the test did not necessarily complete the visual-spatial ability section of the test. A total of 67 Nursing students, 28 SLPA students and 36 Radiography students took part in the aptitude test. The total number of students that completed the linguistic abilities and visual-spatial skill section of the test is demonstrated in Table 2.

Table 2: Number of students from the Nursing, SLPA and Radiography groups that completed the linguistic and visual-spatial abilities sections of the test

	Linguistic ability of aptitude test	Visual-spatial skill of the aptitude test
Nursing students	61 of 67	61 of 67
SLPA students	26 of 28	25 of 28
Radiography students	35 of 36	30 of 36

Any further reference to the number of students that completed the test and for the calculation of percentages to determine total ability of students to perform the test, will refer to the number of students who completed the relevant section of the test, and not the total number of students who took part in the study.

4.2 RESEARCH QUESTION 1:

Which linguistic and visual-spatial deficits could be identified with a specific aptitude test in order to determine academic vulnerability of selected first year students at SMU studying the module: Anatomy?

4.2.1 Linguistic abilities of students

4.2.1.1 Ability to write a paragraph

The students were required to write a paragraph by means of a picture provided (Figure 0-1), to describe the pulmonary and systemic circulations. Students had to coherently describe how oxygenation and de-oxygenation of blood occurs, how blood flows through the lungs and the processes in the systemic capillary beds. Students were tested on their ability to understand what is depicted in the picture. Their ability to perform this task enabled them to obtain marks for comprehension and analysis. If the student had the ability to write a paragraph with the correct information on what was seen and depicted in the diagram, the student obtained marks for the ability to synthesise new information from existing material. Furthermore, if students were able to use the correct vocabulary and terminology, marks would be provided for integration and paraphrasing abilities. Students also obtained a mark for writing coherent sentences and clearly communicating, in a logical order, the events that take place in the picture. Lastly, the student obtained a mark for the overall impression the researcher got of the paragraph. In terms of the long question as described above, the students were graded for each category listed above by means of a Likert scale, where each ability was linked to a mark out of 10. A value of 1-3 indicated that the task required much more attention; a value of 4-5 indicated that the activity required some more attention; a value of 6-8 indicated good abilities and a value of 9-10, excellent abilities. .

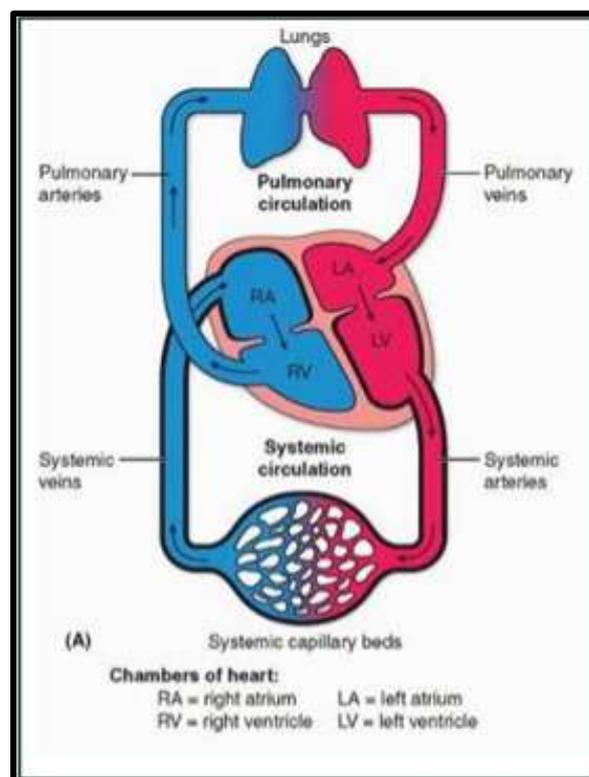


Figure 0-1: Picture depicting the blood flow through the pulmonary and systemic circulations with the processes of oxygenation and de-oxygenation in the human body

The Anatomy students who took part in the study scored mainly on the scale of “needs more attention” for all the sections on the ability of writing a paragraph. For the comprehension and analysis sections, where students had to describe what is seen in the picture and logically describe what is seen, students scored an average of 4.7 ± 0.1 (mean \pm standard deviation) and 4.9 ± 0.3 , respectively. For their ability to correctly use vocabulary and terminology and demonstrate their ability to integrate what is seen and use the correct paraphrasing, students scored an average of 5.0 ± 0.3 and 4.9 ± 0.3 , respectively. The students also had difficulty with the construction of sentences to get the meaning of the picture across to the reader, where they scored an average of 4.5 ± 0.4 (Table 3; Figure 0-2).

Table 3: Average ability of the Anatomy students to write a coherent paragraph on the pulmonary and systemic circulations in the human body

Average ability to write a paragraph	Nursing students	SLPA students	Radiography students	Average	Standard deviation
Comprehension	4.6 ± 1.85	4.85 ± 1.79	4.7 ± 1.54	4.7	0.1
Analysis	4.5 ± 1.18	5.00 ± 1.18	5.1 ± 1.33	4.9	0.3
Integration	4.5 ± 1.18	5.08 ± 1.33	5.3 ± 1.19	5.0	0.3
Paraphrasing	4.5 ± 1.18	5.00 ± 1.49	5.1 ± 1.32	4.9	0.3
Sentence construction	4.1 ± 1.35	5.04 ± 1.51	4.5 ± 1.36	4.5	0.4

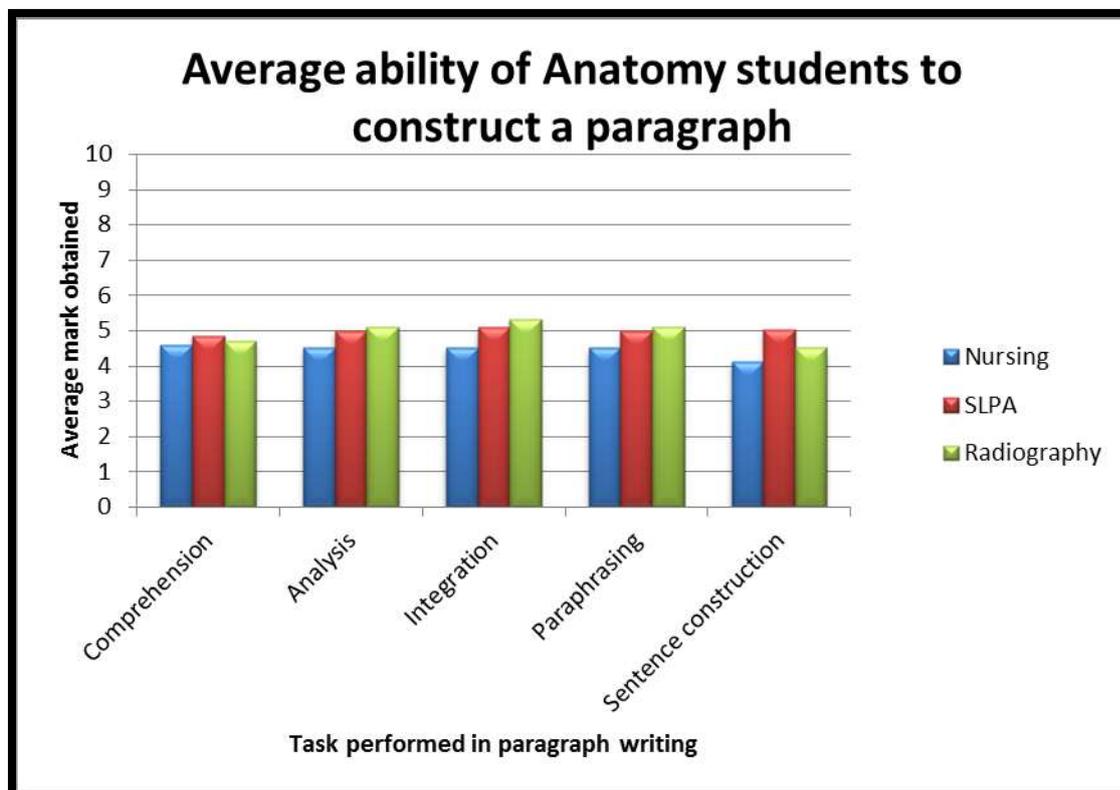


Figure 0-2: Average ability of Anatomy students to construct a paragraph on the pulmonary and systemic circulations in the human body.

The abilities of the students were compared on an arbitrary grading scale of Grades 0 – IV, as developed by Hossain and co-workers (2010) for having difficulty with the task of constructing a paragraph, which was then used to classify the difficulty the students were experiencing. A Grade 0 for difficulty was awarded when the student had no difficulty with executing the task at all, and obtained an overall mark of 80.01% and above for their ability to write a paragraph. A Grade I difficulty was awarded when the student had the ability to execute most of the task and obtained an overall mark of 60.01-80% for the exercise. A Grade II difficulty was awarded if the student showed some difficulty to adequate ability in executing the task and obtained an overall mark of 40.01 - 60% for the exercise. A Grade III difficulty was awarded to a student when he/she could only execute the task with great difficulty and obtained a final mark of 20.01 - 40%. The lowest grade of difficulty was a Grade IV difficulty, which none of the students in the study obtained. A Grade IV difficulty would have been awarded if the student could not perform the task at all and only had up to 20% for the construction of a paragraph and responses in the paragraph correct.

For the Nursing students, only 3.3% had difficulty with the task of compiling a paragraph from a picture. In this group, 19.7% suffered from Grade I difficulty, 41% Grade II and 36.1% Grade III difficulty. For the SLPA group, none of the students had a Grade 0 difficulty, 23.1% had Grade I difficulty, 42.3% Grade II difficulty and 34.6% Grade III difficulty. For the Radiography students, a single student had no difficulty with executing the task of writing a paragraph. For the Radiography students 28.6% had a Grade I difficulty, 51.4% Grade II difficulty and 14.3% a Grade III difficulty. From these results it is clear that most of the students suffered a Grade II difficulty with writing a paragraph, which would mean that they had some difficulty in executing the task but that they still had the adequate ability to perform the task. These results compare well with the results obtained by Hossain et al. (2010), who found that 75% of Bangladeshi students suffer from Grade II and Grade III difficulty in “English used in Anatomy” and none of their students suffered from a Grade IV difficulty. It is therefore clear that most of the students that took part in this study might have some trouble with executing the task of writing a coherent paragraph but they have sufficient ability to complete the task.

4.2.1.2 Ability to construct a sentence

In this section of the test, students had to change the tense in three sentences, correct any grammatical errors that were present in the sentence, as well as correct the homophones and punctuation (Appendix 3; Figure 3-0-4 to Figure 3-0-7). Nursing students obtained an average percentage of 55.8% in their ability to construct a sentence, while the SLPA students had an average percentage of 66.3% ability to construct a sentence. Radiography students exhibited a 58.4% average ability to construct a sentence. Students from all three groups did not change the homophones in the sentence to the correct format, but left it in the incorrect format. Where the students were required to fill in the correct homophones in the sentence provided, they were able to choose the correct homophone from a list provided and scored in the 90% range (Appendix 3; Figure 3-0-23). The Nursing students scored 93.5 %, SLPA scored 92.3% and Radiography students scored 93.9% for choosing the correct homophone from the list provided.

Most of the students in the study were able to change the tense of the sentences to the suggested tense, but had great difficulty in inserting the correct punctuation in the provided sentence. Students were asked to insert the correct punctuation in the following sentence: Ouch she injure me with the scalpel blade said john. The students were also required to correct any grammatical errors in the sentence, such as correcting of

tenses. This exercise counted three and a half marks. If students did not score more than one and a half marks for the punctuation of the sentence, it was seen that students had difficulty in performing the task. Of the Nursing students, 41% had trouble with punctuation of the sentence, while 34.6% of the SLPA students struggled with the same task. The Radiography students had a 51.4% difficulty with the task of punctuation of a sentence. It could therefore be concluded, that when required, students would have great difficulty in the task of punctuating sentences. They would then have a diminished ability to write paragraphs and possibly struggle with the task of writing a medico-legal report.

4.2.1.3 Comprehension of text and different pictures

In this section of the test, students were required to read a text and draw inferences from the text, as well as label structures from the captions provided. The students were tested on their ability to draw inferences from pictures and analyse pictures to answer questions on what is represented by the pictures. A histological picture was included to see whether students could identify structures on an electron micrograph, with the drawing of the same structure provided next to electron micrograph. In this section of the test, a number of questions were also included on basic knowledge that was covered by lecturers during the introduction week, as well as work from Grade 12 Life Sciences done at school (Appendix 3; Figure 3-0-8 to Figure 3-0-15).

Table 4: Average percentage difficulty experienced by the Anatomy students in the comprehension section of the aptitude test

	Nursing % difficulty	SLPA % difficulty	Radiography % difficulty
Answering questions from a paragraph	28.8	36.4	28.4
Label the picture from the caption	43	49.2	48.8
Understanding what is depicted in a picture (two different pictures)	19	25.5	17.5
	42.3	43.5	32.8
Histological picture	73	65	74
Basic knowledge questions	33.2	30.6	39.9

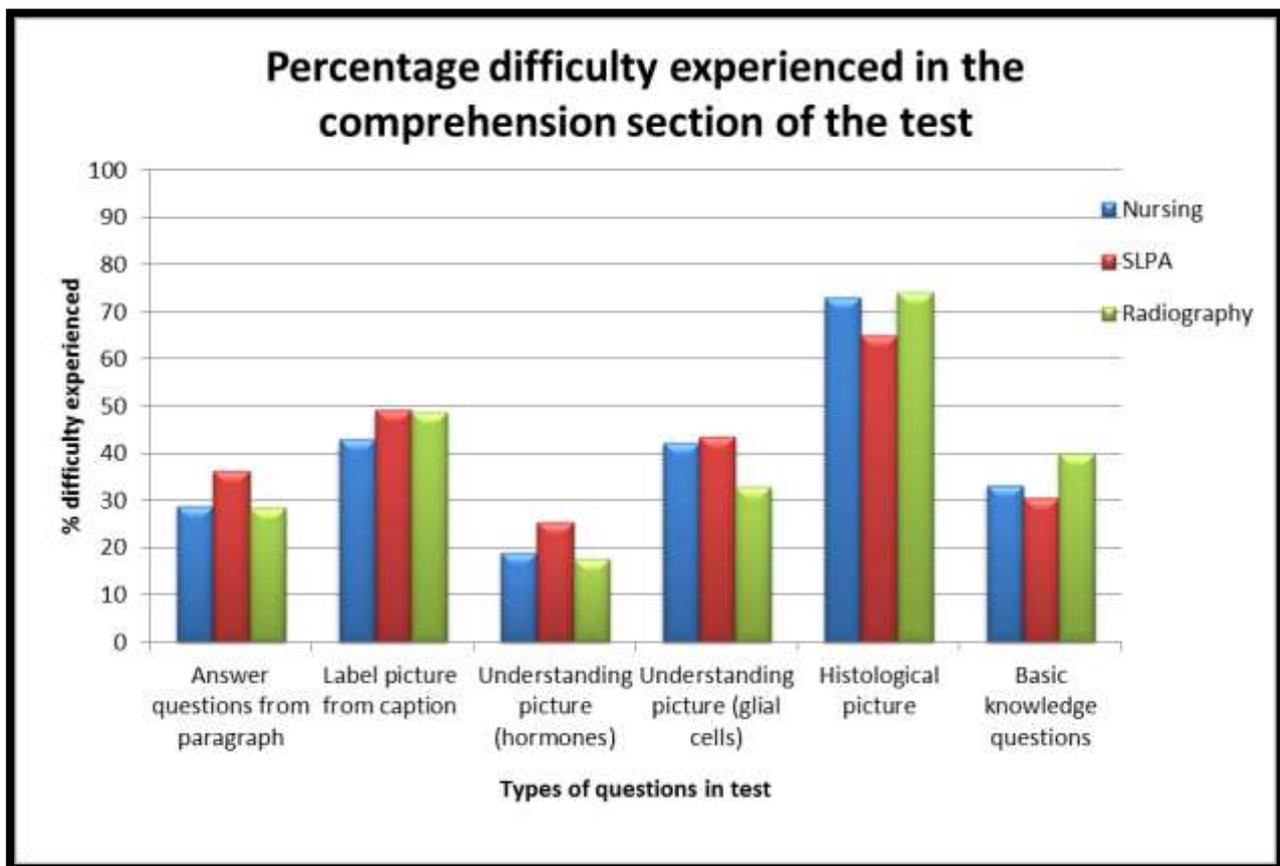


Figure 0-3: Percentage difficulty experienced by Anatomy students in the comprehension section of the aptitude test

When studying the percentage difficulties experienced in the comprehension section of the test (Table 4; Figure 0-3), it was clear that students struggled with labelling pictures and the contents of pictures from the caption that is provided. The Nursing students had 43% difficulty, SLPA had 49.2% difficulty and Radiography had 48.8% difficulty in performing the task. When a picture of glial cells, with a descriptive paragraph, was used to test comprehension, students also struggled and scored in the 40-50% difficulty range. When an electron micrograph was used to determine whether students would be able to distinguish between a histological structure on a photo and a picture provided, the students had great difficulty in performing the task (Appendix 3; Figure 3-0-14). In this electron micrograph it is important that students can change the direction of an image (cross-section and longitudinal section) so that the structures become visible in a single plane. Students had an almost 30% ability to perform the task to satisfaction.

Histology is the study of microscopic anatomy of cells and tissues, which also makes use of different pictures and photos to help illustrate the facts. When students cannot understand what they see under the microscope or in the pictures, the task of learning for histology becomes just a muddle of facts that has to be assembled without the necessary pictures to assist the students during their studies. If pictures are then used in formal assessments, students do not understand what they see.

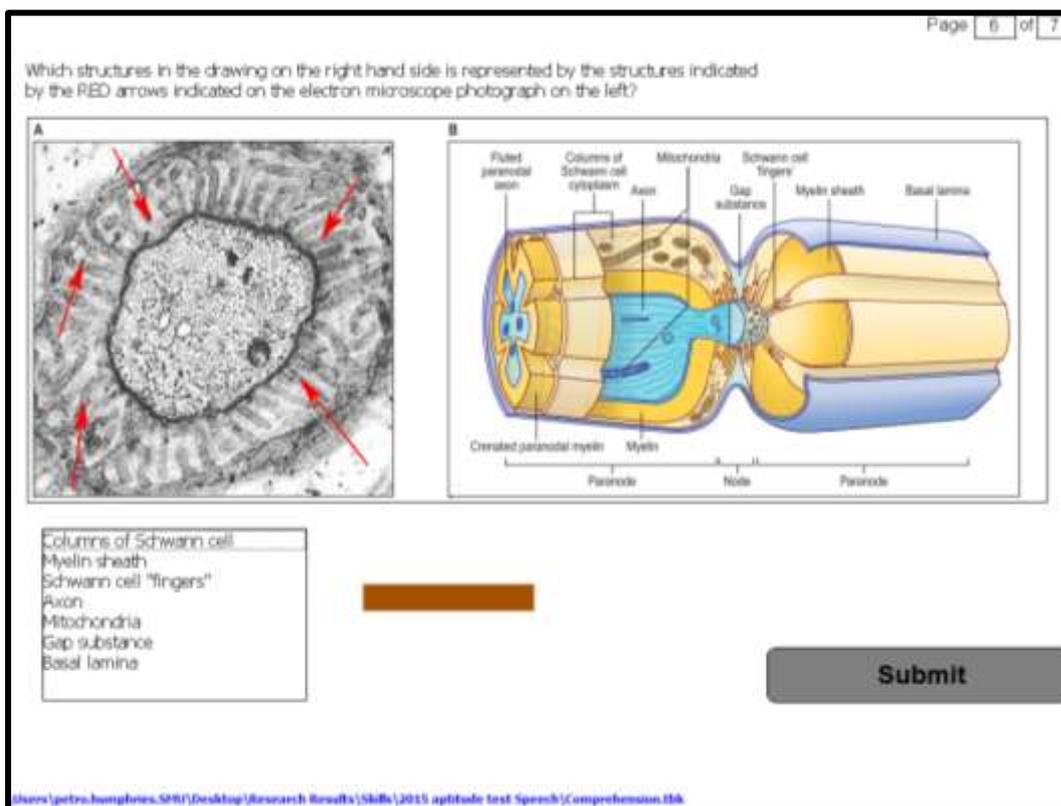


Figure 3-0-14: Sixth page from the comprehension section of the aptitude test: An electron micrograph and annotated picture of the columns of the Schwann cell on a cross-section. Students had to identify the same structure on the two pictures.

In the section of the test where students were asked a number of basic knowledge questions of work that they would have done in their introduction week or in their Grade 12 Life Sciences subject, students only experienced slight difficulty. Nursing students experienced 33.2% difficulty, SLPA 30.6% difficulty and the Radiography students 39.9% difficulty in answering basic knowledge questions. Therefore, students could satisfactorily answer the basic knowledge questions.

4.2.1.4 Ability to choose the correct spelling, prefix and suffix, as well as synonyms of given words

In the spelling section of the test, students were required to perform a number of tasks that included the spelling of medically related words, as well as to insert the correct prefix and suffix. Students were also required to choose the best suited synonym for a provided word in a specific sentence (Appendix 3; Figure 3-0-16 to Figure 3-0-21). Each question in this section of the test consisted of a number of options. The options were presented in a drop down box for each of the questions, from which the student had to select the correct spelling from the list provided. Students did not seem to have trouble with spelling of the words as they scored in the 70% range. Nursing students scored $70.6\% \pm 9.29$, SLPA students scored $69.9\% \pm 8.72$ and Radiography students scored $70.7\% \pm 7.64$. It would therefore seem that students should not have problems with the spelling of medically related words, which is not actually the case if one compares the spelling component of the test with the section of the test where the students were required to write a paragraph. Students exhibited difficulty in spelling the words necessary to describe the blood circulation between the pulmonary and systemic circulations, but spelling did not count for marks in the construction of a paragraph section of the test. It would however be important to understand that it would be easier to answer questions that are in MCQ format where the correct answer has to be selected. It is more difficult to formulate and spell words when you are writing the words and sentences for the first time. It could be

beneficial in future to require students to type the words themselves and then determine whether they are able to spell the words correctly.

Only five synonyms were asked in this component of the test (Appendix 3; Figure 3-0-21). Because such a small amount of questions were asked, a meaningful correlation could not be drawn between the percentage obtained and the amount of knowledge that the student has about the question and answer. Should this test be used in future, more synonyms will have to be included so that the results can be more indicative of the knowledge base of the student.

4.2.1.5 Ability to draw inferences from word relationships

This section of the test attempted to establish a relationship between two words, and to see whether the students can draw inferences from the word relationship (Appendix 3; Figure 3-0-22 to Figure 3-0-25). This was a more difficult type of question and it was observed in the marks that the students obtained for this section of the test. Students clearly struggled in this section of the test as the Nursing students only obtained $26.5\% \pm 14.01$, SLPA students $26.2\% \pm 15.92$ and the Radiography students $24.0\% \pm 13.94$. This indicates that students have greater difficulty with finding the subtle inferences between words. This might prove problematic in studying for their tests as they cannot relate important aspects.

With the linguistic component of the test discussed, the next part will focus on the visual-spatial abilities of the students, and how they scored in the three tests designed to measure visual-spatial ability.

4.2.2 Visual-spatial abilities of students

4.2.2.1 Spatial ability of students

In this section of the test, questions were adapted from Psychometric-success.com (Newton and Bristoll, 2009). This is a webpage that provides practice aptitude tests which can be used for preparation for new employment or enrolment for university. These practice aptitude tests provide the candidate with an opportunity to practice for the psychometric test which the candidate might be subjected to. This section of the test consists of a number of different figures that have been rotated in space. The candidate was required to find the identical figure for the specific options provided. The test consists of multiple choice questions, where the correct option, with three incorrect options, was provided.

The first page consists of two groups of figures. The figure in group one must be related to the same figure in group two (Appendix 3; Figure 3-0-27). The second page consists of four shapes, with four options provided. The identical shape is present in the answers, but rotated in space, to look different (Appendix 3; Figure 3-0-28). The third page consists of two small folded cubes, with deconstructed versions of the cube, where the student has to identify the cube that can be folded to provide the cube in question (Appendix 3; Figure 3-0-29). On the fourth page, students have to assemble a bigger shape by mentally manipulating smaller shapes to fit into the big shape and form the big shape (Appendix 3; Figure 3-0-30). On the fifth page of the aptitude test, a paper is folded a number of times and a hole is punched into the paper at a specific place. The student has to predict in which positions there will be holes on the total paper when it is unfolded (Appendix 3; Figure 3-0-31). On the last page, students have to follow directions on a simple map to locate specific buildings (Appendix 3; Figure 3-0-32).

In this section of the aptitude test students had to mentally rotate different figures and shapes. By obtaining an estimate of ability by using a mark in percentage, it is possible to determine whether the student will be able to rotate images in textbooks, and apply it to structures seen in the dissection halls. Ultimately, the question arises: Will the students be able to mentally rotate images that are seen in the textbook and during dissection, and apply what they see to images seen during their practical spotter tests?

Of the 131 students that took the aptitude test, 30 failed the spatial ability section. Of the Nursing students, 23% failed the test; 24% of SLPA students failed the test. Of the Radiography students, a larger number of students (28.6%) failed the spatial ability section of the aptitude test. This would mean that Radiography students are more likely to struggle with the three dimensional aspects that accompany Anatomy as a subject. The overall percentages that the different groups obtained in the spatial ability section of the test, are illustrated in Table 5 and Figure 0-4. The Nursing students obtained an average percentage of 59.4 ± 15.11 for the spatial ability section of the test; the SLPA students had an average percentage of 63.2 ± 17.78 for the spatial ability section of the test, while the Radiography students had an average percentage of 55.9 ± 13.39 for the spatial ability section of the aptitude test.

Table 5: Percentage of students that failed the spatial ability section of the test, together with the total percentage obtained by the three different groups of students in the spatial ability section of the test

	Nursing students	SLPA students	Radiography students
Percentage of students who failed spatial ability section of the test	23%	24%	28.6%
Total percentage obtained for spatial ability section of the test	59.4 ± 15.11	63.2 ± 17.78	55.9 ± 13.39

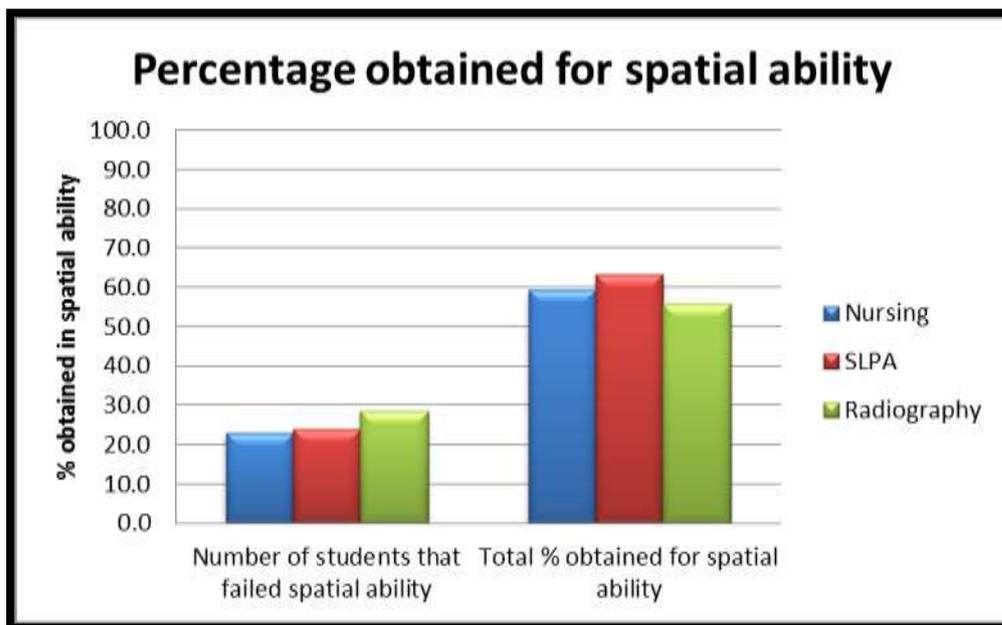


Figure 0-4: Number of students that failed and total percentage obtained in the spatial ability section of the aptitude test

4.2.2.2 Mental rotation ability of students

In this section of the aptitude test, students were required to match pictures taken from a drawing atlas (for example Netters' Atlas), with images taken from actual wet specimen dissections or plastic models (Appendix 3; Figure 3-0-34 to Figure 3-0-36).

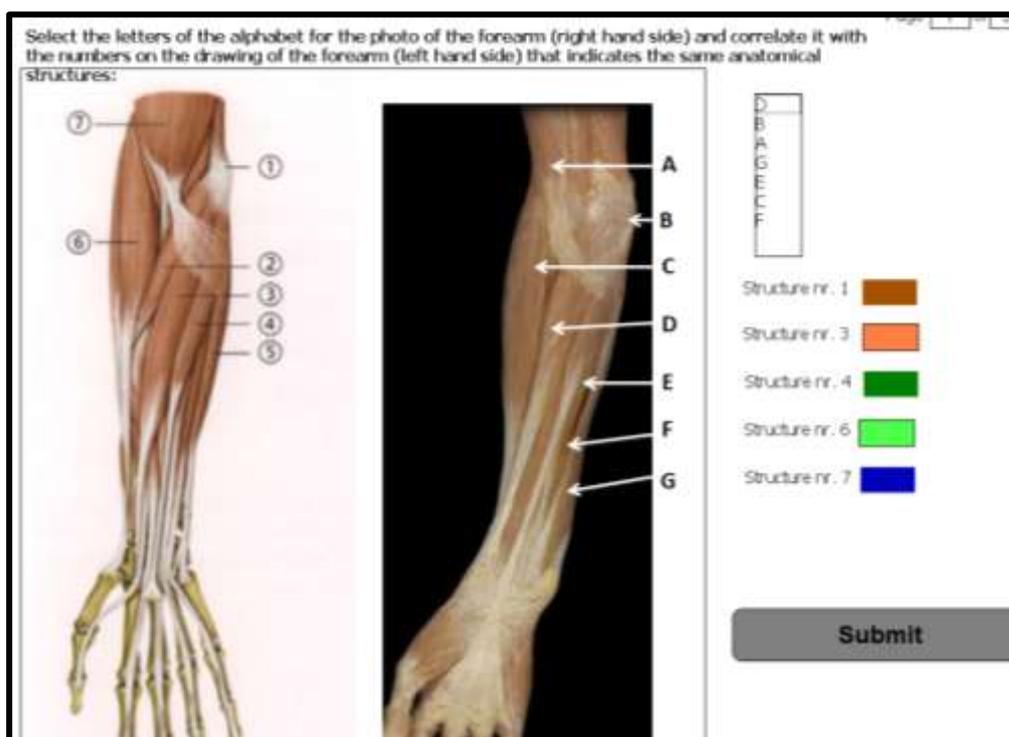


Figure 3-0-34: First page of the anatomical mental rotation section of the aptitude test. Students had to compare a drawing of an arm with an actual wet specimen and then annotate the diagram so that the same structures are labelled.

Fewer students failed the mental rotation ability section of the test when compared to the spatial ability of the test, with only a single Nursing student failing the test, while the SLPA students had a 100% pass rate. Once again, as for the spatial ability section of the test, it seems that the Radiography students had a harder time with the mental rotation ability section of the test. A total of four of the 32 Radiography students failed the mental rotation ability section of the test. Nursing students obtained an average percentage of 74.3 ± 13.25 , SLPA students obtained an average percentage of 68.8 ± 12.29 and the Radiography students obtained an average percentage of 66.3 ± 15.13 . Students performed better in the anatomical mental rotation ability section of the test, when compared to the spatial ability test. This could mean that students have a better ability to rotate anatomical structures in space, than it is to rotate abstract objects in space.

It is, however, the experience of the Anatomy Department that most students struggle most in the practical components of tests. One reason could be that the specimens they see in the practical test do not adequately resemble the cadavers they were taught on. The three groups used in this aptitude test were all first year students who do not dissect cadavers. They only have practical sessions where they are exposed to the specimens which they have to study for practical spot tests. It still remains unclear why students would underperform in the practical test with the specimens that they used during their practical sessions. The question then remains whether anatomical mental rotation plays a role in the marks that students obtain for practical spot tests. Because the students only scored in the 65 – 75% range, it can still be concluded that the students had a 25 – 35% difficulty in performing the tasks at hand.

4.2.2.3 Cause and effect ability of the students

For the cause and effect portion of the aptitude test the students had to predict an outcome for different scenarios exhibited (Appendix 3; Figure 3-0-37 to Figure 3-0-41). On the first page of the cause and effect section of the test, students have to understand that, should the optic nerve be cut at a specific position, it will cause a specific type of blindness. A specific structure might also not be visible with one/both eyes. This was demonstrated to students by means of a picture. By using the picture provided it is possible to predict the outcome of a lesion (Appendix 3; Figure 3-0-38). On the second page, students have to predict the movement of the arm that will occur if two specific muscles contract (Appendix 3; Figure 3-0-39). By understanding the mechanism of muscle contraction, students are able to study the action of the muscle and then determine where the muscle should originate and insert without having to study muscle origins and insertions for hours on end. On the third page, students are required to study two embryological structures, the one structure slightly more developed than the other, with the same colour presenting the same structures in the two pictures. One picture is labelled; the other picture must then be labelled with the same annotations (Appendix 3; Figure 3-0-40).

Page 1 of 4

Select the option that best describes the effect of what would happen if the optic nerve (1), optic chiasma (2) and optic tract (3) were out in the positions as indicated. Select whether a, b, and/or c would be visible:

Question
Muscles of the eye and actions

Labels: Retina, Optic nerve, Optic chiasm, Optic tract, Lateral geniculate body, Lower fibres in temporal lobe, Upper fibres in anterior parietal lobe, Occipital cortex, Optic radiation.

The retina (orange and blue) looks obliquely in the direction of the slope of the eye

a and c

a

b and c

b

a and b

If the optic nerve was out at 1, which letters will be visible to the patient?

Of the optic chiasma was out at 2, what would be visible for both eyes?

Of the optic tract was out at 3, what would be visible for both eyes?

Submit

Figure 3-0-38: First page of the cause and effect section of the aptitude test. Students had to predict what the outcome would be if the optic nerve was severed at different positions. What would be visible to the person with the nerve lesion?

Which structures are represented by the alphabetical letters in the picture on the right by the annotated picture on the left?

Labels: Neural groove, Amniotic cavity, Somite, Notochord, Split lateral plate, Yolk sac.

Yolk sac

Neural groove

Amniotic cavity

Split lateral plate

Neural plate

Notochord

Somite

Structure A Structure D

Structure B Structure E

Structure C Structure F

Submit

Figure 3-0-40: Third page of the cause and effect section of the aptitude test. Two pictures are provided on embryological development. The one figure is more developed than the next figure. Students had to indicate which structures are represented by the alphabetical letters on the right by comparing with the picture on the left.

Students performed quite well in this section of the aptitude test. Only one Nursing student failed the cause and effect section of the test with the class average for the test being 70.2 ± 12.25 . Two SLPA students failed this section of the test with the class average being 70.8 ± 15.91 . Two of the Radiography students failed the cause and effect section of the test, with the class average of 68.8 ± 12.69 . Therefore, students had a 30% difficulty with predicting the effects of different events.

If the overall performance of the students for the visual-spatial ability component of the test was determined, the average for the three tests combined was calculated and a grade difficulty (Grade 0 – Grade IV) assigned to illustrate the ability of the students to perform the visual-spatial ability section of the test. A Grade 0 for difficulty was awarded when the student had no difficulty at all with executing the task and obtained an overall mark of 80.01% and above for their ability to pass the three components of the visual-spatial section of the aptitude test. A Grade I difficulty was awarded when the student had the ability to execute most of the task and obtained an overall mark of 60.01-80% for the combined percentage. A Grade II difficulty was awarded if the student showed some difficulty to adequate ability in executing the task and obtained an overall mark of 40.01 - 60% for the combined percentage. A Grade III difficulty was awarded to a student who could execute the task only with great difficulty and obtained a final mark of 20.01 - 40%. The final grade of difficulty was a Grade IV difficulty, which none of the students obtained.

The grade difficulty (Grade 0 – Grade IV) experienced by the students is illustrated in Table 6.

Table 6: Percentage of students experiencing Grade I – IV difficulty with the visual-spatial ability section of the aptitude test

Grade difficulty	Nursing students	SLPA students	Radiography students
Grade 0	6.45%	18.52%	3.23%
Grade I	79.03%	59.26%	70.97%
Grade II	14.52%	22.22%	22.58%
Grade III	0	0	3.23%
Grade IV	0	0	0

None of the students experienced a Grade IV difficulty with this section of the aptitude test. The Nursing and SLPA students also did not experience a Grade III difficulty with the test, while the Radiography group had a single student that had a Grade III difficulty. Most of the students experienced a Grade I difficulty for the visual-spatial section of the test. This means that most of the students obtained between 60-80% for their combined mark for the three sections (spatial ability, mental rotation ability, cause and effect ability) of the visual-spatial ability section of the test. For the visual-spatial section of the aptitude test, 79.03% of Nursing students, 59.26% SLPA students and 70.97% of Radiography students experienced a Grade I difficulty. This would mean that students ultimately had a 20-40% difficulty when required to mentally rotate structures in space. This would mean that students would have little trouble with performing the task of mental rotation as they only have a Grade I (60-80%) difficulty.

4.3 CONCLUSION

The aptitude test consisted of two sections: linguistic ability and visual-spatial skill. The different tests under each specific section of the test were analysed. Different tests made up the linguistic section of the test. For construction of a paragraph, the students scored between 4 and 5, which indicates that the activity (comprehension and analysis; integration and paraphrasing; construction of sentences) requires more attention. A grade scale (Grade 0 – IV) was used to describe the ability of the students to construct a paragraph. Most of the students had a Grade II difficulty (between 40-60%) for their final mark in executing the task of writing a paragraph. These results are comparable to results obtained by Hossain et al. (2010), for Bangladeshi students. Students had a 35-45% difficulty in executing the task of writing a paragraph.

Students had no problems at all when they had to choose the correct homophones in a sentence. Students were able to choose the correct tense, but they had trouble in inserting the correct punctuation in the sentence. Students also struggled with the comprehension section of the aptitude test where they had to label pictures and contents of pictures from captions that are provided. Students also struggled when they had to identify structures on an electron micrograph. Students performed satisfactorily in the section where they were asked basic knowledge questions. Students did not have trouble with the spelling section of the test. From the word relationship section of the test, it was clear that the students struggle with drawing inferences from the groups of words provided. The linguistic section of the test could therefore identify a number of shortfalls in the language ability of the students, when tested with the current aptitude test.

In the visual-spatial section of the test, three components were tested namely spatial ability, mental rotation ability together with cause and effect. Students scored between 55-65% for the spatial ability section of the test. Fewer students failed the mental rotation ability test when compared to the spatial ability section of the test. Students also performed well in the cause and effect section of the aptitude test, indicating that they will have little trouble with predicting the outcome of certain muscle actions and nerve lesions. When the overall performance of the visual-spatial section of the aptitude test was determined on a grading scale (Grade 0 – IV), the students experienced a Grade I difficulty (between 60-80%). This would mean that students should not have any difficulty when attending practicals where they are exposed to wet specimens.

The next chapter will deal with the validity and reproducibility of the different questions in the aptitude test, as well as the internal consistency of the different subsections of the tests. It will also attempt to determine whether there is a correlation between the first Anatomy test and the overall final mark that was obtained in the aptitude test.

CHAPTER 5: FINDINGS OF THE VALIDITY, RELIABILITY AND CORRELATION COEFFICIENT OF THE APTITUDE TEST

5.1 INTRODUCTION

This chapter discusses the validity and reliability of the questions contained within the aptitude test. It is important to determine the validity and reliability of the questions in the aptitude test to ensure that the test actually measures what it intended to. Should the questions in the aptitude test be found valid and reliable, it would indicate that the test is a good measure of the linguistic~ and visual-spatial abilities of the students. It can also be concluded that the aptitude test can then be utilised to determine academic vulnerability of students.

Two indices (difficulty and discrimination indices) were used to establish criterion validity of the test, while content validity of the test was determined by analysing the type of questions used in the aptitude test. Cronbach's alpha test was used to determine the internal consistency of the aptitude test and to ensure that the questions contained in the aptitude test were reproducible. This was necessary to ensure that the questions really measure what they intended to. If the questions were not valid and reliable, then the results obtained for the linguistic and visual-spatial sections of the test would not be of any value. This chapter also discusses the possibility of a correlation between the final total mark of the aptitude test and the first mark for their first Anatomy block test written by the Nursing, SLPA and Radiography students.

5.2 RESEARCH QUESTION 2:

What is the validity (content and predictive) and internal consistency of the aptitude test used to determine academic vulnerability of the Anatomy students at SMU?

5.2.1 Content validity

The degree to which a test truly measures the intended content areas is known as content validity. Content validity is achieved by both item validity and sampling validity. If a test is aimed at measuring the knowledge on human anatomy, then good item validity will be present if the questions deal with facts relating to the human body (Dent and Harden, 2013). To ensure that this aptitude test has content validity, the questions used in the test were divided into different subsections. The aptitude test consisted of two large sections, linguistic ability and visual-spatial skill, which were then divided into a number of smaller subsections. The lecturers in the Anatomy Department decided on the questions that had to be included in the test and all the questions that were provided related to either the English ability or visual-spatial skill sections of the test. By only providing questions that deal with a specific subsection, questions were representative of possible questions that could be asked and therefore also had good item validity. Because the test could only be executed in a two-hour period, the amount of questions was limited. It could be beneficial to include more questions if more time is allowed in future for the aptitude test to take place.

Linguistic ability was determined by six smaller subsections of the test, namely: ability to construct a paragraph, sentence construction, comprehension, use of medical spelling and prefix and suffix, synonyms and homophones. These subsections only contained questions as described by the title of the test, in other words, the comprehension section of the test dealt with different questions related to comprehension, while

the synonyms and homophones section of the test only contained synonyms and homophones that students had to identify. Because the tests only contained questions that examined a specific linguistic construct, each smaller test had good item validity. The linguistic section of the test also had good sampling validity as different questions were specifically chosen, which then tested the same construct.

The visual-spatial section of the test also had good item validity. The visual-spatial ability of the test consisted of three smaller subsections, namely: spatial ability, mental rotation ability, and cause and effect. To determine the spatial ability of the student, questions were obtained from Psychometric Success (Newton and Bristoll, 2009). Questions in the practice test on spatial ability have been specifically designed to determine the spatial ability of the person taking the test. The mental rotation ability section of the test contained questions that presented pictures of the same anatomical structures, but in different positions. Students then had to identify the same structures on the two pictures provided. Thus, the test attempted to measure the ability of the students to rotate anatomical structures in space.

For the cause and effect section of the test, questions were included where students had to predict a possible outcome by studying the pictures provided. Sampling validity was ensured by selecting as wide a variety of questions as possible.

The homophones and synonym sections of the test could have poor sampling validity as the test only contained five questions for each specific section. A test should not contain too few items as it could cause poor sampling validity (Dent and Harden, 2013). The test could only contain a number of questions that can be completed within two hours. This was the amount of time that the different course coordinators could make available on their respective time tables.

5.2.2 Criterion validity

For assessments to have criterion validity, specific criteria must be set for the results, in order to establish whether the questions and results obtained, are valid. For this aptitude test, two indices were used to establish criterion validity: the difficulty and discrimination indices. These two indices are continuously utilised by the Anatomy Department for the separate assessments that make use of the Riddel program. The set criteria for the two indices are as follows: (a) for the difficulty index, any value obtained between 20-80% difficulty, was seen as valid and reliable, and (b) for the discrimination index, any value between 0.2-0.8 was seen as valid and reliable. It is important to note that both criteria had to be met for the questions to be valid and reliable. The Riddel test program calculates the average for the discrimination and difficulty index for each specific test. This average was used to determine whether the subsections of the test had good criterion validity.

The difficulty index and discrimination index could not be determined for the sentence construction section in the linguistic ability subsection, the reason being that the students had to type in the answer. Only the average that the students obtained for the subsection could be determined and then the percentage difficulty experienced. The Nursing students had an average of 55.8% and thus experienced a 44.2% difficulty. The SLPA students did not seem to struggle as much with the sentence construction section of the test as they had an average of 66.3% and thus experienced a 33.7% difficulty. The Radiography students obtained very

similar results to the Nursing students. The Radiography students had an average of 58.4% and thus experienced a 41.6% difficulty. Furthermore, the spelling section of the test contains sections on spelling of medical related words, prefix and suffix, as well as synonyms. Also, the word relationship section of the test contained the homophones section of the test, as well as groupings of words which students had to identify and then draw inferences from. The difficulty and discrimination indices for the different sections of the subsections for the different groups of students are displayed in Table 7.

Table 7: Difficulty and discrimination indices for the three groups of students for the different sections of the linguistic ability and visual-spatial skill subsections of the test

Group of students	Section of test	Category in test	Difficulty index (%)	Discrimination index
Nursing	Linguistic abilities	Comprehension	51	0.3
		Spelling	71	0.2
		Word relationships	52	0.2
	Visual-spatial skill	Spatial ability	57	0.4
		Mental rotation ability	73	0.3
		Cause and effect	68	0.3
SLPA	Linguistic abilities	Comprehension	68	0.3
		Spelling	69	0.2
		Word relationships	51	0.3
	Visual-spatial skill	Spatial ability	61	0.4
		Mental rotation ability	68	0.3
		Cause and effect	67	0.3
Radiography	Linguistic abilities	Comprehension	52	0.3
		Spelling	70	0.2
		Word relationships	51	0.2
	Visual-spatial skill	Spatial ability	52	0.3
		Mental rotation ability	65	0.4
		Cause and effect	67	0.2

The results obtained by the Nursing and Radiography students are comparable for the difficulty index. Higher percentages for the test indicate that the students found the test to be easier, which was the case for the SLPA students. Students in the three groups scored between 51-73% for the different subsections in the aptitude test. The Nursing and Radiography students scored between 51-57% for the comprehension, word relationships and spatial ability sections of the aptitude test. This then means that there was an even distribution of scores because the students scored in the 50% range. The Nursing and Radiography

students scored between 65-73% for the spelling, mental rotation ability and cause and effect sections of the test. This means that the questions were easier in these sections of the test and that the students obtained higher scores for these sections. The SLPA students scored 51% for the word relationship section of the test, which means that there was an even distribution of scores for the SLPA students in this section. This is comparable with the average obtained by the Nursing (52%) and Radiography students (51%). The SLPA students scored between 61-69% for the comprehension, spelling, spatial ability, mental rotation ability and cause and effect sections of the test. The SLPA students obtained higher scores for these different sections, which means that the students found the questions of these tests easier. Important to note is the fact that the SLPA students performed better in the linguistic ability and visual-spatial skill sections of the test. This could indicate that the SLPA students will struggle less with Anatomy as a subject, if these two parameters (linguistic ability and visual-spatial skill) are the only factors that influence academic success.

The results obtained for the discrimination index are very similar for the Nursing, SLPA and Radiography students. For all sections of the test, all groups scored between 0.2-0.4 for the discrimination index. This means that the subsection in the two test section (linguistic ability and visual-spatial skill) had low to moderate ability to distinguish between the high scoring students and the low scoring students. Modifications are needed in the different sections of the aptitude test to increase the values of the discrimination index for students.

5.2.3 Internal consistency of the aptitude test

The aptitude test made use of Cronbach's alpha test to determine the internal consistency of the questions in the linguistic ability and visual-spatial skill sections of the test. Cronbach's alpha test is used to determine the predictable reliability of the different sections of the tests and a value of 0.7 shows a high degree of reproducibility of the questions within the test. Cronbach's alpha value was determined for each specific subsection of the two sections of the aptitude test to ensure that the different tests had internal consistency as well. Important to note is the fact that the values obtained for the different groups of students cannot be related to each other, as it is three different groups with different individuals.

5.2.3.1 Linguistic ability section of the aptitude test

Table 8 indicates the Cronbach's alpha values obtained in the four components of the linguistic ability section of the test for the Nursing, SLPA and Radiography students. The linguistic ability section of the test consisted of sentence construction (averages), comprehension, spelling and word relationship subsections of the test.

The linguistic ability and visual-spatial skill sections of the aptitude test were divided into smaller subsections to determine the internal consistency of the different questions within the tests. The sentence construction section of the test consisted of three pages and the percentages obtained for the different pages were compared for the internal consistency. The comprehension section of the test, counted 29 marks. The test was divided into ten smaller subsections with two-three questions on a page. The spelling section of the test counted 25 marks and five subsections were formed with five questions per subsection. The word relationship section of the test counted 13 marks. Three subsections were formed, with two of the subsections of the test having two questions per page and one page with three questions on the page.

Most of the subsections in the different tests for the different groups required one page to be removed from the test to improve the internal consistency, except for the sentence construction section of the Radiography group. The sentence construction section of the Nursing and SLPA groups required the same page (Page 1) to be removed from the test. In the spelling section of the test, all three groups required page 2 to be removed. In the word relationship section of the test, page 5 needed to be removed for both the SLPA and Radiography groups of students. It could therefore be concluded that the questions on these pages need to be revisited before including them in the test in future.

Each of the groups only required a single page to be removed from the subsections of the test, to improve the internal consistency (reproducibility) of the test. For the spatial ability section of the test page 6 needed to be removed for both the SLPA and Radiography groups. Page 1 of the mental rotation ability section of the test had to be removed from the test for all the groups. In the cause and effect section of the test, page 3 had to be removed from the test for both the Nursing and Radiography groups. Because there were groups that had similar pages to be removed, it can be concluded that the questions on these pages need further attention and should be adjusted before utilising them in the test again in future.

Table 8: Cronbach's alpha values obtained for the four subsections in the linguistic ability section of the test for the Nursing, SLPA and Radiography students

Group	Test in the linguistic ability section of the test	Internal consistency – Cronbach's Alpha value	Pages removed from test
Nursing	Sentence construction	0.6	Page 1
	Comprehension	0.6	Page 3
	Spelling	0.3	Page 2
	Word relationships	0.1	Page 2
SLPA	Sentence construction	0.4	Page 1
	Comprehension	0.8	Page 1
	Spelling	0.3	Page 2
	Word relationships	0.5	Page 5
Radiography	Sentence construction	0.6	-
	Comprehension	0.4	Page 6
	Spelling	0.3	Page 2
	Word relationships	0.1	Page 5

Only the comprehension section of the SLPA group obtained a Cronbach's alpha value of 0.8, which shows that the comprehension section of the test does not have a high reproducibility between groups. It can therefore be concluded that the test in its current format does not have high reproducibility between different groups. The section of the test with the lowest Cronbach's alpha value is the word relationship section of the test for the Nursing and Radiography groups. This is also the section of the test with which the students grappled the most. Before the test can be utilised in future, a number of modifications, such as removing pages as indicated, or changing the questions on these pages, will have to be made.

5.2.3.2 Visual-spatial skill of the aptitude test

Table 9 indicates the values obtained for the internal consistency of the three components of the visual-spatial skill section of the test. The visual-spatial ability of the test consisted of spatial ability, mental rotation ability and cause and effect subsections.

Table 9: Cronbach's alpha values for the three subsections of the visual-spatial skill for the Nursing, SLPA and Radiography students

Group	Tests in the visual-spatial ability section of the test	Internal consistency – Cronbach's alpha value	Pages removed from test
Nursing	Spatial ability	0.7	Page 7
	Mental rotation ability	0.5	Page 1
	Cause and effect	0.5	Page 3
SLPA	Spatial ability	0.7	Page 6
	Mental rotation ability	0.6	Page 1
	Cause and effect	0.8	Page 2
Radiography	Spatial ability	0.6	Page 6
	Mental rotation ability	0.4	Page 1
	Cause and effect	0.6	Page 3

Similar to the linguistic ability section of the test, the visual-spatial skill section of the test was also divided into smaller subsections to determine the internal consistency of the different tests. The spatial ability section of the test was worth 23 marks and a total of seven smaller subsections were created. Six of the pages were worth two marks each, while the seventh page was worth three marks. The mental rotation ability section of the test was worth 16 marks and was divided into four smaller subsections that counted four marks each. The cause and effect section of the test was worth 10 marks. The test was divided into five smaller subsections, where each was worth two marks.

The internal consistency (Cronbach's alpha values) was higher for the visual-spatial section of the test when compared to that of the linguistic ability section of the test. The three groups had Cronbach's alpha values of between 0.6-0.7 for the spatial ability section of the test. Therefore, the questions in this section of the test had higher reproducibility between the groups and, furthermore, also had high reliability. The mental rotation ability section of the test had, to a lesser degree, reproducibility between groups and the internal consistency had values of between 0.4-0.6. The questions in this section are therefore not as reliable as the questions in the spatial ability section of the test. The cause and effect section of the test had a Cronbach's alpha value of between 0.5-0.8. The Cronbach's alpha value was 0.8 for the SLPA group of students, but was slightly lower for the Nursing (0.5) and Radiography (0.6) groups of students. The test therefore has a wide variation between the three groups and it can therefore be concluded that the cause and effect section of the test has lower reproducibility between the groups of students.

Focus will now be placed on whether there were any correlations present in the test, as well as if there is a positive correlation between the results obtained for the aptitude test and the first Anatomy block test.

5.3 RESEARCH QUESTION 3:

How do the results obtained from the aptitude test (academic vulnerability) correlate with results obtained in the first Anatomy test of the academic year?

5.3.1 Internal correlation within the different subsections of the test

Before the correlation was determined between the aptitude test and the first Anatomy block test, the possible correlations within the aptitude test were studied. Pearson's correlation coefficient was used to determine the correlation between pages, as well as the correlation of the aptitude test with the first Anatomy block test. When a positive correlation was observed, it had to be statistically significant with a p-value of less than 0.05. The sentence construction and spelling subsections of the linguistic ability section of the test were not included in Table 10 because there were no positive correlations between any of the pages.

The different pages which had internal correlations are shown in Table 10. None of the pages that had to be removed from the subsections of the test to improve the internal consistency, and hence the reproducibility of results, had any correlations with other pages. If the pages which had to be removed had positive correlations with other pages, it could mean that these pages then also have an internal error and that they should be removed.

The results of the correlation study indicate that the larger the number of pages having internal correlations with each other, the higher the internal consistency. There were only a few exceptions to this rule. When the cause and effect subsection of the visual-spatial skill section of the aptitude test was compared between the three groups, only the Radiography group had a single page internal correlation, but still obtained a relatively high Cronbach's alpha value (0.6). In a number of instances, the specific pages with internal correlation repeated between the three groups of students, for example page 4 with page 5 of the cause and effect subsection. There is, therefore, a degree of reproducibility between the pages that have internal correlation for different subsections of the test for the Nursing, SLPA and Radiography groups.

Table 10: Internal correlations of the pages within the different subsections of the linguistic ability and visual-spatial skill sections of the test for the Nursing, SLPA and Radiography courses. The correlations are also compared to the internal consistency (Cronbach's alpha value)

Group	Part of the aptitude test	Different subsections of the test	Correlation between pages	Number of pages in the subsections	Page removed from the subsection	Cronbach's alpha value
Nursing	Linguistic ability	Comprehension	Pg. 1 with pgs. 2,4,5 Pg. 2 with pg.4 Pg. 5 with pg. 4 Pg. 7 with pgs. 9,10 Pg. 8 with pgs. 9,10 Pg. 9 with pg. 10	10	3	0.6
		Word relationships	Pg. 1 with pg. 3	6	2	0.1
	Visual-spatial skill	Spatial ability	Pg. 1 with pgs. 2,3,4 Pg. 2 with pgs. 3,4 Pg. 4 with pgs. 5,6	7	7	0.7
		Mental rotation ability	Pg. 3 with pg. 4	4	1	0.5
		Cause and effect	Pg. 1 with pg. 2 Pg. 4 with pg. 5	5	3	0.5
	SLPA	Linguistic ability	Comprehension	Pg. 3 with pg. 4 Pg. 5 with pgs. 7,9 Pg. 6 with pgs. 7,8,9 Pg. 7 with pgs. 8,9 Pg. 8 with pg. 9	10	1
Word relationships			Pg. 1 with pg. 2	6	5	0.5
Visual-spatial skill		Spatial ability	Pg. 2 with pgs. 3,7 Pg. 3 with pgs. 4,7 Pg. 5 with pg. 7	7	6	0.7
		Mental rotation ability	Pg. 3 with pg. 4	4	1	0.6
		Cause and effect	Pg. 1 with pgs. 3,4 Pg. 3 with pgs. 4,5 Pg. 4 with pg. 5	5	2	0.8

Group	Part of the aptitude test	Different subsections of the test	Correlation between pages	Number of pages in the subsections	Page removed from the subsection	Cronbach's alpha value
Radiography	Linguistic ability	Comprehension	Pg. 1 with pg. 2 Pg. 7 with pg. 8	10	6	0.4
		Word relationships	No correlation	6	5	0.1
	Visual-spatial skill	Spatial ability	Pg. 2 with pg. 3 Pg. 4 with page 5	7	6	0.7
		Mental rotation ability	No correlation	4	1	0.4
		Cause and effect	Pg. 4 with pg. 5	5	3	0.6

5.3.2 Correlation between aptitude test and first Anatomy test

Since the onset of the study I have come to realise that the first Anatomy block test is not the best measure of academic vulnerability. Students are still adapting to their new surroundings and the new culture of the university. They might also experience that studying at a university requires new study methods in order to be successful. Therefore, it has been my experience that many students fail their first Anatomy test. Fortunately, the test marks of all the tests during the year were available to determine a possible correlation between the aptitude test and the tests during the year for the three different groups.

No positive correlation could be found between the aptitude test and the first Anatomy block test. Thus, academic vulnerability could not be proven between the aptitude test and the first Anatomy block tests. The rest of the tests during the year also had no correlation with the aptitude test, which means that the aptitude test has to be adapted to provide an accurate correlation between it and academic vulnerability.

5.4 CONCLUSION

The item and sampling validity was investigated and it was found that the aptitude test had good content validity. It was also found that the homophones and synonyms subsections of the linguistic ability section of the test could have poor sampling validity, as the subsections contained only five questions for each section. The criterion validity of the aptitude test was determined by a difficulty index and discrimination index.

The results for the Nursing and Radiography students were comparable for the difficulty index. The students scored in the 50% range, which means there is an even distribution of easy and difficult questions. The SLPA students scored between 61-69%, which means that they found the questions to be easier in the linguistic and visual-spatial sections of the test. This could be a good indication of the success SLPA students could achieve in Anatomy.

When the discrimination index is compared between the different groups for the different subsections of the test, this index was in the lower range (0.2-0.4) of the acceptable spectrum (0.2-0.8). This means that the questions, to a lesser degree, discriminate between low scoring and high scoring students.

To determine the internal consistency (reproducibility) of the results obtained, Cronbach's alpha value was used. Most of the subsections of the test only required a single page to be removed to obtain the optimal Cronbach's alpha value. Because pages needed to be removed from the different subsections of the test, it can be concluded that modifications are necessary on these pages before utilising the aptitude test again. Because the internal consistency was so low, it can be concluded that in its current format, the linguistic ability section of the test does not have high reproducibility between the groups of students. The internal consistency was higher in the visual-spatial section of the aptitude test, which indicates that there is higher reproducibility between the questions and the groups of students.

Furthermore, the correlation between different pages within a subsection was determined. None of the pages that needed to be removed from the subsections to improve the internal consistency, had to be removed from the pages that had an internal correlation. This indicates that the pages left in the test were adequate and did not have any discrepancies or errors. This correlation study also indicated that the more pages that are internally correlated, the higher the internal consistency of that section or subsection. There were only a few exceptions to this rule. A degree of reproducibility was observed for a few questions within the subsections for the three groups of students.

Pearson's correlation coefficient was used to determine the possible correlation between the aptitude test and the first Anatomy block test. No correlation was found between these two tests. Also, no correlation was found between the aptitude test and any of the other tests written during the year. It can therefore be concluded that the aptitude test in its current format cannot accurately predict academic vulnerability and the test should therefore be adjusted for future use.

CHAPTER 6: CONCLUSION

6.1 INTRODUCTION

It has been the experience of lecturers in the Anatomy Department at SMU that students who do Anatomy for the first time, struggle with the English language, as well as with the visual-spatial skill which is required to be successful in Anatomy. Students struggle to understand the “new anatomical language” (Lucas et al., 1997) which stems from Greek and Latin. In addition to having trouble with the English language, students also struggle with mentally rotating two dimensional structures and transforming them into three dimensional structures (Guillot et al., 2007). Vandenberg and Kuse (1978: 599) define visual-spatial ability as “the ability to mentally manipulate objects in three dimensions”.

Having the ability to mentally rotate structures in space is of the utmost importance in the Nursing, SLPA and Radiography careers. This study was based on the hypothesis that should students lack the necessary mental rotation capabilities, as well as fundamental English skills, they would struggle with Anatomy as a subject and would continue do so throughout their subsequent careers.

The purpose of the study was to develop an aptitude test that could possibly measure the linguistic ability and visual-spatial skill of the students to determine possible academic vulnerability.

6.2 PURPOSE OF THE STUDY

The primary research question this study attempted to answer was:

Which linguistic and visual-spatial deficits could be identified with a specific aptitude test in order to determine academic vulnerability of selected first year students at SMU studying the module: Anatomy?

Secondary research questions that were investigated:

1. What is the validity (content and predictive) and internal consistency of the aptitude test used to determine academic vulnerability of the selected first year Anatomy students at SMU?
2. How do the results obtained from the aptitude test (academic vulnerability) correlate with results obtained in the first Anatomy test?

This study aimed to achieve the following objectives:

1. Determine whether the aptitude test can measure linguistic and visual-spatial abilities of selected first year Anatomy students, in order to indicate student academic vulnerability.
2. Determine the validity (content and predictive) and internal consistency of the aptitude test.
3. Determine whether there was a correlation between the results obtained in the aptitude test and the first Anatomy test.

6.3 SUMMARY OF FINDINGS

The aptitude test consisted of two sections, namely English language ability and visual-spatial skill. The sections had smaller subsections. For the average ability of an Anatomy student to write a coherent paragraph on the pulmonary and systemic circulations in the body, the students scored mainly in the “needs more attention” range of the devised Likert scale (Table 2). When the ability to construct a paragraph was

measured on a grade scale (Grade 0-IV) developed by Hossain et al., (2010), students mainly obtained a Grade II difficulty, which means they had adequate ability to perform the task. These results compare well with results obtained by Hossain and co-workers (2010). Students from the three groups had an average ability to construct a sentence, but they did not change the homophones in the sentence to suit the sentence construct. They were, however, able to choose the correct homophones in the homophone section of the test.

Students struggled with the different questions in the comprehension sub-section of the linguistic ability section of the aptitude test. Students had trouble in identifying a structure on a cross-section picture and then relating that structure to an electron micrograph. In the spelling section of the aptitude test, students did not seem to have a problem with the spelling of medically related words. They did, however, have difficulty in constructing a paragraph and using the correct spelling in the paragraph. Only a small amount (five) of questions were asked in the synonym section of the test, resulting in no meaningful correlation between the knowledge of the students and the percentage obtained for that part of the test. Students had trouble drawing inferences and finding links between groups of words.

The study also investigated the visual-spatial skill of the three different groups of Anatomy students. It seemed that the Radiography students, more so than the Nursing and SLPA students, struggled with this section of the test. In the mental rotation ability section of the test, the Nursing students had a single student who failed; SLPA had a 100% pass rate and the Radiography group had four students (out of 32) who failed. The students exhibited 25-35% overall difficulty in executing the task of rotating anatomical objects in space. It is important to note that a key view of the anatomical structure should be presented for each question. These findings are shared by Garg and co-workers (2001) in their study on the spatial relationships of carpal bones. In the cause and effect section of the test, students had a 30% overall difficulty of predicting different outcomes from the pictures provided.

When the performance of the three components of the visual-spatial sub-section of the test was compared on an arbitrary grading scale, developed by Hossain and co-workers (2010) (Grade 0 – 80.01% and above; Grade I – 60.01 to 80%; Grade II – 40.01 to 60%; Grade III – 20.01 to 40%; Grade IV – below 20% on overall performance), none of the students obtained a Grade IV difficulty. Most of the students experienced a Grade I difficulty, followed by a smaller number of students having a Grade II difficulty. A few students had a Grade 0 difficulty (3-19%). The Radiography students had a single student who obtained a Grade III difficulty.

When the content validity of the test was determined, results indicated that the different questions in the different subsections of the test had good item validity. Both sections of the test had good sampling validity, meaning that the test consisted of a wide variety of questions. The homophones and synonym sections of the test had poor sampling validity as the test contained only five questions for each of these sections. Two criteria were used to determine predictive validity, namely the difficulty and discrimination indices. Specific criteria were set for the two indices to determine whether the results had good predictive validity. The students obtained scores between 50-73% for the difficulty index for the subsections in the aptitude test. This means that there was an even distribution of scores for the three groups. The results obtained for the discrimination index is very similar for the three groups of students. All groups scored between 0.2 – 0.4 for the discrimination index. This means that the tests in the two sections of the aptitude test (linguistic ability and visual-spatial skill) had low to moderate ability to distinguish between high and low scoring students.

When the internal consistency (reproducibility) of the test was determined, only a single page had to be removed from the subsections of the test to increase the internal consistency. The section of the linguistic ability test with the lowest reproducibility was the word relationship section, where a value of only 0.1 was obtained. For the visual-spatial skill part of the aptitude test, only a single page had to be removed, similar to that of the linguistic ability section of the test. The internal consistency was higher in the visual-spatial section of the test than in the linguistic ability section of the test.

When the internal correlation of the different pages was studied, it was found that there were quite a number of pages that had internal correlations. In certain instances, specific pages with internal correlations repeated between the three groups.

No correlation could be made between the aptitude test and the first Anatomy test. The remainder of tests during the year also showed no correlation with the aptitude test.

6.4 CONCLUSIONS

When the average performance of the three groups of students was calculated, none of the groups displayed good to excellent abilities when undertaking the task of writing a paragraph. Not understanding English, or how to use the English language to express what one has learned, could also jeopardise the understanding of textbooks and facing written examinations. Students can construct sentences, but they do not use the correct homophones. They are also unable to punctuate these sentences. Should the students be required to write a paragraph, they would not be able to punctuate the sentences or use the correct homophones, thus answering of essay type questions in assessments would be challenging.

The fact that students struggled with the comprehension sub-section of the aptitude test, could indicate that they might experience difficulty when reading long paragraphs, or when they have to draw inferences from pictures provided. It could also be an indication that students will have problems in transcribing to words what they see in pictures. This is a huge stumbling block, as Anatomy is a visual subject and pictures play an integral part of understanding the subject. Students could not draw inferences between groups of words, which could mean that they will not be able to relate important aspects when studying for Anatomy.

For the visual-spatial section of the test, the Radiography students struggled more than the other two groups. This could pose a problem for their chosen profession, as they see two dimensional structures that have to be manipulated in space. With the mental rotation ability subsection of the aptitude test, it seemed that students have a greater ability to rotate anatomical structures in space, when compared to describing abstract objects being rotated in space. These results compare well with the findings of Rochford (1985), whose study found that students with either high or low spatial ability perform equally well on testing of non-spatial anatomical knowledge. Students performed well in the cause and effect section of the test, indicating that they should have little trouble predicting the outcome of muscle actions and nerve lesions. The results obtained in the grading scale section of the visual-spatial section of the test indicate that students should not experience difficulty in using their knowledge of the wet specimens and applying it to the spotter tests. This is however not the case and more research is needed to clarify this phenomenon.

Good item and sampling validity was maintained in the test, except for two sections of the linguistic section of the test, namely synonyms and homophones. It is clear from these findings that any section in any

assessment should not contain too few questions, as it provides the test with poor sampling validity (Dent and Harden, 2013). The SLPA students obtained higher scores for the different sections, which means that SLPA students will struggle less with Anatomy, if linguistic ability and visual-spatial skill are the only factors influencing academic success.

The discrimination index of the test indicates that, in its current format, the test has low to moderate ability to discriminate between high and low scoring students. Therefore, modifications are needed in the different sections of the aptitude test to increase the discrimination index for the different questions. The internal consistency (reproducibility) measure of the test indicated that there are clear deficiencies on certain pages and that these pages will have to be altered before the test can be used in future to obtain reliable internal consistency. It was also found that high reproducibility is not present between different groups. This could be due to the fact that different individuals are writing the test. To ensure a higher degree of reproducibility it would be beneficial to repeat the test on the same students, once in the beginning of the year and again later in the year. The results for a specific group can then be used to test the reproducibility of the test.

When internal correlations were determined between the pages of the different subsections of the test, it was found that a corresponding page also had high reproducibility. It could therefore be concluded that the larger the number of pages having internal correlations, the higher the internal consistency. Academic vulnerability could not be proved between the aptitude test and the first Anatomy block test. No correlation could be found between the aptitude test and the remaining tests during the year. Therefore, the aptitude test will have to be modified in future to provide an accurate correlation between academic vulnerability and the aptitude test.

Lastly, it can be concluded that the aptitude test can determine certain linguistic and visual-spatial deficits of students. Currently, the test can indicate a small number of students that struggle with a certain section of the test, but it does not clearly show that the same students struggle in all the sections of the aptitude test. The aptitude test will have to be adjusted to clearly indicate whether a student that struggles in one section of the test, will also struggle in other sections of the linguistic and visual-spatial sections of the test. However, it is not definite that students will necessarily struggle in both sections of the test. Students can struggle in only one section of the test and still have trouble with Anatomy as a subject.

6.5 SUMMARY OF CONTRIBUTIONS

The aptitude test in its current format provided a good indication that a test, developed originally as an aptitude test, will have to be piloted and used quite a number of times before it is suitable and reliable for use. The test verified that using a grading scale, as developed by Hossain and co-workers (2010) to determine overall linguistic ability and visual-spatial skill, is a credible and reliable tool to determine the English abilities and visual-spatial skill of the students.

Furthermore, difficulty index and discrimination index, are two good measures to use for establishing criterion validity. This aptitude test, adapted according to the results of this study, could become an invaluable tool to determine academic vulnerability of students early in the year.

This test demonstrated a number of important aspects that have to be in place for the test to be successful which will be discussed in the following section.

6.6 SHORTCOMINGS IDENTIFIED FOR FUTURE RESEARCH

With this aptitude test being in its infancy stages, it is very important to realise that a test of this magnitude could never be 100% successful on its first attempt in its current format. The results of this study indicate that a number of key modifications need to be made to the aptitude test before attempting to use the test in future. The following shortcomings were identified:

- Firstly, all the subsections in the aptitude test must carry the same weight in marks. Each page must also have the same number of questions so that the subsections within a section of the aptitude test have good validity and internal consistency. Certain sections of the test that only counted five marks (homophones, prefix and suffix, synonyms) need to be expanded so that the content of the subsection determines the actual knowledge base of the student in English.
- It is important to use words that the students will already know before the introduction week.
- Also, it will be of great value to possibly include positive controls in the test. This could be second year students that excelled in their first year in Anatomy.
- It would also be important to study the time that each individual student took on the aptitude test. This could be a good indicator of ease with which the students complete the aptitude test.
- Another important change that should be investigated is to combine the results of the different groups to increase the number of data points in the analysis, which will then also increase the reliability of the results.

Drawing on the results obtained in the visual-spatial ability and mental rotation ability sections of the test, this study highlights the fact that students do not perform as expected in their spotter test. It would therefore be necessary to undertake a study on factors causing students not achieving the marks they are supposed to, while they do have the ability to transfer information in textbooks and atlases, to the wet specimens used in practicals and spotter test and -examinations.

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APPENDICES

APPENDIX 1 – PARTICIPANT INFORMED CONSENT FORM AND INFORMATION LEAFLET

TITLE OF THE RESEARCH PROJECT:

AN APTITUDE TEST THAT MEASURES LANGUAGE AND VISUAL-SPATIAL ABILITIES IS USED TO IDENTIFY POTENTIAL ACADEMIC VULNERABILITY OF STUDENTS IN ANATOMY.

REFERENCE NUMBER:

PRINCIPAL INVESTIGATOR: Dr Petro Humphries

ADDRESS: *Sefako Makgatho Health Sciences University*

Department of Anatomy

P.O.Box 232

Garankuwa

0204

CONTACT NUMBER: 012 521-4021

Dear Student

My name is Dr. Petro Humphries and I am registered for my MPhil degree in Health Professions Education at Stellenbosch University. I would like to invite you to participate in a research project that aims to investigate whether an internally developed aptitude test can be utilised to determine the language and visual-spatial abilities of Anatomy students and also predict academic vulnerability of the Anatomy students at SMU.

Please take some time to read the information presented here, which will explain the details of this project and please feel free to contact me should you require further explanation or clarification related to any aspect of the study. Your participation is **entirely voluntary** and you are free to decline to participate. Should you decide not to participate, this will not affect you negatively in any way. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the **Health Research Ethics Committee (HREC) at Stellenbosch University** and will be conducted according to accepted and applicable National and International ethical guidelines and principles, including those of the International Declaration of Helsinki, October 2008.

What is this research study all about?

- *This leaflet serves to inform you why it would be to your benefit to complete the aptitude test. This test forms part of a study that aims to identify “academically vulnerable” students in Anatomy at the very beginning of the year by testing basic skills that are needed to excel in Anatomy. Why is it necessary to know which students are academically vulnerable and why does the test have to be*

performed so early in the year? When an academic vulnerable student is identified, a student-specific intervention program can be implemented to help such students throughout the year to obtain the skills needed for knowledge retention and application in Anatomy. If academic vulnerability is only identified halfway through the year, it is too late to make a significant change/impact on the students' skills, abilities and knowledge through intervention programs.

- This aptitude test will test basic skills, namely linguistic and visual-spatial abilities, which includes such skills as reading and comprehension, language skills, interpretation abilities, abilities to compare structures with each other, mental rotation and mental visualisation of structures, to name but a few. Anatomy is considered a completely new language and your foundation of English has to be firm in order to build on it. If you are identified as a vulnerable student, you will be introduced to a student-specific intervention program but you will not be treated any different from any other student in the medical group. Should you decide to participate in the study, it would have no influence, either positive or negative, on your course evaluation.
- Intervention methods will be both student-oriented and lecturer-oriented. Student-oriented intervention methods will include empowering students to be able to perform the above mentioned skills and to apply them to the Anatomy course. This can be achieved by directing students to reading sources, assisting with study methods and time management, or individual/group classes where a specific skill, identified in the aptitude test as lacking from an individual, will be taught.
- Lecturer-oriented interventions will include changes/variations in lecturing styles, implementation of more practical periods, small-group learning and/or tutorials. These interventions will be mainly driven by the data obtained from the results of each individual student, as each individual reacts differently to new knowledge presented and retention of that knowledge.
- None of your personal information will be used during publications or presentation of results. All personal information will remain confidential at all times, and will be filed away in the departmental safe for safekeeping for 10 years, after which it will be destroyed. No academically vulnerable student will be "labelled" as such, and will also not be treated any different from any other student registered for the same course, apart from receiving appropriate and necessary interventions.

Why have you been selected to take part in this research study?

- You have been selected to participate in this study because you are currently registered as an Anatomy student.

What will your tasks be during the research study?

- Your responsibility will be to complete the computerised aptitude test in one of the computer facilities that has been allocated to your group for writing to the best of your ability during the two-hours, in the time assigned to you by the Department. This aptitude test will not contribute to your year mark in Anatomy in any manner and does not form part of the formal evaluation of the course.

Will you benefit from taking part in this research study?

- *Should you experience difficulties in any one of the sections of the aptitude test (English or visual-spatial abilities/ mental rotation and mental visualisation), you will be identified and you will be introduced to a specific intervention program to help.*

Are there any risks involved in your taking part in this research study?

- *None*

Are there any alternatives should you decide not to partake in the research study?

There are no repercussions for those who decide not to participate and as such there will be no alternative options.

Will anybody have access to your academic records?

- *Not directly. There might be an instance where the members of the Health Research Ethics Committee from Stellenbosch want to inspect the research records. This is the only occasion on which the results will be viewed by anybody other than the principal researcher.*

What will happen in the unlikely event of some form of injury occurring as a direct result of your taking part in this research study?

- *No injury is foreseen when partaking in this research study.*

Will you be paid to take part in this study and are there any costs involved?

- *You will not be paid to participate in this study and there will be no costs involved for you if you do take part. The only cost you will incur is the two hours it will take you to complete the aptitude test.*

Is there anything else that you should know or do?

- *The results from your first Anatomy test will also be used as part of the research study, to establish a possible link between your academic performance and the your linguistic (English) and visual-spatial abilities. Please be sure to only sign the consent form when you consent that the researcher may use these results in the research study.*
- *You can contact the Health Research Ethics Committee at 021-938 9207 should you have any concerns or complaints that have not been adequately addressed by the principal investigator.*

You will receive a copy of this information and consent form for your own records. Should you be willing to participate in this study, please sign the attached Declaration of Consent and place it in the box available).

Yours sincerely,

Dr P Humphries
(Principal Investigator)

Declaration by participant

By signing below, I (full names and surname) agree to take part in a research study entitled

.....
.....

I declare that:

- I have read the attached information leaflet and I understand the content. It is written in a language with which I am fluent and comfortable.
- I had an opportunity to ask questions and all my questions were adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or discriminated against in any way.
- I may be asked to leave the study before it has been completed, should the researcher be of the opinion that it is in my best interest, or if I do not follow the study plan, as agreed to.

Signed at (*place*) on (*date*) 20.....

.....

Signature of participant

Declaration by investigator

I **Dr Petro Humphries** (full name and surname) declare that:

- I explained the information in this document to **Nursing, SLPA and Radiography students**.
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she understands all aspects of the research, as discussed above.
- I did/did not use an interpreter. (*If an interpreter is used, then the interpreter must sign the declaration below*).

Signed at (*place*) **SMU, Garankuwa** on (*date*) 11 July 2015


.....

Signature of investigator


.....

Signature of witness

APPENDIX 2 – CONSENT FORM OF STATISTICIAN

Sefako Makgatho Health Sciences University
Department of Anatomy
P.O.Box 232
0204

Date: 22 April 2016

Title of Research: An aptitude test that measures language and visual-spatial abilities is used to identify potential academic vulnerability of students in anatomy.

Principal Researcher: Dr P Humphries

Statistical program used during statistical analysis:

SAS (SAS Institute Inc, Cary, NC, USA), Release 9.4.

Statistical analysis completed for thesis:

Basic descriptive statistics, including frequency counts
and percentage calculations, correlation analysis, Cronbach alfa.

I hereby confirm that I am aware of the project and also undertake to assist with the statistical analysis of the data generated from the project.

PROF H S SCHOEMAN

Initials and Surname


Signature

11 October 2016

APPENDIX 3 – APTITUDE TEST

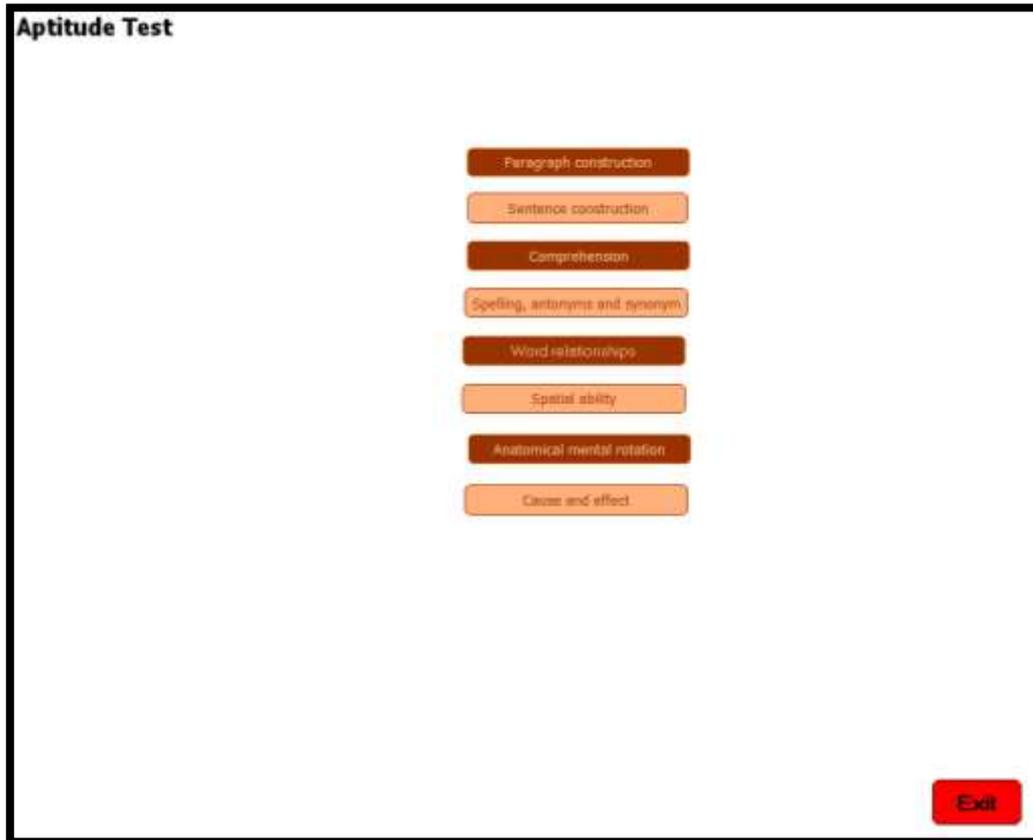


Figure 3-0-1: Menu of the aptitude test with all the smaller subsections of the tests.

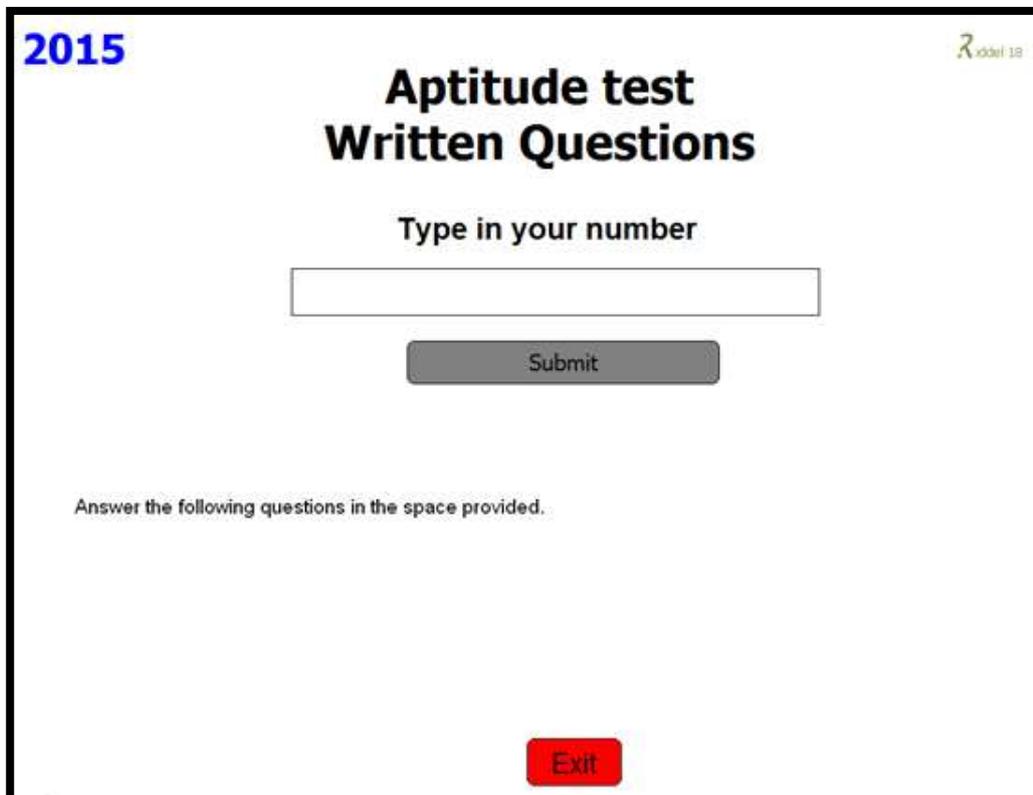


Figure 3-0-2: Front page of the written component of the aptitude test.

1 10 30 30 Charactercount 10 30

Look at the flow diagram of the pulmonary and systemic circulation. Use the direction of the arrows and describe all the processes that are taking place to the best of your ability. (Write a paragraph of no more than 350 words)

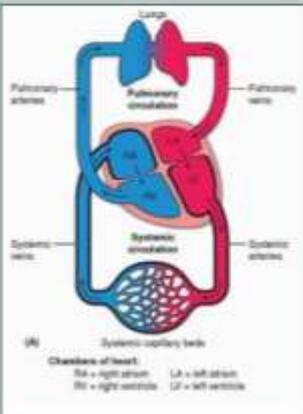


Figure 3-0-3: Question in the written section of the aptitude test where the students had to describe the pulmonary and systemic circulations in the human body.

2015 Ridder 161

Aptitude Test Sentence Construction

Type your number in here

Submit

Answer the following questions in the space provided.

Exit

Figure 3-0-4: Front page of the sentence construction section of the aptitude test.

1 Question counts
1 Wordcount 0 Charactercount
Test is out of 6

Correct the errors in the sentence, while also changing the tense in the sentence to future tense:
The medical students was learning to use anatomical terminology.

Figure 3-0-5: First page of the sentence construction section of the aptitude test. Students had to change the sentence to future tense and correct other errors in the sentence.

2 Question counts
1.5 Wordcount 0 Charactercount
Test is out of 6

Correct any mistakes in this sentence, while also changing the sentence to past tense:
All medical students will be encourage to learn there Anatomy every day four at least two hours.

Figure 3-0-6: Second page of the sentence construction section of the test. Students had to change the sentence to the past tense and correct other errors in the sentence.

3 Question counts 3.5 Wordcount 0 Charactercount 0 Test is out of 6

Correct the mistakes in the following sentence. (Use the correct punctuation)
Ouch she injure me with the scalpel blade said john

Figure 3-0-7: Third page of the sentence construction section of the aptitude test. Students had to correct the errors in the sentence and correct the punctuation of the sentence.

2015 Riddell 15

Comprehension

Aptitude Test

Type your number in here

Submit

Answer the following questions.

Exit

Figure 3-0-8: Front page of the comprehension section of the aptitude test

Page 1 of 7

General information:

Please provide your student number

Do you have any of the following:

Tablet

Laptop

Smart phone

Was this your first choice of study? If not, please specify which course you wanted to study.

Submit

Users\petro.humphries.SMU\Desktop\Research Results\Skills\2015 aptitude test Speech\Comprehension.Htk

Figure 3-0-9: First page of the comprehension section of the aptitude test. This page asked the student for their student number to be able to link the student to the results. This page did not count towards the results of the aptitude test.

Page 2 of 7
Pages left 7

Read the explanation on bone development then answer the questions after reading the passage.

Intramembranous Ossification
 Intramembranous ossification occurs within a membrane-like, condensed plate of mesenchymal cells. At the initial site of ossification (ossification centre) mesenchymal cells (osteoprogenitor cells) differentiate into osteoblasts. The osteoblasts begin to deposit the organic bone matrix, the osteoid. The matrix separates osteoblasts, which, from now on, are located in lacunae within the matrix. As soon as the osteoblasts become trapped in the lacunae they are called osteocytes. The collagen fibres of the osteoid form a woven network without a preferred orientation, and lamellae are not present at this stage. Because of the lack of a preferred orientation of the collagen fibres in the matrix, this type of bone is also called woven bone. The osteoid calcifies leading to the formation of primitive trabecular bone.

Further deposition and calcification of osteoid at sites where compact bone is needed leads to the formation of primitive compact bone.

Give the sequence of cell development during the formation of bone.

1

2

3

spicules
 trabeculae
 blastemas
 osteoclasts
 osteoprogenitor cells
 osteoblasts
 osteocytes

Calcification leads to the formation of

Which cells end up in the lacunae?

Figure 3-0-10: On the second page of the comprehension section of the aptitude test students had to read a passage on bone development. They then had to answer questions on the provided passage.

SATELLITE CELLS

Many non-neuronal cells of the nervous system have been called satellite cells, including small round extracapsular cells in peripheral ganglia, ganglionic capsular cells, Schwann cells, any cell that is closely associated with neuronal somata, and precursor cells associated with striated muscle fibres (p. 117). Within the nervous system, the term is most commonly reserved for flat, epithelioid cells (ganglionic glial cells, capsular cells) that surround the neuronal somata of peripheral ganglia (Fig. 3.26). Their cytoplasm resembles that of Schwann cells, and their deep surfaces interdigitate with reciprocal infoldings in the membranes of the enclosed neurones. Capsular cells are succeeded by similar cells that enclose the initial part of the dendroaxonal process of unipolar sensory neurones in dorsal spinal ganglia, and these in turn are continuous with the Schwann cells that surround the peripheral and central processes of the neurones.

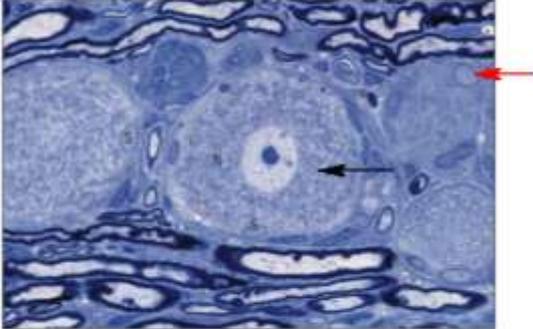


Fig. 3.26 Sensory neurones in a dorsal root ganglion (rat). Neurones (N) are typically variable in size but all are encapsulated by satellite cells (S). Myelinated fibres are seen above and below the neuronal somata. Toluidine blue stained resin section. (By courtesy of Dr Clare Farmer, King's College, London.)

Read the passage provided on the satellite cells and state whether the statements are TRUE or FALSE.

State whether it is true or false that all sensory neurones are encapsulated by satellite cells.

Schwann cells surround the neuronal somata of peripheral ganglia?

What is the shape of the cells that surround the neurones of the peripheral ganglia?

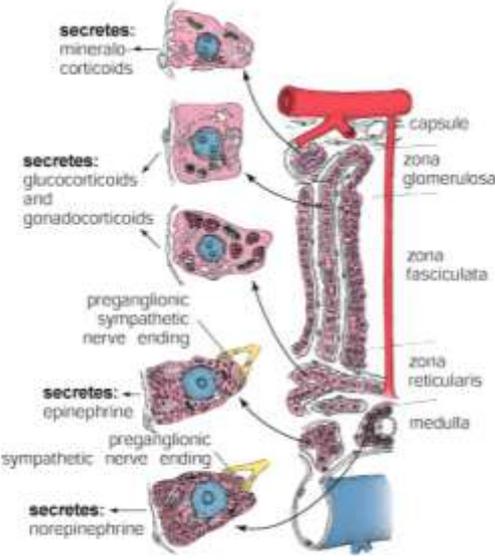
Identify the structure indicated with the BLACK arrow.

Identify the structure indicated with the RED arrow:

Ganglionic capsular cells
 True
 False
 Schwann cells
 Ganglionic glial cells
 Neuron
 Flat, look squarish in shape
 Non-neuronal cells
 Flat, look oval in shape
 Satellite cells
 Flat, look like epithelium

Figure 3-0-11: On the third page of the comprehension section of the aptitude test students had to read a passage on support cells of the nervous system. They then had to answer questions on the provided passage.

Use the following diagram to distinguish which substances are secreted by the following cells:



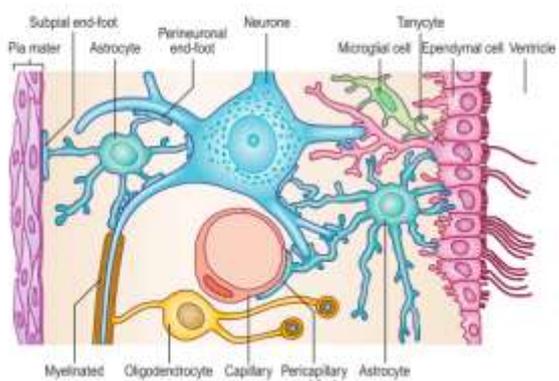
Zona glomerulosa
 Zona fasciculata
 Zona reticularis
 Medulla

glucocorticoids
 norepinephrine
 epinephrine
 gonadocorticoids
 mineralocorticoids

Figure 3-0-12: On the fourth page of the comprehension section of the aptitude test, students were provided with a picture on substance secretion by certain cells. By looking at the picture students should be able to distinguish which substance is secreted by which cells.

Page 5 of 7
Pages left 7

Answer the following questions regarding the picture provided below on the glial cells that provide support to the neurons of the central nervous system (CNS).



Which glial cell has an end-foot on a neuron, capillary and the pia mater?

Which glial cell is responsible for forming myelin sheath around the axons of a neuron?

The different types of non-neuronal cell in the CNS and their structural organization and interrelationships with each other and with neurones.

Which cells line the outside of a ventricle?

Which specific part of the astrocyte end on the axons and neuronal bodies?

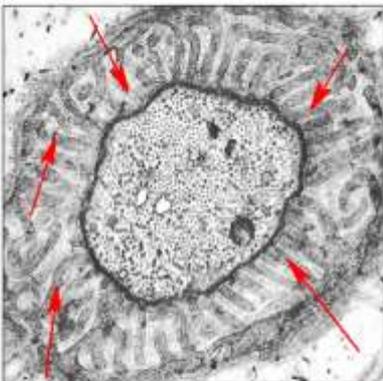
Astrocyte
Microglial cell
Ependymal cell
Oligodendrocyte
Pericapillary end-foot
Perineurial end-foot
Tanyocyte
Subpial end-foot

Figure 3-0-13: Fifth page of the comprehension section of the aptitude test. Students were provided with a picture on glial cells. Students had to extract information from the annotations to answer the questions.

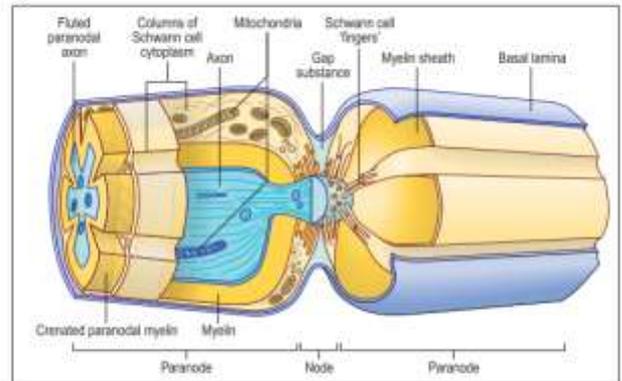
Page 6 of 7
Pages left 7

Which structures in the drawing on the right hand side is represented by the structures indicated by the RED arrows indicated on the electron microscope photograph on the left?

A



B



Schwann cell "fingers"
Mitochondria
Columns of Schwann cell
Myelin sheath
Basal lamina
Gap substance
Axon

Figure 3-0-14: Sixth page from the comprehension section of the aptitude test. An electron micrograph and annotated picture of the columns of the Schwann cell on a cross-section. Students had to identify the same structure on the two pictures.

Choose the answer from Column B that fits with Column A and put the answer in Column C

Column A	Column B	Column C
Artery	Cerebrospinal fluid	Carry oxygenated blood
Right atrium	Pump that supplies the body with oxygenated blood	Receives all deoxygenated blood from the body
Liver	Protecting membranes of the brain	One of the organs' major functions are detoxifications
Kidney	Carry oxygenated blood	Urine is produced here
Lungs	Centre of the body where all neurological formation is interpreted	Oxygenation of blood
Vein	One of this organs' major functions are detoxifications	Carry deoxygenated blood
Heart	Oxygenation of blood	Pump that supplies the body with oxygenated blood
Brain	Cerebrospinal fluid flows in this area	Centre of the body where all neurological formation is interpreted
Subarachnoid space	Carry deoxygenated blood	Cerebrospinal fluid flows in this area
Dura, arachnoid and pia mater	Urine is produced here	Protecting membranes of the brain
	Receives all deoxygenated blood from the body	

Pump that supplies the body with oxygenated blood
 Receives all deoxygenated blood from the body
 Carry deoxygenated blood
 Carry oxygenated blood
 Protecting membranes of the brain
 One of this organs' major functions are detoxifications
 Urine is produced here
 Centre of the body where all neurological formation is interpreted
 Cerebrospinal fluid
 Oxygenation of blood
 Cerebrospinal fluid flows in this area

Exit

Figure 3-0-15: Seventh page of the comprehension section of the aptitude test. Students were requested to answer a few basic knowledge questions on work covered in the introduction week and in Grade 12 Life Sciences

2015

Spelling, Antonyms and Synonyms
 Aptitude Test

Type your number in here

Submit

Answer the following questions.

Exit

Figure 3-0-16: Front page of the spelling, antonyms, synonyms and homophones section of the aptitude test

Page 1 of 5
Pages left 5

Select the word that is spelled correctly in each drop down box:

Choose the correct spelling for each word in a drop down box:

Severly

Esaly

Likely

Sufficient

Medicine

Figure 3-0-17: First page of the spelling, antonyms and synonyms section of the aptitude test. Students were required to choose the word that was correctly spelled from a list of four words.

Page 2 of 5
Pages left 5

Select the word that is spelled correctly in each drop down box:

Choose the correct spelling for each word in a drop down box:

Relieving

Omitted

Preceding

Reservoir

Exceed

Figure 3-0-18: Second page of the spelling, antonyms and synonyms section of the aptitude test. Students were required to choose the word that was correctly spelled from a list of four words.

Page of
Pages left

Select the word that is spelled correctly in each drop down box:

Choose the correct spelling for each word in a drop down box:

Intervertebral

Figure 3-0-19: Third page of the spelling, antonyms and synonyms section of the aptitude test. Students were required to choose the word that was correctly spelled from a list of four words.

Page of
Pages left

Select the word (prefix or suffix) that has the same meaning as the sentence provided. Select your answer from each drop down box:

Which word in the list provided in the drop-down box has the same meaning as the sentence provided:

A patient with cancer will only live for 2 years.

The patient fell in the pool and is now dead.

Children end up in the Emergency room during December holidays because they are _____ at home.

Which of the following mean anterior (towards the front)?

When you study the development of the fetus, it is known as:

Figure 3-0-20: Fourth page of the spelling, antonyms and synonyms section of the aptitude test. Students were required to choose the correct prefix or suffix from the list provided in the drop down boxes.

Page of
Pages left:

Select the synonym for the word underlined in the sentence provided:

Please address these problems promptly.

To which vein are these nodes closely related?

Where does the portal vein drain to?

Where does the pulmonary trunk originate?

Classify the following joints

Figure 3-0-21: Fifth page of the spelling, antonyms and synonyms section of the aptitude test. Students were required to choose the correct synonym from the list provided in the drop down boxes.

2015 R eddel 15

Verbal ability - Word relationships

Aptitude Test

Type your number in here

Answer the following questions.

Figure 3-0-22: Front page of the word relationship section of the aptitude test

Page 1 of 3
Pages left 3

Choose the correct homophone for the sentence provided.

The students must provide student numbers at the beginning of a test.

Attending classes are essential understanding Anatomy.

one is the correct one?

The students wanted to know they are writing a test tomorrow.

You are too noisy. Please keep .

Figure 3-0-23: First page of the word relationship section of the aptitude test. Students were required to choose the correct homophone from the options provided in the drop down box.

Page 2 of 3
Pages left 3

Choose the word pair from the drop down box that has a similar meaning to the word pair provided.

Examples: Embankment: Flood
A) Dam: Lake B) Armour: Helmet C) Helmet: Injury D) Water: Tide (Answer: C)

Colour: Spectrum
A) Verse: Rhyme B) Tone: Scale C) Noise: Waves D) Waves: Sound (Answer: B)

Fatigue: Tonic

Blade: Slice

Note: Bar

Slight: Hurt

Figure 3-0-24: Second page of the word relationship section of the aptitude test. Students were required to choose the word pair from the drop down box that had a similar meaning to the word pair provided. Students had to draw some inferences from the word pair provided before choosing the answer.

Choose the word from the drop down box that best fits with the group of words provided.

Page 3 of 3
Pages left 3

Examples: Barber, Florist, Draper
A) Flower B) Cloth C) Milliner D) Hair (Answer: C)

Bourbon, Whisky, Gin
A) Beer B) Vodka C) Wine D) Lager (Answer: B)

Throw, Volley, Sling

Wool, Silk, Leather

Bright, Gleaming, Brilliant

Vulture, Hyena, Crow

Figure 3-0-25: Third page in the word relationship section of the aptitude test. Students had to choose the word from the drop down box that best fit with the group of words provided.

2015 Riddell 15

Spatial Ability Aptitude Test

Type your number in here

Answer the following questions.

<http://www.psychometric-success.com/aptitude-tests.htm>

Figure 3-0-26: Front page of the spatial ability section of the visual-spatial sub-section of the aptitude test.

The shapes in Group 1 and Group 2 are identical, although some of them may be rotated. Which shape in group 2 corresponds to the shapes (1-25) in Group 1:

Page 1 of 6
Pages left 6

Group 1: 1-25
Group 2: A-Y

3:
11:
21:
25:

5:
16:
22:

7:
20:
24:

<http://www.psychometric-success.com/aptitude-tests.htm>

Figure 3-0-27: First page of the spatial ability section of the aptitude test. Students were required to identify identical shapes between group 1 and group 2. Shapes differ because they are rotated in space.

In the figures below, one of the shapes (A-D) is identical to the first figure but has been rotated. Identify the identical figure for each question. (The figures may only be mentally rotated, NOT flipped)

Page 2 of 6
Pages left 6

1:

2:

3:

4:

<http://www.psychometric-success.com/aptitude-tests.htm>

Figure 3-0-28: Second page of the spatial ability section of the aptitude test. Students were required to find the figure that is identical to the provided figure. The figures in the options were rotated in space to differ from the original.

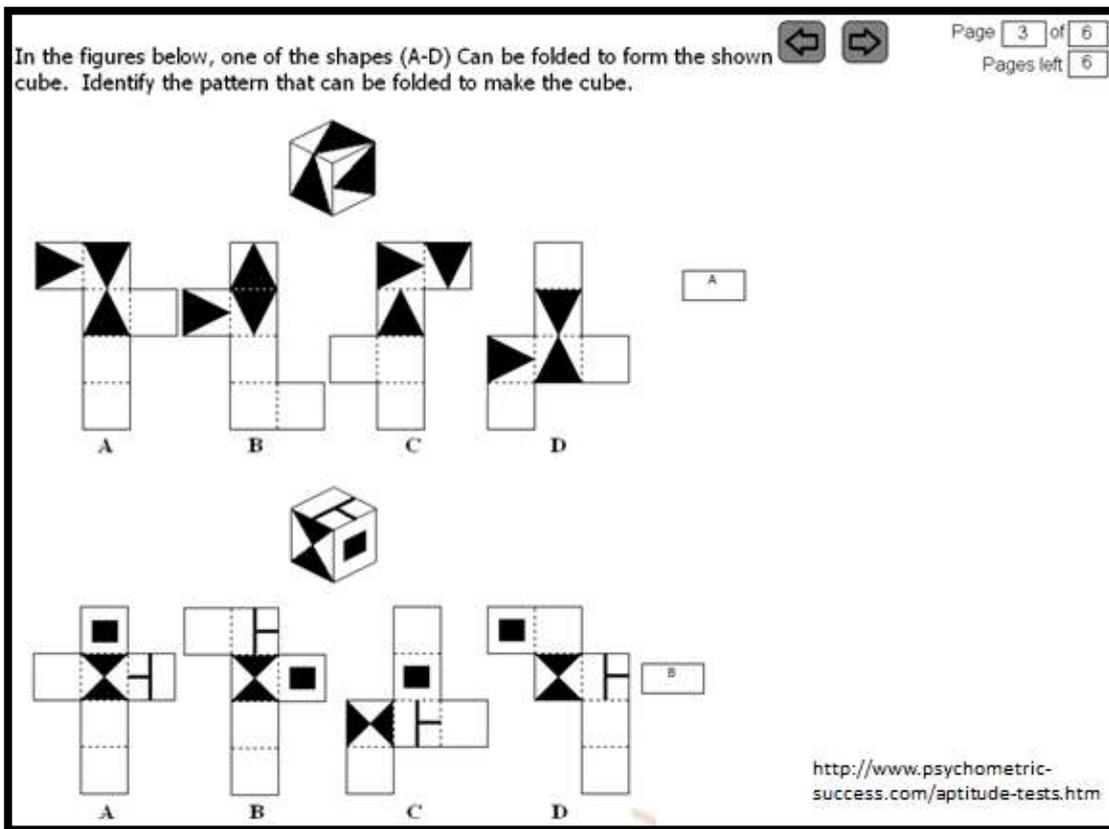


Figure 3-0-29: Third page in the spatial ability section of the aptitude test. Students were required to choose the deconstructed box that will form the box provided when folded into a box shape.

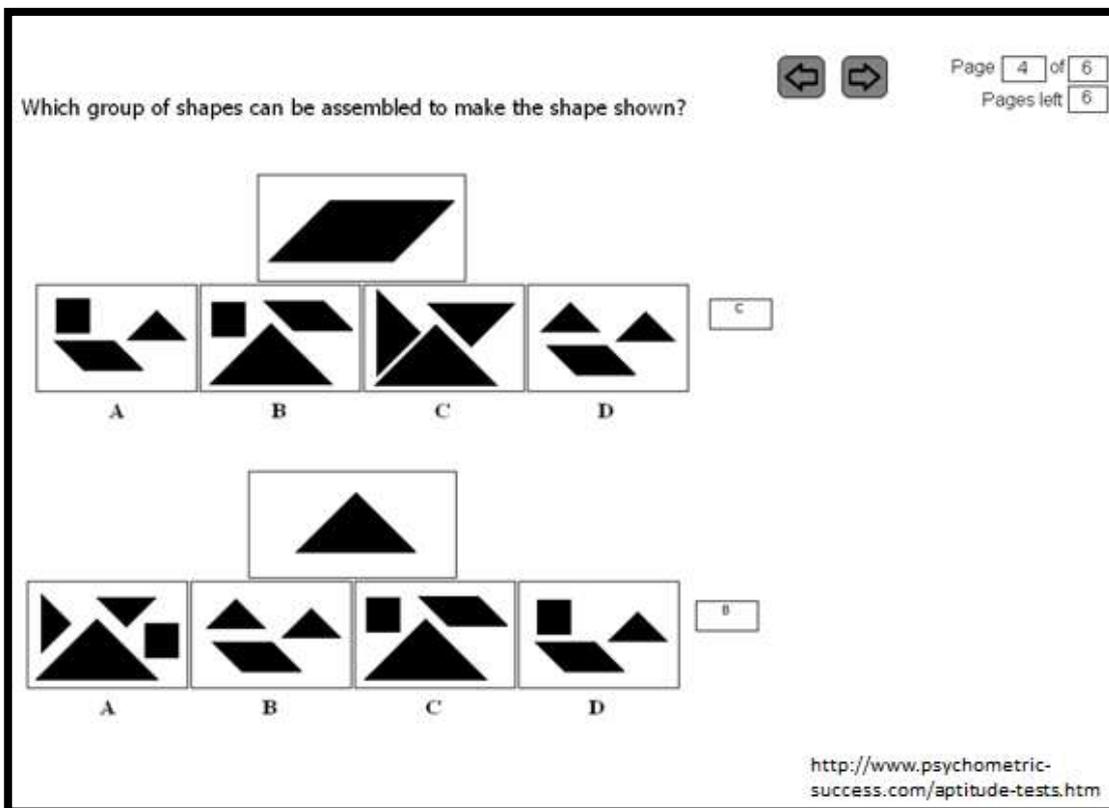


Figure 3-0-30: Fourth page in the spatial ability section of the aptitude test. Students were required to choose the box of shapes that can be assembled to make the shape that is provided.

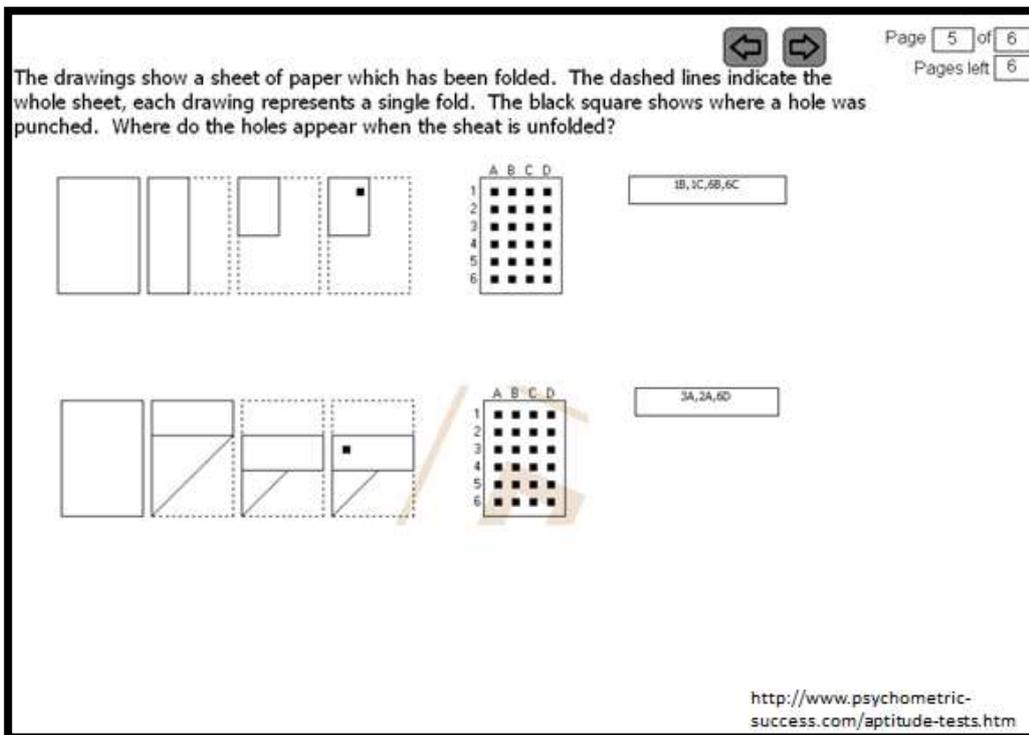


Figure 3-0-31: Fifth page of the spatial ability section of the aptitude test. Students were provided with drawings that show a piece of paper which has been folded. The dashed lines indicated the whole paper, and each drawing indicated a single fold of the paper. A hole was punched into the paper, which was indicated by a black square. Students had to determine where the holes would appear in the paper if the paper was unfolded.

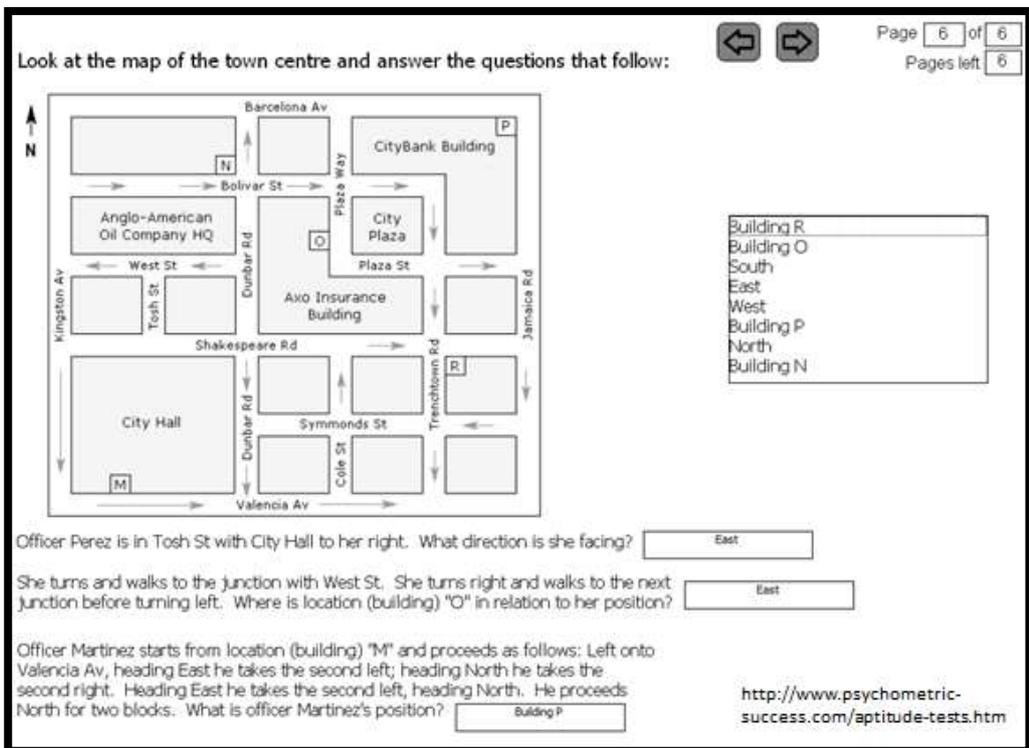


Figure3-0-32: Page six of the spatial ability section of the aptitude test. Students had to read a map of a few city blocks and locate a building or determine in which street the police officer would be if she walked in certain directions.

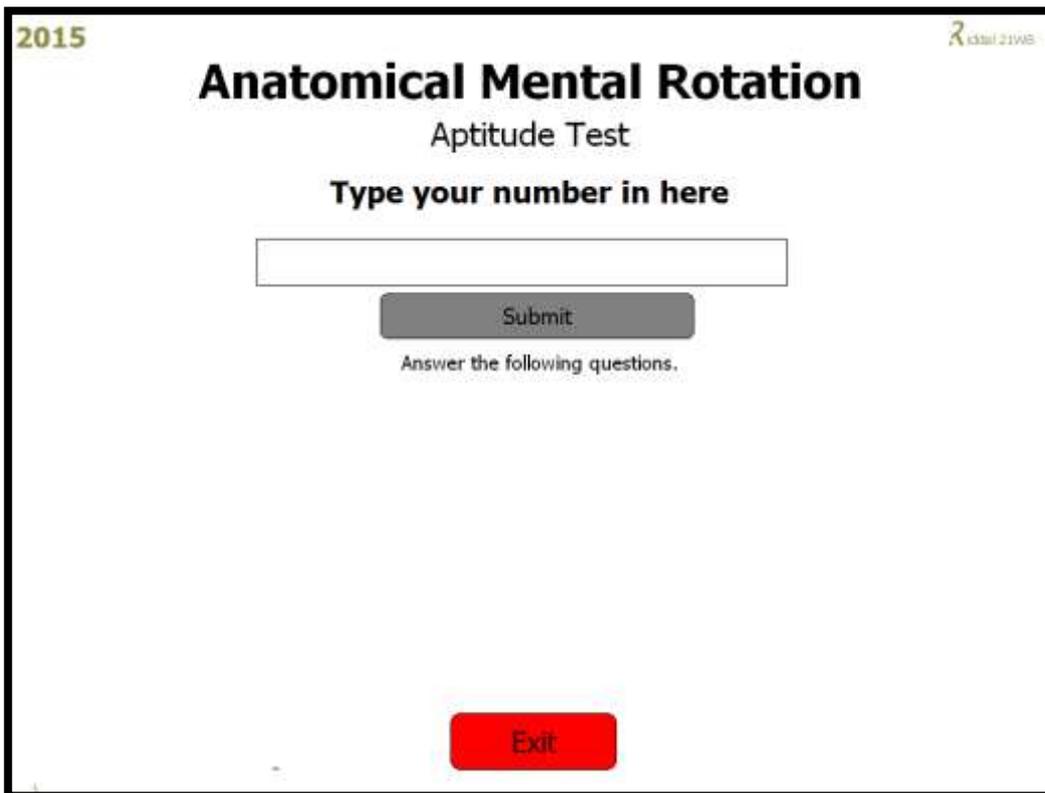


Figure 3-0-33: Front page of the anatomical mental rotation section of the aptitude test.

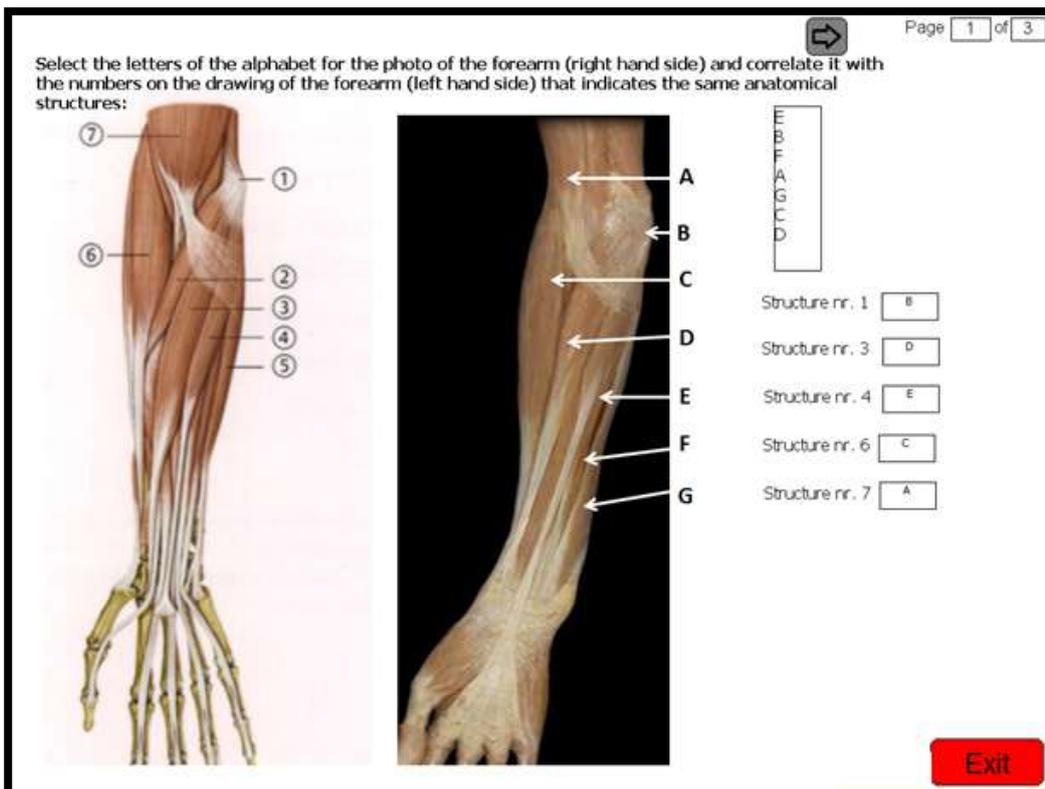


Figure 3-0-34: First page of the anatomical mental rotation section of the aptitude test. Students had to compare a drawing of an arm with an actual wet specimen and then annotate the diagram so that the same structures are labelled.

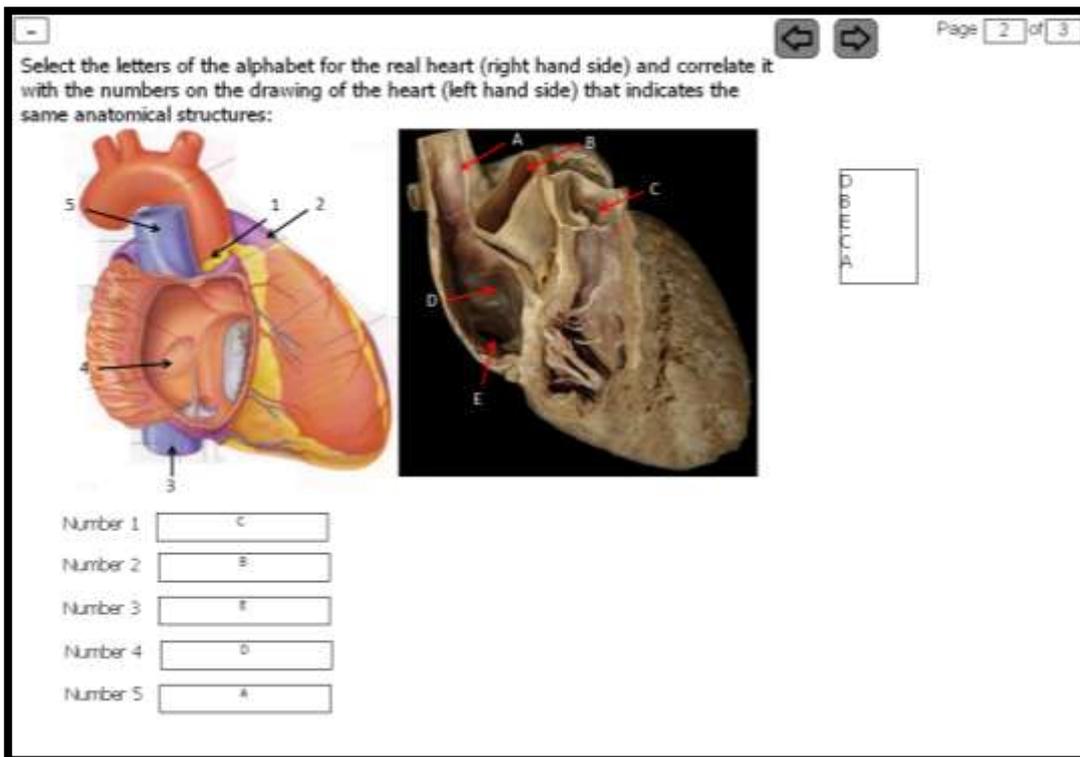


Figure 3-0-35: Second page of the anatomical mental rotation section of the aptitude test. Students had to compare a picture of a heart with an actual wet specimen of the heart and label the same structures between the two pictures.

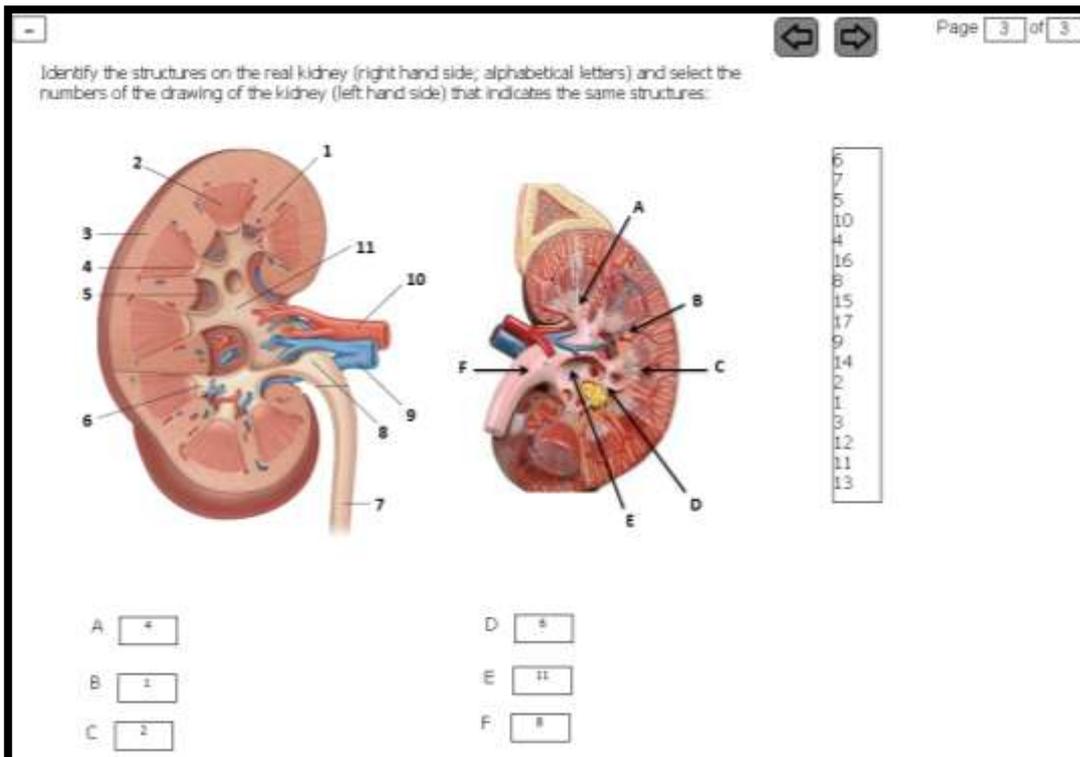


Figure 3-0-36: Page three of the anatomical mental rotation section of the aptitude test. A picture of two kidneys (one a drawing and one a picture of a plastic model) was used to determine whether students could label the same structures on the left and right kidneys.



Figure 3-0-37: Front page of the cause and effect section of the visual-spatial skill sub-section of the aptitude test.

Select the option that best describes the effect of what would happen if the optic nerve (1), optic chiasma (2) and optic tract (3) were cut in the positions as indicated. Select whether a, b, and/or c would be visible:

Page 1 of 4
Pages left 4

Question: Muscles of the eye and actions
The retina (orange and blue) looks obliquely in the direction of the slope of the eye

Options:
 a
 b
 c
 a and c
 a and b
 b and c

If the optic nerve was cut at 1, which letters will be visible to the patient?

If the optic chiasma was cut at 2, what would be visible for both eyes?

If the optic tract was cut at 3, what would be visible for both eyes?

Figure 3-0-38: First page of the cause and effect section of the aptitude test. Students had to predict what the outcome would be if the optic nerve was severed at different positions. What would be visible to the person with the nerve lesion?

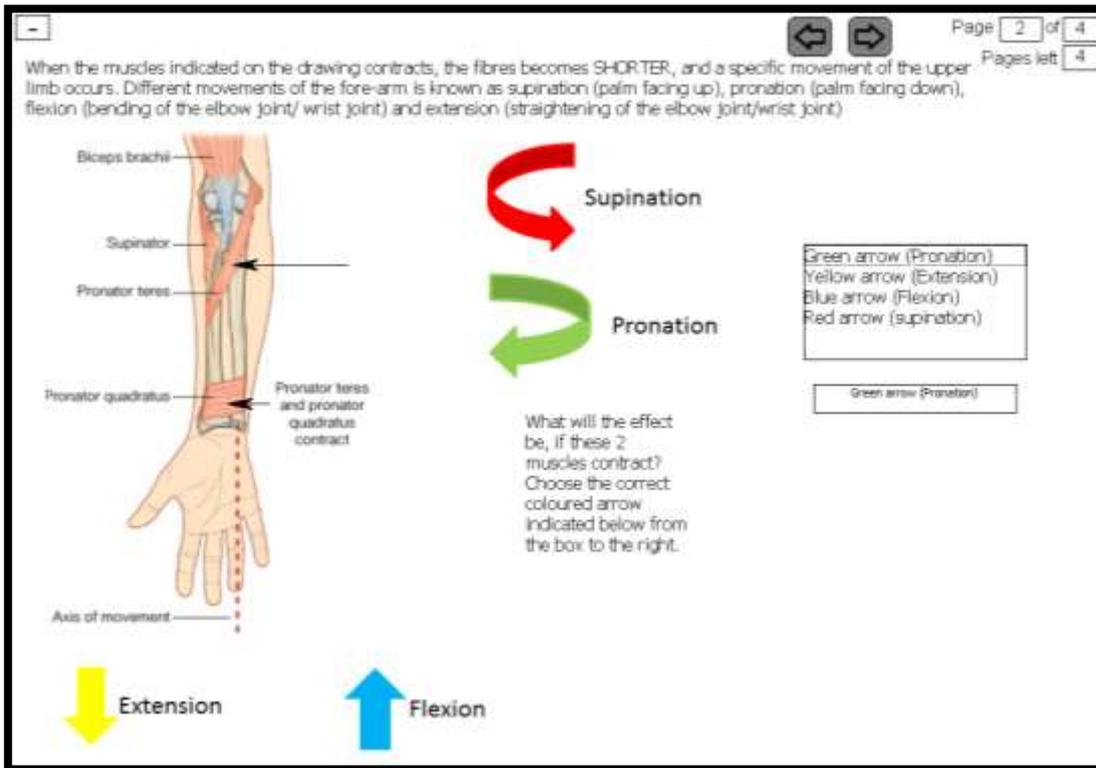


Figure 3-0-39: Second page of the cause and effect section of the aptitude test. Students had to predict what the movement of the fore-arm would be when the pronator teres and pronator quadratus muscles contract.

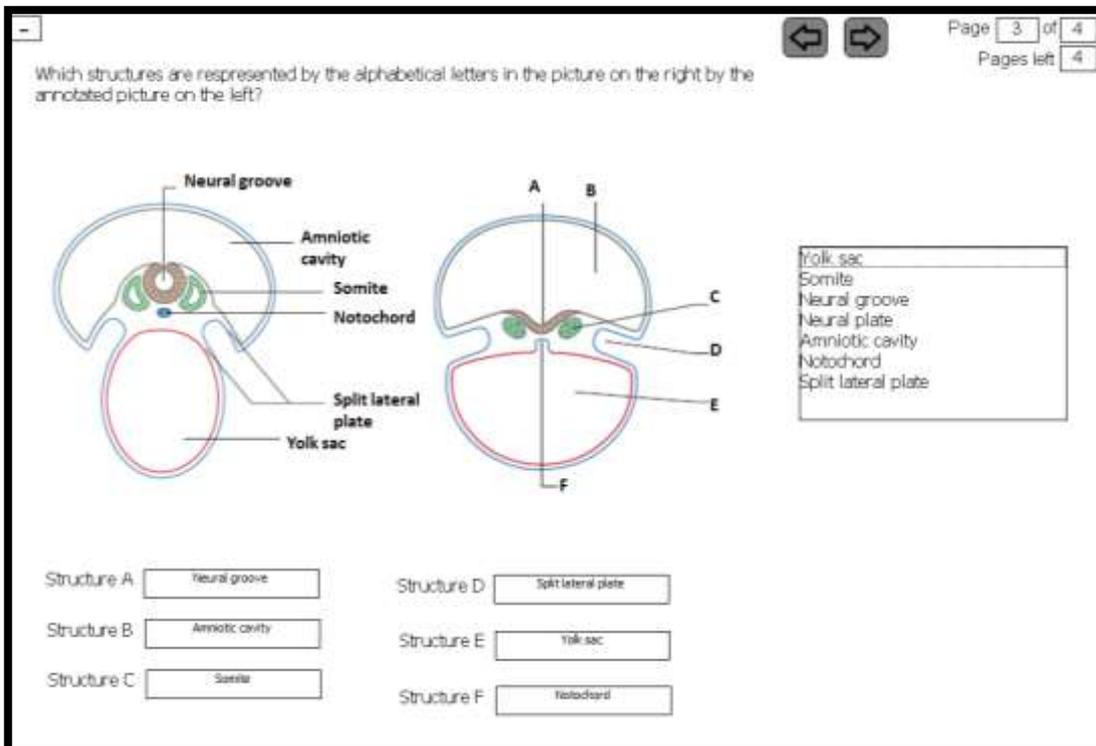


Figure 3-0-40: Third page of the cause and effect section of the aptitude test. Two pictures are provided on embryological development. The figure on the right is more developed than the figure on the left. Students had to indicate which structures are represented by the alphabetical letters on the right by comparing with the picture on the left.

Click on the structure in drawing 2 that originates from the indicated structure in drawing 1.

Page 4 of 4
Pages left 4

1

2

A blue "X" will appear on the spot where you click.
If you are satisfied with your choice click the green button.

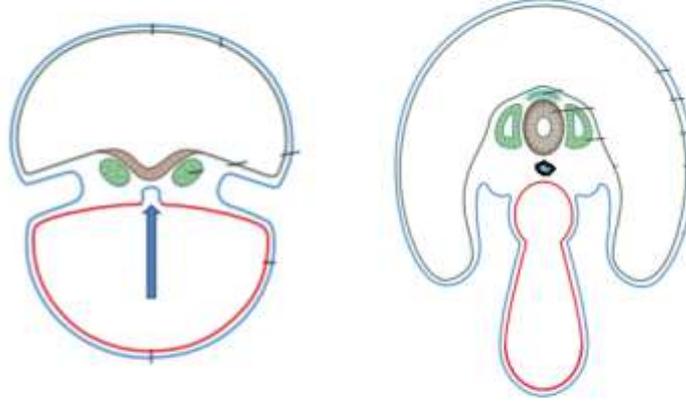


Figure 3-0-41: Fourth page of the cause and effect section of the aptitude test. Students had to click on the structure in drawing 2 that originates from the indicated structure in drawing 1.