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THE USE OF ANIMAL ORGAN DISSECTION IN PROBLEM-SOLVING AS A TEACHING STRATEGY

by

PORTIA KAVAI
(10451987)

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Supervisor
Prof J J R de Villiers

Co-supervisor
Prof W J Fraser

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DEDICATION

This study is especially dedicated to my husband Sabastan and children Alcidez, Alvarez and Alegra. To God be the Glory!

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SUMMARY

The major purpose of this study was to investigate the effects of using animal organ dissection in general, and its use specifically in problem-solving as a teaching strategy in Grade 11 Life Sciences education. A multiple methods research design was used for this study.

The data collection methods for the quantitative approach were the pre-test, post-test and a questionnaire. The pre-test and post-test had predominantly problem-solving questions. The questionnaire and the tests were administered to 224 learners from four Pretoria East secondary schools from different environments. The data collection methods for the qualitative approach were the interviews with the Grade 11 Life Sciences teachers of the selected schools, lesson observations and relevant document analysis. The interviews were conducted with six Grade 11 Life Sciences teachers teaching at the four selected schools.

Findings from both the quantitative and the qualitative approaches were integrated to give an in-depth understanding of the study. The findings show that there were significant differences between the means of the pre-test and the post-test for the total for the whole group of 224 learners. The variables in which the tests were categorised were the rote learning, problem-solving and three learning outcomes of the National Curriculum Statement (NCS). The way in which the learners answered the questions in terms of terminology they used, the confidence they displayed, the level of answering and the explanations they gave when they wrote the post-test were significantly different from when they wrote the pre-test. The significant differences between the means of the pre-test and the post-test may possibly have been due to the intervention. This showed the effectiveness of the intervention which was animal organ dissection in problem-solving. The study also showed that most teachers are not well-acquainted with problem-solving strategies which made it challenging for them to use animal organ dissections to develop problem-solving skills in learners. The attitudes of the teachers and learners towards animal organ dissection and its use in problem-solving as a teaching strategy were predominantly positive with less than a quarter of the whole group being negative due to a variety of reasons which include: moral values, religion, culture, blood phobia, squeamishness and being vegetarian. The majority of learners acknowledged the importance of animal organ dissections in developing skills like investigative, dissecting

and problem-solving skills. This acknowledgement resulted in them being positive towards the use of animal organ dissections in problem-solving.

One can conclude that animal organ dissections can be used in problem-solving as a teaching strategy in Life Sciences education. The level of learner engagement with animal organ dissections can determine the level of development of problem-solving skills as was evidenced by the differences between the mean scores of the four schools. The study recommended that the teachers should be encouraged to use animal organ dissections more frequently where it is applicable to develop problem-solving skills in learners and not merely let the learners cut, draw and label the organ. Teachers should also focus on problem-solving in general and develop this as a prime strategy. All activities should be prepared by the teacher and implemented in class to encourage and develop problem-solving skills.

KEYWORDS:
Life Sciences, animal organ dissections, problem-based learning, problem-solving skills, problem-solving strategies, outcomes-based education, learning-outcomes, attitudes and perceptions, science process skills, teaching strategies.

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ACRONYMS

AAAS:	American Association for the Advancement of Science
ANOVA:	Analysis of Variance
APIE:	Assess Plan Implement and Evaluate
BSCS:	Biological Sciences Curriculum Study
CAPS:	Curriculum and Assessment Policy Statements (South Africa)
CDE:	Centre for Development and Enterprise
DBE:	Department of Basic Education (South Africa)
DoE:	Department of Education (South Africa)
FET:	Further Education and Training
GLM:	General Linear Model
LO:	Learning Outcome
NABT:	National Association of Biology Teachers
NCS:	National Curriculum Statement (South Africa)
NRC:	National Research Council
OBE:	Outcomes-Based Education (South Africa)
PBL:	Problem-Based Learning
SAQA:	South African Qualifications Authority

DEFINITION OF TERMS

Learner	A term used in South Africa to indicate a school going person.
Learning Outcome	A broad statement of an intended result of learning and teaching. It describes knowledge, skills and values that learners should acquire by the end of the Further Education and Training phase (Grade 10-12).
Life Sciences	The scientific study of living things from molecular level to their interactions with one another and their environments.
Model 'C' schools	Historically advantaged schools, well-resourced former whites only schools during apartheid
National Curriculum Statement	The policy document for Grades 10-12 that replaces the Core Curriculum, Curriculum 2003.
Outcomes	The contextually demonstrated end-products of the learning process (SAQA Regulations, 1998 p.4). These end-products are now being replaced by aims and objectives in the CAPS syllabus.

Outcomes-Based Education	A learner-centred methodology and activity-based approach that allows learners to pace their own learning in order to acquire knowledge, skills and attitudes.
Pace-setter	A sequence of activities and time allocation per topic according to the National Curriculum Statement
Public schools	Historically disadvantaged schools, under resourced former black only schools
Problem	Some difficulty or question that needs to be overcome, when the course of action towards a desired objective is not easy.
Problem-solving	A specialised skill within a domain of knowledge rather than a generalised skill that applies across a variety of content areas.
School diverse environments	In this study means different school set up determined by the location in which the school is, the owner and availability of laboratory facilities
Students	A term used in South Africa to indicate persons educated in tertiary institutions.

CHAPTER 1

GENERAL INTRODUCTION, STATEMENT OF THE PROBLEM AND OVERVIEW OF THE STUDY

1.1 BACKGROUND TO THE STUDY

> "…… it is better that you should learn the manner of cutting by eye and touch than by reading, listening and observing. For reading alone has never taught anyone how to sail a ship, to lead an army, to compound a medicine, which is done rather by use of one's own sight and training of one's own hands" (Sylvius, J. as cited in Baker, 1909, p. 329)

It is not clear when exactly animal dissections first became a regular part of the secondary school Biology curriculum. During the late eighteenth and early nineteenth century, many philosophers and educational academics advocated that children should be able to make discoveries for themselves, rather than being bored with rote learning, memorisation and narration (Hart, Wood, & Hart, 2008). For centuries, educators in different parts of the world have used dissections in the teaching of learners either by demonstration or hands-on practice allowing learners to learn through discovery (Morton, 1987). Orlans (1993) refers to examples in the 1920s, but there are reports of animal dissections being part of the Biology curriculum in American colleges in the late 1800s (Fleming, 1952; Le Duc, 1946). Until the 1960s, most, if not all, of the average learners had contact with animals in education involving the dissections of animal organs and dead organisms. Many Biology learners never studied a living animal (Russell, 1996). In the sixties the new Biological Sciences Curriculum Study (BSCS) was introduced by a team of research scientists, science educators, and secondary school teachers under the oversight of the United States National Science Foundation (National Research Council 1990). BSCS resolved to replace, or at least supplement the look, dissect, draw, label and memorise approach, with an emphasis on the 'hands-on' study of animals. The positive impact of BSCS was that it encouraged learners to actually conduct exercises in scientific inquiry and to think more about scientific and biological concepts.

Animal dissection is a long-accepted teaching practice in secondary school curricula (Physicians Committee for Responsible Medicine, 2009). Authors like Marszalek and Lockard (1999), and Offner (1993), all agree that the value of dissections lies in being hands-on and exploratory, which promotes learner inquiry.

There are many reasons why animals have been used for so long in education and why "dissection is a familiar, comfortable, tried-and-true teaching method" (Orlans, 1993, p. 79; see also Balcombe, 2000). Many of these reasons are deeply personal ─ "My family and friends have benefited greatly from medical advances based on dissections. I, too, have benefited. My interest in Zoology skyrocketed when, as an undergraduate, I dissected a pig. That experience was unlike any photograph, model, or movie that I had seen. I was overwhelmed by the complexity and beauty of biological structure and function. That experience also prompted me to become a biologist. The continued and judicious use of dissections, where appropriate, will do the same thing for many other students" (Keiser & Hamm, 1991, p. 14). This also shows that learners have different feelings and attitudes towards dissections and therefore cannot be generalised as being for or against dissections. The researcher, in agreement with Hart et al. (2008), has noticed that there seems to be scarcity of information on dissections especially on the aspect of secondary school Life Sciences education. They observed that most of the published discussions on dissections are initiated by humane societies or animal welfare organisations advocating eliminating dissections but in the professional education literature dealing with secondary schools, the topic of dissections has languished.

Dissections for the primary purpose of studying the anatomical structure of animals have been used for centuries in science education, and remain an important part of secondary school biology and environmental science. Animal or organ dissections are still widely used irrespective of facing controversy and social pressure, prompting the use of alternative methods in North America, Canada, Australia, UK and other parts of the world including South-Africa (Hart et al, 2008; Lieb, 1985; Morton, 1987). In countries like North-America and Canada, animals like rats, frogs or foetal pigs are still being used for dissections from high school to tertiary level. In South Africa, animal organs like the heart, lungs, kidneys, eyes and many others depending on the topic are also dissected in schools. Three broad aims are encompassed within secondary school science teaching in most countries including South-Africa, Canada and USA. These are: (i) an understanding of the process of scientific inquiry, (ii) the acquisition of skills considered essential for work in science and technology and (iii) the development of sensitivity about science and its influence on, and response to societal issues and values (Bowd, 1993; Hofstein & Lunetta, 2004). Laboratory-based activities, including dissections, have been generally assumed to enhance *scientific thinking* and problem-solving skills which are presumed to involve analytic and organisational abilities, as well as practical investigative skills. However, there is a need for research to document such assumptions (Hofstein & Lunetta, 1982).

This study therefore seeks to explore the use of dissections in the teaching and learning of organ morphology in Grade 11 Life Sciences education and whether the dissections can enhance the problem-solving skills of learners as presumed by some authors including Hofstein and Lunetta. Organ morphology is the external structure of the organ, and organ anatomy is the internal structure of the organ. In this study the term morphology will be used since anatomy is part of morphology. Life Sciences (previously known as Biology) is one of the school subjects taught in Grades 10 to 12 in South Africa. According to the Department of Education (DoE) (2003), in the National Curriculum Statement (NCS), three Learning Outcomes have to be achieved by animal organ dissections. Learning Outcome 1 involves scientific inquiry and problem-solving skills where the learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem-solving, critical thinking and other skills. Learning Outcome 2 is basically construction and application of Life Science's knowledge. The learner is able to access, interpret, construct and use Life Sciences concepts to explain relevant phenomena. Learning Outcome 3 is for learners to relate knowledge acquired to technology, culture and society. This study was carried out focussing on the National Curriculum Statement; however, a new syllabus (CAPS syllabus) has since been introduced which has replaced the three learning outcomes with aims and objectives but with the same goal as the learning outcomes. The new syllabus still requires the Grade 11 Life Sciences learners to carry out animal organ dissections which still make this study valuable.

The content and critical learning outcomes of the Life Sciences curriculum in the teaching of morphology therefore seem to suggest that hands-on enquiry using dissections of organs could lead to the acquisition of the skills mentioned in the previous paragraph, with the main focus of this study being on problem-solving. The questions that arise are: 'Is the Life Sciences curriculum on the teaching of morphology being implemented to fulfil the critical outcomes 1, 2 and 3 which include problem-solving skills?' 'Are the Life Sciences teachers well-acquainted with the use of animal organ dissections to acquire problem-solving skills?' 'How do learners engage with animal organ dissections and use it with regard to problem-solving?' and 'What problems do teachers and learners experience with animal organ dissections in large classes that characterise South African schools?' These questions need to be interrogated in order to establish the extent to which animal organ dissections are used in problem-solving.

1.2 STATEMENT OF THE PROBLEM

Internationally the call for scientific literacy for all citizens in society is growing as world communities realise that science and scientific issues are exerting an ever-increasing impact on their peoples' daily lives (American Association for the Advancement of Science [AAAS], 1990; Jenkin, 2002; Millar & Osborne, 1998).

From the observation of the performance of learners and the years of experience as a Life Sciences classroom practitioner, the researcher has noticed that the performance and acquisition of skills and knowledge of learners with more exposure to Life Sciences practical work, including dissection, are better than those of learners exposed to theoretical concepts only. This observation agrees with work done by other researchers in the same field including Marbach-Ad, Seal and Sokolove (2001), Preszler, Dawe, Shuster, and Shuster (2007), Prince (2004), Weimer (2002) and many others. This has also been supported by a series of articles and by researchers such as the American Association for the Advancement of Science (1989), Boyer (1998) and the US National Research Council (1990). The traditional teaching (focus on rote learning and memorization) format of most Life Sciences topics are educator-focused present many challenges to both teaching and learning (Gozo, 1997; Welch, 2002). Although traditional teaching which is a teacher-centred approach may be effective for efficiently disseminating a large body of content to a large number of learners, thereby 'finishing the syllabus in time for exams', these one-way exchanges often promote passive and superficial learning (Bransford, Brown, & Cocking 2000) and fail to stimulate learner motivation, confidence, and enthusiasm (Weimer, 2002). As a consequence, the theoretical or traditional teaching can often lead to learners completing their secondary school education without skills that are important for tertiary education success (Wright & Boggs, 2002, p. 151). In most classes the teachers have a tendency to focus on two short-term tasks: delivering the subject content and classroom management. The goal is to cover the material in the syllabus so that learners can write the tests having finished the syllabus; the teachers tend to use the *stand and deliver* approach (McCain, 2005, p. 13). Because this approach is so boring, learners become restless. Classroom management skills are then required to keep the learners focused. Time is wasted managing learner behaviour instead of focusing on problem-solving processes or equipping learners with skills that will serve them well when they leave the school system for tertiary education or work. Hands-on skills, like dissections and observations, link the theory with the observed and are important and needed for most Life Sciences related courses at tertiary level. Over the past few decades, numerous influential reports and articles have called attention to the need for changes in approaches to science education. Ways that promote meaningful learning, problem-solving, and learning by discovery include. dissections, identifying parts of organs, and critical thinking (American Association for the Advancement of Science, 1989; Boyer, 1998; Handelsman, 2004; National Research Council, 1999, 2003). First-hand experience is particularly important when introducing a topic and also as a way of consolidating a topic. It helps to eradicate any misconceptions that might have arisen by just using the learners' imagination regarding what an organ looks like.

Allen and Tanner (2005, p. 262) define active learning as "seeking new information, organizing it in a way that is meaningful, and having the chance to explain it to others." This form of instruction emphasises interactions with peers and instructors and involves a cycle of activity and feedback where learners are consistently given opportunities to apply their learning in the classroom. By placing learners at the centre of instruction, this approach shifts the focus from teaching to learning. Furthermore, this approach promotes a learning environment more amenable to the metacognitive development necessary for learners to become independent and critical thinkers with practical skills (Bransford et al., 2000). Numerous studies have shown that learner attitudes can improve through the active-learning approach relative to a traditional teaching approach (Marbach-Ad et al., 2001; Preszler et al., 2007; Prince, 2004). Similarly, there can be improved learning outcomes or gains (Ebert-May, Brewer & Sylvester 1997; Freeman, Cunningham, Dirks, Haak, Hurley, O'Connor, Parks, & Wenderoth, 2007; Hake, 1998; Knight & Wood, 2005; Udovic, Morris, Dickman, Postlethwait, & Wetherwax, 2002). There seems to be consensus among these researchers that the traditional way of teaching science as mastery of abstract concepts and factual knowledge, makes Life Sciences appear to be difficult and does not reflect the relevance of learning science. It takes the excitement of discovery, firsthand experience and the adventure of finding out how the world works, out of learning. Discovery generates interest which is critical to learning. According to Wurman, (2001, p.85), "Learning can be seen as the acquisition of information. But before it can take place, there must be interest. Interest permeates all endeavors and precedes learning. In order to acquire and remember new knowledge, it must stimulate your curiosity in some way."

Taking Wurman's view into consideration, one can also say the traditional way does not guarantee the acquisition of skills which students may acquire through hands-on activities; hence it has often failed to engage the interest of learners. It appears that learners taught using traditional teaching methods are unable to see the link between science education and their day-to-day experiences. Some learners even pose questions like: "Why must I learn this stuff?" and to explain to them that it is because it is part of the curriculum is not exactly persuasive. It is possible that learners may develop an attitude of apathy towards certain topics because they do not see how they are relevant to their daily lives unless the teacher facilitates for them to discover that link. Learners might have problems applying what they have learnt to solving day-to-day problems, and this could obscure the relevance of science education. Onwu (2000), Stears, Malcolm and Kowlas (2003) highlighted the influence of learners' daily experiences on learning. They argued that the environment and personal circumstances of learners' lives could influence their worldview and activities to such an extent that they may feel alienated from a schooling system that does not take their circumstances into account.

Many educational philosophers and academics (Capps, Constas, & Crawford, 2012; National Research Council [NRC], 2000; Roehrig, MacNabb, Michlin, & Schmitt, 2012) have advocated that it is of vital importance and necessity for enquiry to be part of Life Sciences education. They assert that inquiry-based approaches to teaching and learning provide a framework for learners for the acquisition of critical-thinking and problem-solving skills. Dissection, as a way of enquiry, plays an important role in the teaching and learning of Life Sciences but, unfortunately, very few teachers are using inquiry-based instructions in actually building problem-solving activities and skills into their dissections lessons in secondary schools (Capps et al., 2012; Hudson, McMahon, & Overstreet, 2002; Smith, Banilower, McMahon, Onwu, 2000 & Weiss, 2002). This means that the dissections are just being carried out to comply with the National Curriculum Statement requirement instead of using it to develop other skills which one could acquire using dissections. However, enacting inquiry in science classrooms may have its challenges which might discourage teachers from using it, these challenges according to Abd-El-Khalick, Boujaoude, Duschl, Hofstein, Lederman & Mamlok, 2004; Rowell and Ebbers, 2004 include:
(a) the absence of a clearly formulated philosophy of the nature of scientific inquiry in science policy statements and curriculum documents produced by local education authorities, (b) teachers' lack of first-hand experience with authentic science inquiry during their education, (c) teachers' lack of pedagogical content knowledge and discursive skills to support inquiry,

(d) accountability pressures and teachers' efficiency beliefs in having to cover science content to help students prepare for high stakes standardized tests, (e) lack of resources that support inquiry (e.g., appropriate textbooks and technical support), (f) lack of monetary and human resources in developing experiments, designing assessment tools, and in the professional development of teachers, and (g) students who may not have the motivation, knowledge, and skills to engage in inquiry.

The South African Department of Education (2003) stated in the Life Sciences National Curriculum Statement the need to include dissection as part of the study of organ anatomy in Grades 10 to 12, considered as the Further Education and Training (FET) phase. In Life Sciences education internationally, including South Africa, the study of animal organs and structure has traditionally involved animal and organ dissections. The dissections are not aimed at merely cutting through animal organs for the sake of fulfilling the requirements of the curriculum but to ensure that the learners acquire practical, observation and problem-solving skills, which can help them to generally improve their performance in the subject. For almost a decade now, South African schools have been characterised by poor performance in science-related subjects, including Life Sciences, in both local and international comparative assessments (Beaton, Martin, Mullis, Gonzalez, Smith & Kelly, 1997; Centre for Development & Enterprise, 2007; Reddy, 2006). In addition, educational statistics show that the rates of students enrolling for science-related courses in South African public higher institutions of learning have not shown significant improvement in the past years (Department of Education, 2002-2009). The South African government and other stakeholders, realising the importance of science, have responded to the problem of low access and poor performance in sciences by putting several interventions in place. Despite all the interventions, little progress has been made to improve the situation (Muwanga-Zake, 2001; Reddy, 2006). In support of the National Curriculum Statement, McCain (2005) argues that it is important to equip learners with useful skills like problem-solving because being able to think logically and independently is just as critical for solving academic, personal and house-hold problems as it is for solving work-related problems, thereby equipping the learner with a lifelong skill.

Due to a variety of reasons which range from finances, apparatus availability, religion, gender, culture, race and background, the carrying out of dissections is very inconsistent in different schools. As a result, learners may be less confident of success in the subject and lack the necessary practical and problem-solving skills acquired through this activity.

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to explore the contribution of animal organ dissections instruction to the development of teachers' teaching strategies and Grade 11 Life Sciences learners' problem-solving skills in diverse environments.

The study seeks to fulfil the following objectives:

1. To establish the teachers' understanding and how well-acquainted they are with problem-solving strategies.
2. To establish how teachers use animal organ dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners; and how effectively they use dissections instruction.
3. To establish how learners' engagement with animal organ dissections aids in developing problem-solving skills.
4. To explore the perceptions and attitudes of teachers and learners towards animal organ dissections in general, and its use specifically in problem-solving.
5. To establish the problems learners experience in doing animal organ dissections in general and in its use in problem-solving.
6. To establish the extent to which Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) are being achieved by integrating dissections into the teaching and learning of animal organ morphology in Grade 11.

1.4 RESEARCH QUESTIONS

In response to the statement of the problem and in pursuance of the aim, the study seeks answers to the following main research question and sub-questions:

1.4.1 Main question

What is the contribution of animal organ dissections to the development of teachers' teaching strategies and Grade 11 Life Sciences learners' problem-solving skills in diverse environments?

1.4.2 Sub-questions

1. *What is the teachers' understanding and how well-acquainted are they with problem-solving strategies?*
2. *How do teachers use animal dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners?*
3. *How does learners' engagement with animal organ dissections aid in developing problem-solving skills?*
4. *What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*
5. *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?*
6. *To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?*

1.5 RATIONALE OF THE STUDY

The interest in the use of dissections in improving the teachers' teaching strategies and the acquisition of problem-solving skills in Life Sciences started as a result of the researcher's experiences as a Grade 11 Life Sciences teacher, where it is a requirement for learners to carry out animal organ dissections of hearts, kidneys, and lungs as part of anatomy learning. The question that has always come to the researcher's mind is: "What is the use of carrying out dissections in secondary schools?" Through her teaching experience, she observed that learners seemed to be more interested in dissections when they cut through the organs, observed the connection between structure and function, and when they were presented with challenging questions related to day-to-day health problems linked to these organs. From these observations she reasoned that it would make more sense to use dissections of animal organs as a way of helping learners acquire skills like problem-solving which would help them realise the relevance of studying Life Sciences at school. The abysmal performance of a good number of Life Sciences learners (35% and 38% pass rate in 2009 and 2010 respectively) in South African schools, coupled with this line of thinking, led to the desire to find out whether linking animal organ dissections with challenging situations could lead to acquisition of problem-solving skills which learners could use in their day-to-day life experiences. The proposed study is therefore meant to apply the notion of using dissections in problem-solving in Life Sciences education.

Through this study it is hoped to establish the use of animal organ dissections in problem-solving in Life Sciences education with emphasis on viewing animal organ dissections as an integral aspect of learning and excelling in the subject. The findings are also expected to provide valuable information for guidance and encouragement to educators and the young South African learners so that they acknowledge the importance of animal organ dissections as a way of consolidating understanding of morphology and anatomy concepts. It is also hoped that from the findings of the study, the Department of Education will work together with the school administrators, subject advisors and cluster leaders to encourage Life Sciences teachers to use hands-on dissections of animal organs coupled with challenging relevant situations or questions, as a way of consolidating anatomy concepts. This will help to bridge the gap between secondary school and tertiary level Life Sciences and avoid unnecessary first year university dropouts. Furthermore, the findings may also help to increase learners' interest and achievement in Life Sciences by developing in them a positive attitude towards the subject. This is important because practical work in the sciences helps learners acquire scientific skills, as well as scientific attitudes and values needed in solving everyday problems, especially in the courses related to Life Sciences at tertiary institutions. It can also equip learners to think in a logical way about everyday events and to solve simple practical problems. Finally, the study is likely to enhance the professional development and experience of participating teachers and other future researchers.

1.6 STRUCTURE OF THE STUDY

The chapter layout in Figure 1.1 indicates all the chapters that are included in the study:

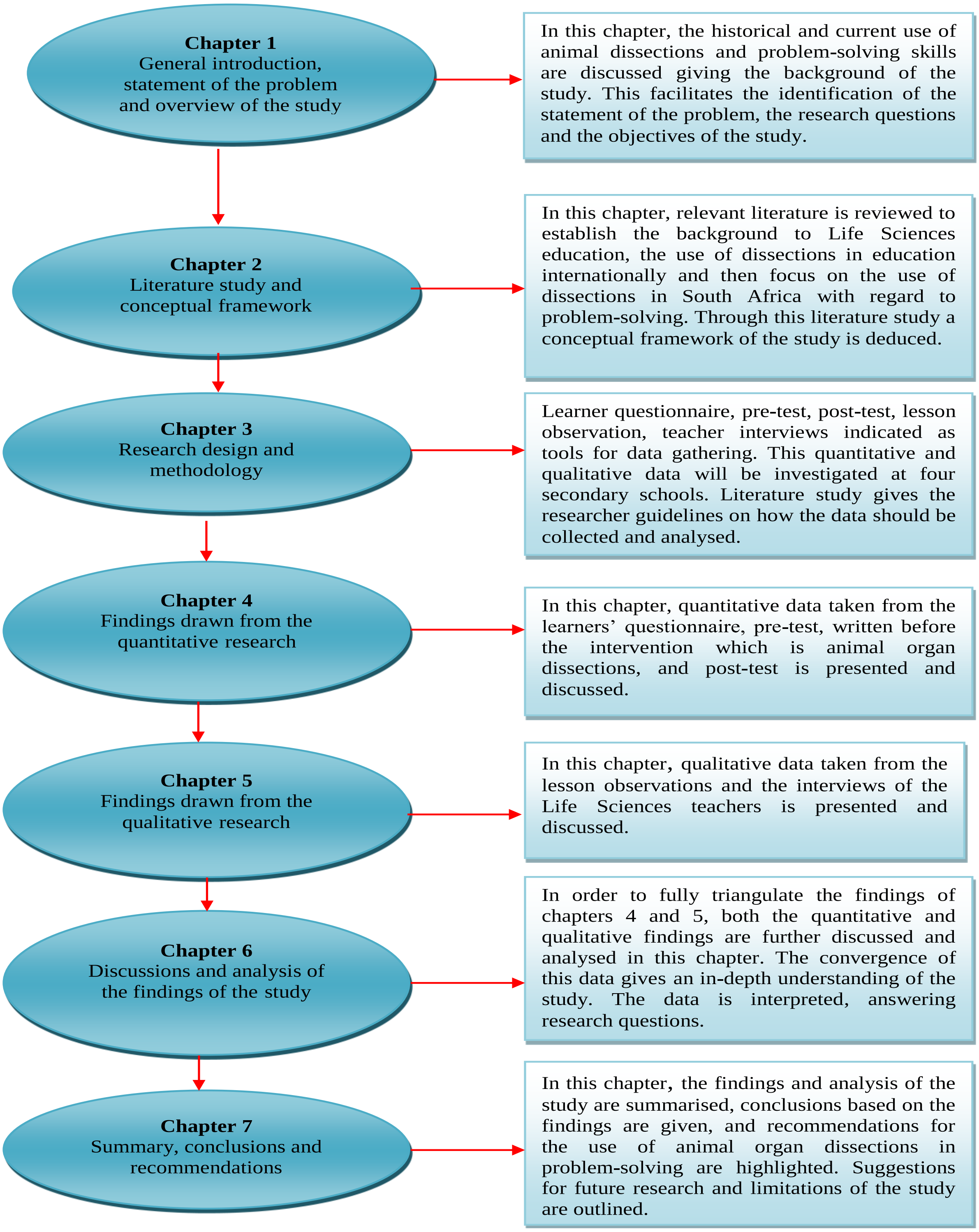


Figure 1.1: Chapter layout of the study

1.7 SUMMARY

In this chapter the historical use and current use of animal dissections was briefly highlighted. The advocacy of using active learning through inquiry or investigations like animal dissections as teaching strategies in problem-solving is emphasised. The statement of the problem and the objectives and aims of the study were established. The research design as well as the methodology of the study is outlined in Figure 1.1. Before conducting the data collection, it was deemed essential to take note of the most recent literature on the use of dissections in secondary schools and if some authors have alluded to animal dissections and problem-solving. In light of this, the review of literature was done first.

The next chapter highlights the literature on animal or organ dissections in problem-solving as a teaching strategy.

CHAPTER 2

LITERATURE ON THE USE OF ANIMAL ORGAN DISSECTIONS IN PROBLEM-SOLVING AS A TEACHING STRATEGY IN LIFE SCIENCES EDUCATION

2.1 OVERVIEW OF THE CHAPTER

The purpose of this study is to establish the use of animal organ dissections in problem-solving as a teaching strategy in Grade 11 Life Sciences education. The literature review seeks to provide a background to Life Sciences education, the use of dissections in education internationally and then to focus on the use of dissections in South Africa with regard to problem-solving. Literature on the South African Outcomes-Based Education (OBE) system and hands-on approaches focusing on dissections will be reviewed to establish the extent to which dissections forms part of the OBE curriculum, the National Curriculum Statement (NCS) and the Curriculum and Assessment Policy Statements (CAPS). Literature on animal organ dissections and how the teacher can use it with regard to problem-solving in the teaching of Life Sciences is also reviewed, and based on this background literature, a conceptual framework for the study is discussed.

2.2 THE NATIONAL CURRICULUM STATEMENT (NCS)

In 1997, shortly after the apartheid era, the South African education system underwent a radical change from a content-based education system, to the development of a new national curriculum which was centred on Outcomes-Based Education which was learner-centred. The South African Government was compelled to engage with large scale educational reforms to change the education system to conform to the expectations of an Outcomes-Based Education (OBE) which it believed would be the only possible solution to empower its former disadvantaged majority who were victims of the apartheid education system (Smith, 2000). According to Pretorius (2002), the implementation of the OBE curriculum was meant to integrate what had been taught practically or theoretically with day-to-day experiences as a way of equipping learners to solve daily life challenges. According to Beekman (2000), the OBE curriculum focused on the outputs, on what the learner knew and could do, rather than on how long it took to complete a programme of learning. This emphasised the development of thinking skills for problem-solving and decision-making. The Further Education and Training (FET) phase of the South African national curriculum, which involves the last three years of schooling (Grades 10 to 12), includes Life Sciences as one of the science subjects (Department of Education, 2003). In line with scientific inquiry and hands-on activities, the Life Sciences National Curriculum Statement has included content dealing with the study of organ structures relating to function. It is a requirement for learners to dissect different organs and relate the observed structure to the function of the organ as a whole. During the dissections, learners are then expected to relate their observations to health complications like cardiovascular, kidney and lung-related diseases and appreciate which parts of the organs are affected (DoE, 2003, p. 34-40). These topics provide a platform for the use of animal organ dissections in problem-solving which is the focus of this study. The *critical outcomes* of the Life Sciences NCS include the development of decision-making skills, inquiry skills, and problem-solving skills (DoE, 2003, p. 2, 9-12), which could be achieved through the use of hands-on activities like dissections (Bennett & Lubben, 2006). The Grade 11 Life Sciences curriculum has been incorporated in a new syllabus from January 2013: The Curriculum and Assessment Policy Statements (CAPS). This syllabus does not deviate much from the National Curriculum Statement (NCS). It still requires the learners to carry out animal organ dissections from Grades 10 to 12 (DoE, 2011, p. 32, 50 & 62). Hence this study is applicable to both the National Curriculum Statement (NCS) and the Curriculum and Assessment Policy Statements (CAPS).

A review of literature on the Life Sciences curricula shows that most research has been done on topics like evolution, genetics and attitudes towards practical work (Hatice, 2012; Donnelly, Kazempour & Amirshokoohi, 2008; Downie, 2004) but researches on dissections under the OBE curriculum linking it with problem-solving are yet to be carried out, hence the researcher's choice of this focus area. Studies on the use of animal dissections with regard to problem-solving have not specifically been dealt with; the researcher is tempted to believe that the dissections of the animal organs might be done just to fulfil the curriculum requirements, if they are done at all, in the diverse school environments. In this study, diverse school environments relates to: location of the school (township or low-density suburb); public or independent school and availability of laboratory facilities and apparatus. The fact that the South African education system is still largely examination oriented (Muwanga-Zake, 2001; Onwu, 2000), compounds the problem of non-compliance with the carrying out of animal organ dissections, as teachers tend to teach for examination purposes, instead of *wasting* time on skills that are not examinable at that level. Moreover, the competence of South African teachers in dissections and its use in developing problem-solving skills has not been established.

2.3 LIFE SCIENCES EDUCATION IN SOUTH AFRICA

Life Sciences is one of the subjects taught in South Africa. In most countries the same subject is known as Biology which is basically the study of life. After a series of transformations of the education curriculum since 1997, the then Department of Education published transition programmes in 2003. The OBE curricula advocated learner-centredness, where learners are active participants in the learning process. This enables the learners to develop their own skills and understanding in contrast to the traditional teacher-centred environment in which the teacher is dominant and uses the *show and tell* or the *chalk and talk* approaches to education (DoE, 1997). The transformations showed that the Department of Education was acknowledging the importance of active hands-on learning and learner-centred approaches. This resulted in a shift from teacher-centred approaches to learner-centred approaches. The researcher mainly focused on the areas of this programme and the three learning outcomes which were specific for Life Sciences. These included:

- Encouraging an active and critical approach to learning rather than rote and uncritical learning of given truths.
- Learners must be able to identify and solve problems and make decisions using critical and creative thinking.
- Providing learners with the opportunity to develop a range of skills that they can use and apply throughout their lives.
- Learners must be able to synthesise, integrate insights and understandings, from the physical and human sciences, in order to construct biological knowledge, to apply to issues and problems facing us. (DBE, 2011)

The three learning outcomes included:

- Learning Outcome (LO) 1 ─ Scientific inquiry and problem-solving skills where the learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem-solving, critical thinking and other skills.

- Learning Outcome (LO) 2 ─ Construction and application of Life Sciences knowledge. The learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.
- Learning Outcome (LO) 3 ─ Life Sciences, Technology, Environment and Society. The learner is able to demonstrate an understanding of the nature of science, the influence of ethics and biases in the Life Sciences, and the interrelationship of science, technology, indigenous knowledge, the environment and society (Department of Education, 2003, p. 12).

The above focuses, and many others, insinuate learner-centred approaches which promote active learning in the classroom and laboratories. The approach by the Department of Education (DoE) has been supported by many authors. According to Dehmel (2006), the National Research Council (2000) and Wang, Song and Kang (2006), life-long learning has become one of the educational policies of many countries, to enable learners to continuously use what they learn in sciences and related skills in their daily and professional lives. As a result, it has been strongly recommended that the learning approach shifts from being teacher-centred to a learner-centred approach which balances knowledge, skills and attitudes. Through investigative activities like animal organ dissections, group work, group discussions and problem-based learning activities, learners may construct the interrelated knowledge. Learners engage all their senses and thinking in the learning process and this results in acquiring skills like problem-solving.

2.4 DISSECTIONS IN LIFE SCIENCES EDUCATION

Life Sciences curricula in South Africa require sessions that include dissections of animal organs. It is a requirement that a learner must conduct a minimum of five dissections each year from Grade 10 to Grade 12 (Isaac, 2002). "Dissections can be defined as cutting and separating of constituent parts of an animal or a plant specimen for a scientific study or as cutting into a dead animal for purposes of learning anatomy or physiology" (Balcombe, 1997b, p. 34). "It is thought that dissections enhance the knowledge and understanding of internal organs, their structures, their relationships and their functioning, and that maximum learning is most likely to be achieved by maximising the personal experience of the reality being taught" (Wheeler, 1993, p. 39). According to Altweb's Alternatives Glossary (2005), dissection is to "cut apart for scientific examination, usually in reference to the study of animals or humans". Internationally, dissections are conducted from as early as primary school level depending on the country's curriculum. In the case of North America, students may dissect at least one animal during their kindergarten to Grade 12 school years, and most of them carry out multiple dissections (Balcombe, 2000). In some countries like Canada, dissections are conducted from Grade 2 depending on the teacher (Oakley 2011a). In Australia, dissections can start from middle to high schools (Bowd, 1993; Caravita, 1996; Oakley, 2011a; Wheeler, 1993). In South Africa, the National Curriculum Statement of the Department of Education and the new Curriculum and Assessment Policy Statements (CAPS) of the Department of Basic Education (DBE) require practical dissections of animal organs from Grades 10 to 12 which is the Further Education and Training (FET) syllabus. The FET level is considered as the stage of preparing learners for tertiary education where such practical skills are required to generate knowledge of different concepts.

The use of dissections in Life Sciences education began in the early twentieth century and it has been used to teach morphology of animals since then. The traditional way in which the dissections are usually taught in the schools, where learners just cut, draw and label the dissected animal or organ, is weak on concept learning and problem-solving. This was supported by a two year research carried out on first and second year UK and Ireland medical students from selected universities using the traditional and problem-based curricula. It was found that the knowledge and retention base of the traditionally taught anatomy concepts were weaker than the problem-based taught concepts (Heylings, 2002). The traditional way of teaching dissections is too focused on the acquisition of facts without teaching learners to conceptualise and synthesise. These are very important attributes for a Life Sciences learner (Jacobs & Moore, 1998). Dissections can play many roles in the educational process: it can provide learners with the opportunity to verify their learning, trust their observations and appreciate the concept of variability as it presents itself and not as it is presented to them. "If directed creatively, dissections provide the platform for the independent learning and independent thinking that underpins the development of diagnostic aptitude" (Pawlina & Lachman, 2004, p. 2). Dissections take many of the things learners have heard and read about and give them first-hand experience. One of the educators, Wheeler (1993, p. 30), emphasises this when he says:

> "By confirming all the things I had been taught, it helped me understand that the world was a rational place, and that knowledge and understanding can come from serious study of real

> specimens and real data. We must never lose sight of the fact that every time a student dissects, an animal or its organ has been sacrificed for the purpose of that student's education."

The sentiments expressed by this educator reflect the sentiments of many other educators and the belief in the importance of hands-on dissections in education. This was evidenced by the study carried out by De Villiers and Sommerville (2005) in which 77% of the 242 prospective Biology teachers from the University of Pretoria acknowledged that animal dissection was important and they would expect their learners to carry it out in high school. However, there are also some dissenters to this opinion which include anti-vivisection societies in England and the US. According to the New England Anti-vivisection Society (2004), these societies are totally against the use of animals in laboratories.

Historically, an important tool of investigation in human and animal anatomy has been dissections. However, a complete anatomy learning experience that includes dissections of animals or animal organs goes beyond identification of the parts of the dissected animal or organ. It should improve the learner's conclusions and insights about the nature and relatedness of living organisms. For learners to succeed in their future careers related to Life Sciences, they must become thoroughly familiar with anatomical structures, their design features and their relationships to one another. According to the Human Anatomy and Physiology Society (HAPS) (2012), dissections are based on observational and kinaesthetic learning that instils a recognition and appreciation for the three-dimensional structure of the animal body, the interconnections between organs and organ systems, and the uniqueness of biological material. This means that a learner can generate knowledge through dissections of animals or organs and integrate the information and the interrelatedness of concepts. Balcombe (2000) acknowledges that dissections convey the inherent variability of living organisms which include the real texture of the tissues, the colour of the different parts of the animal or organ that one cannot observe on simulations and models even though they are imitations of the real organism. He also emphasises that the key question, with which the researcher agrees, is not whether one method is equal to the other but, rather, how well a given method promotes learning. There are some Physiology experiments that involve humans and live animals which provide an excellent opportunity to learn the basic elements specific to scientific investigation and experimentation. As learners work on these experiments, they can pose questions, propose hypotheses, develop technical skills, collect data, analyse results, develop, and improve critical thinking and problem-solving skills (HAPS, 2012). The experiments or practicals may include exploring of animal organs through dissections and using the knowledge generated to answer problem-solving questions which will have been provided by the teacher.

Many authors including Lieb (1985), Marszalek and Lockard (1999), McCain (2005), Oakley (2011b), Offner (1993) and Preszler et al. (2007) have advocated the importance of animal dissections. They concur that dissection, as practical work, can be used by Life Sciences teachers as a means to break the monotony of classwork. Learners also get to bond and establish teamwork skills as the activity is usually carried out in groups. This can, with time, be extrapolated into various other social and academic settings as the learners grow up. Learners who have dissected organs with close interest will certainly 'dissect' the theory with accuracy. A close participation in organ and animal dissections will also arouse some interests and opportunities that a learner may not have considered exploring. Dissections of animals or their organs may also be considered important because it:

- Helps learners to learn about the internal structures of animals.
- Helps learners to learn how the tissues and organs are interrelated.
- Gives learners an appreciation of the complexity of organisms in a hands-on learning environment.
- Provides one of the most memorable and instructive units in a Life Sciences course.
- Furthermore, it is said that to a wise man, a picture is worth a thousand words. This means that by observing the dissected organs, learners can acquire more knowledge than if they just receive theoretical knowledge from their teachers.

Some of the benefits mentioned above are not necessarily unique to dissections, but since it is a requirement to dissect animal organs according to the National Curriculum Statement (NCS) in the case of South Africa, it would be essential for teachers to ensure that dissections achieve the benefits as well. Dissections in education can be meaningful if correctly carried out with proper supervision and guidance from the teacher with clearly defined objectives which will engage both the learners' hands and brains. Michael (1993) observes that hands-on activities like the dissections of animals are only effective for learning if the learners' heads are being kept as busy as their hands. This point has particular relevance to animal dissections, where the behaviour of poorly supervised learners can degenerate to a point where little or no meaningful learning is taking place (Hertzfeldt, 1994; Long, 1997). Dissections should not be done as a way of satisfying haphazard curiosity. In as much as curiosity is a basic aspect of science, it is not enough justification for dissections of animals or their organs. Justified animal dissections must be performed in the context of an intelligently planned and educationally valid curriculum. As in the case of this study, using animal organ dissections to develop problem-solving skills in learners is a valid educational reason to carry it out. If dissections are used to develop other skills, learners will realise that there is more to dissection than just mutilating the dissected animal or organ. Active learning is not something that is done for the learners; it is something they do for themselves (Michael, 1993). It involves asking questions, not merely answering them, solving problems, and generating hypotheses. Sampson (1998) calls this *inquiry learning*, and it carries the added benefit of learning how to learn, rather than merely learning to become *knowers*. Active learning effects better retention, better retrieval, and better application of knowledge to other contexts (Heiman, 1987). "Facts can be efficiently transmitted by passive learning, but problem-solving skills are learned most effectively by active, hands-on experience" (Balcombe, 2000, p. 8). Through the use of animal organ dissections, there is a shift from the passive learning experience to an active learning experience in which a learner can acquire the problem-solving skills which one needs in real life. Animal organ dissections, as it is usually taught where learners just cut and draw, does not do this, hence the need to establish how teachers operationalise dissections, linking it to problem-solving.

2.5 LEARNERS' ATTITUDES TOWARDS ANIMAL DISSECTIONS

Attitude is a personal or emotional feeling expressed by a person. It also refers to the manner in which a person acts when dealing with a specific situation. Attitudes can also be regarded as enacted beliefs. Researchers and authors worldwide, including the United States, Europe and South Africa, (Balcombe, 1997b; Balcombe, 2000; De Villiers & Sommerville, 2005; Donaldson & Downie, 2007; Downie & Alexander, 1989; Moore, 2001; and others) have explored how learners at different levels of education feel about doing dissections as part of the Life Sciences curriculum. The outcomes have been varied according to the diversity of the school environments, which is also very common in South Africa. The National Curriculum Statement for Life Sciences (2003) raises learners' and students' awareness of the existence of different viewpoints in a society, and encourages open-mindedness towards perspectives that are based on scientific knowledge, values, ethics, beliefs, attitudes and biases. The diversity of opinions is influenced by gender, culture, career orientation, religion, beliefs, being vegetarian, teacher or societal influence and many others. Some learners have shown interest in dissections while others have ruled it out and some even take schools to court if they are forced to do it, but in South Africa, in spite of the varied opinions, cases of being taken to court have not yet been established, as shall be discussed later in the chapter. Questions that may come to mind are: What are the attitudes of learners towards dissections? What sort of challenges do they face when dealing with dissections?

Studies of the attitudes of learners towards animal dissections were first undertaken around the 1980s. Rowan (1984) and Balcombe (1997b) have noted that it takes a great deal of courage for learners to protest if there is a lack of explicit leads from teachers. The small number of learners who are conscientious objectors in classes where dissections are used (and hence judged meritorious by the teachers) reflects this. Downie and Alexander (1989) explored the attitudes of the teachers and students at the University of Glasgow and other Scottish universities to the use of animals in education. They found that more than a third of the students objected to the dissection of rats bred for laboratory use or biochemical analysis of its liver but the majority (>60%) of the students approved the dissection of slaughterhouse material such as sheep’s heart or lungs, and ox eyes. The reason for the approval of the slaughterhouse by-products was that the animals were killed anyway, so it was not deliberate killing of the animals for solely educational purposes. About 25% of the Glasgow University students and other Scottish universities’ students favoured the idea of allowing the students who strongly objected to dissections to opt out of the practical involving dissections and any other animal use. Millett and Lock (1992) examined the United Kingdom (UK) secondary school learners' attitudes towards the use of animals in schools. They found that only 32% found it interesting to dissect dead animals. According to a study conducted by Stanisstreet, Spofforth and Williams (1993), 48% of secondary school learners believed animal dissections to be wrong. In a study of the attitudes of undergraduate educational psychology students towards animal dissections, Bowd (1993) found that 27% reported negative reactions to dissections, whilst others (38%) reported mixed, that is. both positive and negative reactions. In their study of the opinions of undergraduate students from various disciplines with regard to animal dissections, Lord and Moses (1994) found that almost half (48%) objected to the idea of dissecting a rabbit, whilst the majority of the students (80%) did not object to the dissections of preserved animals. Donaldson and Downie (2007) reported a study wherein university-level students were questioned on their attitudes to animal uses in higher education. These students recognised the educational value of animal uses, while disapproving of killing animals for this purpose which posed some conflict of interest within these students. De

Villiers and Sommerville (2005) involved prospective Life Sciences teachers in South Africa to find out what their attitudes were towards dissections and found that 71% of the students expected their learners to do dissections, which showed that they did not have a problem with dissections. Interestingly, none of the aforementioned surveys explicitly involved secondary school learners in South Africa; therefore, the researcher takes that into consideration in this study.

According to Hart et al. (2008), some learners cannot stand the smell of formalin used to preserve the organs and the *squishy-looking* and blood organs are just too *disgusting* for some learners; they would rather forfeit the marks than touch the fresh organs. For some learners it is both unpleasant and very intriguing and if the intrigue is stronger than the unpleasantness, then the *disgust* plays a role in making the experience much more memorable.

Nabi (2002) argues that the effects of dissections on the learners may differ between genders; there is some degree of disgust especially salient for women, raising a possibility that disgust could be discouraging some girls from entering the medical field. One can argue, however, that dissections are not only done to orientate learners towards the medical field. Anyone can learn about animal organ anatomy and morphology. Being able to use all aspects of Life Sciences in managing one’s health and that of family members is beneficial to all. The same observation on the effects of dissections being different between genders was made by DeVilliers and Sommerville (2005) who found that the female learners were more uncomfortable with dissections of animals than their male classmates. In surveys of the UK secondary school learners, 38% would object to the dissections of any animal material, organs or the whole animal (Millett & Lock, 1992), and between 33% and 50% would carry out dissections. Researchers have found that learners tend to gain an affinity towards whatever learning methods they are exposed to with regard to dissections. Lock and Millett (1991) found that learners’ attitudes toward dissections and animal research were reinforced by participation in or exposure to these endeavours. Strauss and Kinzie (1994) found that secondary school learners’ opinion of frog dissections improved when they dissected frogs, while the opinion of learners who used an alternative to the dissections improved towards the alternative. Taking this into consideration, one can conclude that the attitude of learners towards dissections tends to vary according to the diverse school environments they are in and the teacher influence.

2.6 TEACHERS' INFLUENCES AND ATTITUDES TOWARDS ANIMAL DISSECTIONS IN GENERAL

Without question, teachers can exert an enormous influence over their learners. The amount of wakeful time the average child spends in the presence of a teacher is not much less than that spent in the presence of his or her parents and, in many cases, may be more. Teacher attitudes, values, and personal preferences are apt to influence those of the learner. There is evidence that the attitudes of those around one may exert more influence on one's attitudes and values than does information and knowledge. "The human dimension of the student versus instructor relationship can convey values, attitudes, and signals that transcend the content of textbooks and other written curriculum materials" (Brennan, 1997, in Balcombe, 2000, p. 17). Since it is the responsibility of teachers to provide the best education and to encourage the greatest possible learning, to dissect or not will definitely depend on the teacher's attitude towards it.

Hart et al. (2008) add that it seems highly likely that the choice of the teacher's use of certain teaching methods is influenced by the teacher's related experiences and knowledge. The teacher's family's attitude, culture, religion and specific lifetime experiences with animals may influence the extent to which they become engaged with animal-related dissections in their classes. This means that one would expect a teacher's prior experience with dissections to affect their choices as to having learners perform dissections in their classes and how they respond to a learner's preference to decline participation in dissections. Working with animals requires an emotional comfort level as well as a feeling of proficiency with the dissections. This means that there are some implications if the teachers are affected by the sight or touching of blood, being squeamish or if they are not proficient with dissections. These include not having dissections lessons in their classes or they will let the learners carry out the dissections on their own without their involvement (ibid).

In many cases, Life Sciences teachers are not merely encouraged but expected to use animal and organ dissections in their classrooms, regardless of the teacher's personal preference for teaching method. In South African Life Sciences FET syllabi, it is a requirement for the teachers to use animal organ dissections irrespective of their feelings towards dissections. The question is: What do these teachers really feel about dissections? This study also aimed to understand, from teachers' perspectives, the use of animal organ dissections in problem-solving and what perspectives they hold towards the use of alternatives to fresh organs dissections. Bringing teachers into this discussion was deemed important as their voices have largely been under-represented in existing research. According to the survey in the UK of teachers' attitudes towards animal use in Biology teaching by Downie and Alexander (1989), teachers at Glasgow University and those at Scottish universities agreed that observational skills and the impact of direct experience with material was important for first year Biology practicals work. The Glasgow University teachers also considered the experimental design skills to be of great importance. This shows that according to these teachers, practical work like dissections can fulfil a variety of important objectives. However, teachers, unlike students, also look at other factors besides the educational objectives when considering animal use. These can influence their attitudes as well as how the practicals will be done by students. These factors include: cost factors and ethical considerations, as echoed by Downie and Meadows (1995). King, Ross, Stephens, and Rowan (2004) indicated: "The use of animals in dissections activities in high school biology education is believed to be widespread … but, currently, there are few data regarding its prevalence, or its role as an educative resource, from the biology teachers' perspective" (p. 475). Likewise, Hart, Wood, and Hart (2008) note that: "Although the subject of animal dissections has been a lively focus of articles among animal welfare organisations and philosophers, educators have had much less involvement in addressing this question than one might expect" (p. 49). This study therefore aimed to investigate the choices teachers make about this controversial practice, their attitudes towards animal organ dissections and the use of alternatives. Donaldson and Downie (2007) in a follow-up to a survey 20 years before, found that teachers still highly approved the use of animals for purposes of research as it would likely bring important benefits such as saving human lives, and the teachers still considered ethical factors by minimising the number of animals used. When considering the importance of educational objectives of animal-based practical work which include observational skills and the impact of direct experience with biological material, some teachers agreed that "only dissection can demonstrate the intricacy of tissues and organs" (page 5).

Despite the fact that the attitudes of people with regard to the use of animals could form barriers to effective teaching, little is known about South African Life Science teachers' attitudes and the implications these might have. Teachers, especially those who favour dissections, frequently report that conscientious objections to animal dissections among their learners are a rare event (e.g. Dudlicek, 1998; Freeman, 1995; Offner, 1995; Schmidt, 1999).

Based on such reports, Balcombe (1997a) estimates that unsolicited questions about, or objections to, dissections average about 3 to 5% of the class population. Conversely, teachers who are openly sensitive to student concerns report that many learners do not want to dissect animals (e.g. Asada, Akiyama, Macer, Macer, & Tsuzuki, 1996; Long, 1997; Mayer & Hinton, 1990). These researchers found that significantly more learners raised concerns about doing classroom experiments on animals if their teachers were also concerned than when teachers had not expressed concerns. All of these findings show the influence that teachers' values and their teaching methods have on learners' attitudes and preferences. If a role of the educator is to stimulate critical thinking and not to indoctrinate, these findings suggest that it would be a sound educational decision for teachers to give learners a choice whether or not to take part in a laboratory that they may find distasteful or with which they are uncomfortable (Rowan, Loew & Weer, 1995). The issue of giving students the opportunity to *opt-out* of dissections was explored by Downie and Meadows (1995) as a way of dealing with those students who objected strongly to dissections and other practicals that use animals. In this case, students who opted out would work through the practical schedule with models and charts under the guidance of a demonstrator.

2.7 ANIMAL DISSECTIONS: PROBLEMS FACED BY TEACHERS AND LEARNERS

Due to a variety of reasons mentioned in Sections 2.5 and 2.6, teachers can be faced with problems which range from dealing with learner dissent, attitudes of the learners, their own attitudes, costs or availability of resources. Some learners can refuse to carry out dissections of any type, which can be of live, preserved animals or even organs, as required by the subject syllabus. The question is: What does the teacher do under such circumstances? Does one fail the learner, award a lower mark, and force the learner to do it anyway or use alternatives to dissections?

A typical US example is quoted in this regard, as "the most celebrated dissection lawsuit was filed in June 1987 by Jenifer Graham, a California secondary school student who was told by her school board to either dissect a frog or accept a lowered Biology grade and negative evaluation on her school transcript. Ms. Graham's case marked the first time that a student had made a legal challenge to required dissections exercises. Nine months after the lawsuit was filed, the then California governor George Deukmejian signed into law a bill requiring that elementary and secondary learners be allowed to choose whether or not to dissect animals in science classes. In August 1988 Judge Manuel Real dismissed Ms. Graham's suit when the school agreed to reinstate her grade and to remove the notation from her transcript". (Balcombe, 2000, p.73). However, such outstanding actions against dissections by secondary school learners have not yet been established in South Africa, possibly because they only dissect animal organs unlike in other countries where they are required to dissect whole animals like foetal pigs, rats and frogs.

Another problem faced by teachers is the continuous debate on the role of dissections in Life Sciences education (De Villiers & Monk, 2005) and there has been much criticism with many organisations, authors and individuals advocating the abolition of dissections. These debates put some teachers that advocate for animal dissections in very difficult positions and unless they are prepared to adjust and use alternatives, the teaching of Biology might be compromised. Hugs (2005) in her reaction to De Villiers and Monk advocates that teachers need to always ask how much the use of dissections align with the learning goals, if the learning goals can only be met through dissection, then dissection is appropriate. However, she emphasizes that if the use of alternative activities or simulations is sufficient to achieve these goals, alternatives must be considered. Some teachers who are strong supporters of dissections, Moore (2001), Schrock (1990) and Wheeler (1993), believe that the use of alternatives will not be the same as real dissections and they argue that the use of animals for educational reasons is for a good cause. The main reason why Schrock prefers dissections rather than alternatives is that only the former provides the learner with *real material* and *real experience* (Schrock, 1990). He points out, correctly, that no model can completely replicate an actual organ or organism. According to Moore (2001), the National Association of Biology Teachers (NABT) in the US believes that the study of organisms, including nonhuman animals, is essential to the understanding of life on earth. There is also some emphasis on the responsibility of the Life Sciences teacher to foster respect for life by ensuring that the learners respect the animal or the organs they will be dissecting and avoid mutilating them. The teachers should also teach about the interrelationship and interdependency of organs and organisms, as well as an organism and its environment so that learners can value them.

Safety is another consideration as dissections might pose direct harm to the students. Where sharp objects like scalpels, razor-blades or knives are used, it is important to adhere to quite stringent laboratory safety rules. The teachers need to be vigilant, walking around all the time to avoid any incident which might pose harm to the learners during the dissections practical. There are also psychological concerns which the teachers need to watch out for all the time, especially when using real animals. Both these issues can be solved by the use of alternatives to dissection. Berman (1984) and Wheeler (1993) argue that dissection is a worthwhile skill in itself and the fact that it is difficult to perform helps to teach learners that there are practical difficulties and limitations in the pursuit of scientific knowledge. In spite of the various problems, however, dissections have been used since the early 1900s to aid in the learning of Life Sciences, and its benefits have been acknowledged by both students and staff (Donaldson & Downie, 2007).

Learners also face some problems as they dissect, including the fact that some of them are blood phobic, and might even shun a possible successful future career in the biological sciences because of the prospect of dissections. It is possible that one may completely disregard a discipline like Life Sciences only due to the fear of working with animal parts, or worse still, *slaughtering* the animal. All these problems might be avoided by introducing the *opt-out of dissection* scheme which allows learners to use alternatives to work through the practical schedule with models, charts or interactive videos (Downie & Meadows, 1995). Teachers and learners may be unaware that there actually exist artificial organs or prostheses that can be used in place of the exact organ to accomplish the objective of dissections. In some cases the teachers may be aware of them but the schools may not have funds to acquire such organs, even for a few learners who are uncomfortable with fresh organ dissections.

2.8 THE USE OF ALTERNATIVE ORGANS IN TRADITIONAL, VIRTUAL OR ONLINE DISSECTIONS

Literature has shown that there are some learners who are totally against dissections to the extent of choosing to forfeit the marks rather than touching fresh animal organs (Balcombe, 2000). Learners like that would rather dissect artificial animals or organs (plastinated specimens) and practise virtual or online dissections. A few authors have argued *for* and some *against* the use of artificial organ or virtual dissections (Kinzie et al., 1993; McNeely, 2000; Moore 2001; Orlans, 1988).

The researcher is of the opinion that both ways of dissections have their own advantages and would rather let those learners who are uncomfortable with fresh organ dissections dissect the artificial ones than have them not do it at all. The only stumbling block in the case of most South African schools might be affordability because the fresh animal organs are much cheaper than the plastinated or artificial specimens. In the South African context, the fresh sheep kidneys cost about R30 (South African Rand) which is about 3 USD (American Dollar), per kilogram consisting of five or six kidneys whilst one artificial kidney costs about R100 (about 10 USD). The interactive videos cost about R600 which is about 60 USD, disposable scalpel blades cost R122 (about 13 USD) for a box of ten and a box of 100 latex gloves cost R60 (approximately 6 USD). These costs are beyond the reach of many schools in South Africa, to invest on one practical for one subject.

Hart, Wood and Weng (2005) argue that new computer technology can transform the possibilities for providing effective and efficient learning of human animal morphology in the absence of the old-fashioned dissections. This new software allows learners to dissect on-line; it could minimise problems faced by learners due to the smell of the organs, squeamishness or blood phobia during real organ dissections. According to King, Ross, Stephens and Rowan (2004), the use of dissections alternatives is not very popular with teachers. The teachers are mainly using alternatives as supplements, rather than substitutes, to fresh animals or organ dissections. Their study demonstrated that teachers reported using charts, videos, 3D models, CD-ROMS, and other computer-based resources, but only 31.4% of these teachers agreed that alternatives were as good as dissections of fresh animals or organs for teaching anatomy and/or physiology. This shows that the teachers are not yet convinced that the alternatives to fresh animals or organs are just as good for dissections. Almy, Goldsmith, and Patronek, (2001) have come to similar conclusions as King et al. that teachers were not certain about considering computer simulation as a pedagogical tool, even though 78.1% of the teachers in the study acknowledged using alternatives but mostly as supplements to real dissections.

There are many variables that can influence the teachers' decision to use alternatives as a substitution for, or in conjunction with traditional dissections. Cockerham (2001) and Hart et al. (2008) highlighted some of the factors that increase teachers' likelihood of using virtual dissections alternatives: a teacher's positive attitude towards virtual dissections, their previous experience using virtual dissections, their access to them, perceptions of effectiveness, willingness to explore new modes of learning, negative attitudes towards the use of animals in dissections, availability of resources, budgets, time and support. Taking into consideration the factors highlighted by Cockerham (2000) and Hart et al. (2008), the researcher is of the

opinion that in as much as some teachers might acknowledge that the use of online dissections is good enough, if they are not confident in their use or if the school cannot afford the alternatives, they would rather use the traditional way of dissections and force their learners to carry out the fresh organ dissections as well.
According to Oakley's (2011a) study, the majority of the teacher participants "… found unparalleled value in traditional dissections" (p. 256). The majority of the teacher participants (87.5%) acknowledged that real animal dissections is important to the teaching of Life Sciences and more than half (56.3%) strongly argued that there are no substitutes for real animal dissections. It is evident from the findings of these authors that the teachers are still far from being convinced that the use of alternatives for dissections is just as good as the traditional animal or organ dissections.

In as much as teachers acknowledge that there are some negative impacts of the traditional dissections in schools, they are of the opinion that the benefits of the traditional dissections outweigh the concerns. The benefits of the traditional dissections include its pedagogical value. Many teachers considered that the best possible way learners can learn is to work with an actual organ and observe real-life interconnections between the organ parts.

> "…..when students first study images, and then proceed to an actual dissection, they are often surprised: They can't identify structures, because what the structures look like virtually or on the textbook diagrams and what they look like in reality, is different. With a virtual dissection, you don't get the opportunity to feel the texture of the organ. There are all these sorts of surprises to doing a real organ dissection". Oakley (2011. p. 256)

These *surprises*, mentioned by Oakley (2011a), along with the hands-on nature of dissections, are considered as benefits only physical dissections can provide. Another benefit which was considered important is the development of motor skills as they manipulate dissection instruments. A high degree of safety precautions is needed as they use sharp scalpels, and a delicacy of hand-eye coordination is also required. Learner engagement or enjoyment during dissections of animal organs is an exciting, one-of-a-kind experience that interests them and promotes desire for further studies as Life Scientists. Animal organ dissections give learners an opportunity to appreciate, develop respect and admiration for animals from which the organs were acquired. Opponents of dissection might argue that animal dissection desensitizes students to animal cruelty and encourages them to regard animals as mere things, but according to the survey carried out by Donaldson and Downie (2007), the majority of both staff and students disagreed with that line of thinking but considered that dissection attributed to a better understanding of the animal value. Measures like introducing ethics teaching in bioscience education (Downie, 1993) may improve ethical sensitivity of the students to animal use according to the findings of (Clarkeburn, Downie and Mathew, 2002). Alessi and Trollip (2001) argue that the use of alternatives can be used instead of the actual experience when the latter is unsafe, costly, very complex or logistically difficult but in the case of animal organ dissections it is much cheaper to use the traditional dissections.

Oakley (2011b) highlights that some advocates for artificial organs or online dissections draw attention to the concerns of some teachers. These include health and safety if they are exposed to formalin solution for too long during the dissections which can be a health hazard to the learners as well. This concern does not apply to the South African context because the animal organs dissected are usually bought a day before the practical and are stored in the fridges; hence there is no need to put them in formalin solution. Pedagogical concerns include misbehaviour of learners who deliberately mutilate, abuse, or otherwise disrespect the animals' bodies or organs. This situation can be avoided if the teacher moves around. Pedagogical concerns were also expressed about the retention of learners in the subject; some of them will have been *turned off* Life Sciences because they think it is *gross*. Some difficulties can arise when a learner refuses to dissect. Some are not willing to participate even as a helper or observer, despite having the requirement in the curriculum. Further difficulties are encountered in giving any learner who has an objection to dissections a meaningful alternate project which can count for the year mark. Others worried about the impact dissections could have on learners who were opposed to it for animal rights or other reasons. All these concerns may be addressed by the use of alternatives to fresh organs like the plastinated specimens or virtual dissections if the school has such resources. A small selection of the possible alternatives available for dissections can be found in appendices, (See Appendix XVII).

Cross and Cross (2004) compared advanced adolescent biology students' performance when completing a physical dissections protocol. Prior to completing the protocol, they completed either computerised frog dissections using the multimedia application Biolab Frog Dissections or physical dissections. They found that students completing the physical dissections performed better on the protocol. Similarly, Marszalek and Lockard (1999) found that adolescent science students completing physical dissections produced superior learning gains from pre-test to post-test when compared to Digital Frog, a multimedia dissections application. When they measured retention over time, however, they found that these differences dissipated. It is interesting to note that these results conflict with those of Montgomery (2008) and Kinzie, Strauss, and Foss (1993), who found no learning differences between physical and virtual dissections. Downie and Meadows (1995) reported a scheme in which first year university Biology students were given a choice between dissecting a rat or opting out and doing an equivalent laboratory exercise using models, charts and demonstrators as alternatives. More than 10 examinations were recorded, opt-out and non-opt-out learners recorded exactly the same mean mark. The opt-out students acknowledged that they generally found the model rat satisfactory as an alternative to the real rat. All these authors acknowledge that animal or organ dissections are important, the only difference is that some advocate for real animal dissections against those that say the performance is the same whether using real organs, artificial or virtual dissections. The researcher, having taken into consideration the arguments and evidence from the above-mentioned authors, is of the opinion that teachers should be flexible and use both real and artificial organs. In that way, they can accommodate all learners for maximum participation in the dissections which will result in acquisition of important skills like problem-solving skills.

The researcher's opinion is supported by Duncan (2008) who argues that this issue extends beyond instructional choice: the need to offer choice has been mandated in many educational settings. In such circumstances, virtual dissections may provide learning opportunities to students who would not engage in, and learn from, physical dissections for either moral or ethical concerns, and/or health concerns related to chemicals and hazardous laboratory instruments. Regarding the notion of overlearning, if there is sufficient instructional time, virtual dissections and physical dissections could likely produce better learning outcomes than either would individually, in that students would be given the opportunity to learn, and possibly overlearn, on multiple occasions.

Numerous dissections alternatives are now available, including computerised virtual dissections, anatomical models, films, websites, and plastinated specimens. Learners now have a choice on the type of dissections they would like to carry out (Jukes & Chiuia, 2003; Smith & Smith, 2004). These developments should be welcomed by teachers because they minimise the controversies around real organ dissections for those learners who are uncomfortable in dissecting them. Many teachers regard traditional dissections as the *best* way to learn and those dissections continue today as much as (if not more than) it did 50 years ago in countries like Canada, US and South Africa (Hart, Wood, & Hart, 2008). The same authors wondered how its privileged position as the teachers' first choice connected to learners' choice. The qualitative data in their study identified that the ways teachers offer choice can differ dramatically: what counts as choice is not consistent from one classroom to the next. While the quantitative data revealed that 73.7% of teachers said they offer students choice, five clear subthemes arising from the study elucidated how choice was offered. The top five themes from the qualitative data were: (a) the *choice* or *alternative* some students were offered was to observe other students dissecting; (b) some teachers offer choice conditionally; (c) some teachers offer choice freely and provide an alternative for students to use; (d) some teachers do not offer choice at all; and (e) some teachers connect choice to grades. This showed that what teachers really consider as choice is ironically not giving much choice to the learners but indirectly forces them to carry out the real organ dissections, since that is apparently what they believe in, (Hart, Wood, & Hart, 2008).

2.9 PROBLEM-SOLVING SKILLS IN LIFE SCIENCES EDUCATION

> "*If you give a man a fish, you feed him for a day. If you teach a man to fish, you feed him for a lifetime"* (Chinese proverb).

This old saying illustrates the significant difference between the value of process and content. The skill of fishing (process) remains useful long after a single fish (content) has been eaten. Processes empower people far more than specific content (McCain, 2005). In order to cope with complex issues in the science-technology-environment-society context, it is essential for teachers to develop learners' high-order learning skills such as critical thinking, evaluative thinking, decision making and problem-solving capabilities within science education (Dkeidek, Mamlok-Naaman, & Hofstein, 2010). Problem-solving, as one of the high-order learning skills, is one of the skills which Life Sciences learners should acquire according to the National Curriculum Statement of the Department of Basic Education (DBE). Nationally and internationally, teachers have been called to teach in a way that promotes the application of concepts to solve problems, not just the recollection and comprehension of basic facts. (American Association for the Advancement of Science, 2011 & National Research Council, 2003). It was therefore considered essential to look at the literature on attributes of a problem and problem-solving

2.9.1 Attributes of a problem and problem-solving

Before looking at problem-solving, it is essential to establish what a problem is. It is crucial to look at two critical attributes of a problem: (i) it has an unknown entity in some situation (ii) solving or finding a solution for the unknown may have some social, cultural or intellectual value. According to Jonassen (2000), the process of finding the unknown is the problem-solving. Smith and Ragan (1999) define problem-solving as the ability to combine previously learned principles, procedures, declarative knowledge and cognitive strategies in a unique way within a domain of content to solve previously unencountered problems. This activity yields new learning as learners are more able to respond to problems of a similar class in future. According to Olivier, Greyling and Venter (in Gouws, Kruger & Burger, 2000, p. 124), "problem-solving is a process of identifying a problem, obstacle or an inability to act: it involves thinking of possible solutions, testing and evaluating these solutions". Albrecht (in Gouws et al. 2000, p. 124) defines problem-solving as … "A state of affairs one must change in some way to get the wanted outcomes". These definitions emphasise complete acts of thought, as referred to by Dewey in Lawson (2002, p. 157), which are:

- Sense the problem or question
- Analyse the problem
- Investigate or inquire to collect evidence
- Interpret the evidence
- Draw and apply conclusions

The above-mentioned acts of thoughts by Dewey in Lawson (2002) are essential to be instilled into learners as problem-solvers so that they do not rush to solve a given problem or question without understanding it first by analysing the problem. Thereafter they need to carry out an investigation, if applicable, to collect evidence or information necessary to solve the given problem, then interpret the evidence collected and use it to draw and apply the conclusions.

There are some important principles for teaching problem-solving that teachers can apply whether they are teaching in classroom or laboratory settings:

(i) First, introduce a problem-solving context, letting learners generate their own knowledge to solve the problem through inquiry or discussions.

(ii) Teach problem-solving skills in the context in which they will be used. Use authentic problems in explanations, practice and assessments, with scenario-based simulations. Problem-solving should not be taught as an independent, abstract, decontextualised skill.

(iii) Within a problem exercise, teachers should guide the learners to understand or define the problem so that they discover the possible solutions for the given problem.

(iv) Use errors made by learners in problem-solving as evidence of misconceptions, not just carelessness or random guessing, and clarify the misconceptions.

(v) Ask questions and give suggestions that may encourage learners to reflect on the problem-solving strategies they use. (This is sometimes called cognitive coaching).

(vi) Give practice of similar problem-solving strategies across multiple contexts to encourage generalisation.

(vii) Ask questions which encourage learners to grasp the generalisable part of the skill, across many similar problems in different contexts.

(viii) Use familiar contexts, problems and teaching styles which will build interest, motivation, confidence, persistence, and, knowledge (Kirkley, 2003, p. 11).

The researcher is of the opinion that the principles mentioned by Kirkley may also be considered by Life Sciences teachers when implementing problem-solving strategies using animal organ dissections.

2.9.2 Problem-solving strategies or models

Many authors (Ali, Hukamdad, Akhter & Khan, 2010; Dehaan, 2009; Dogru, 2008) have suggested *problem-solving* strategies, some of which are only applicable to mathematical or physics problem-solving. This literature study has focused on the ones that are relevant to the use of animal organ dissections in problem-solving. Some authors have referred to the problem-solving strategies as models depending on how the strategy is presented. A model for problem-solving can be described as the plan that guides one in finding a solution to a problem. The essence of problem-solving is to know what the real problem is, to plan how to solve it, and to evaluate whether the solution has solved the problem. There are two types of strategies that can overcome difficulties in problem-solving: *pedagogical strategies*, which are teacher-centred methods, and *methodological strategies*, which tend to be learner-centred (Keller & Concannon, 1998). According to these authors, pedagogical strategies allow the teacher to facilitate class discussion which reinforces success and transfer of learned skills.

They also suggest that active involvement is critical in developing problem-solving skills, so using student learning groups to promote active experimentation with problems given by the teacher is a sound pedagogical strategy. Methodological strategies provide a series of steps to assist students in addressing and solving a new problem, and work hand-in-hand with the pedagogical techniques already discussed. The combination of the two main strategies may result in an important development of problem-solving skills. To develop better problem-solvers, instructors must help students overcome both emotional and cognitive barriers to learning effective problem-solving skills. By first creating a comfortable classroom environment and helping students overcome their fears and anxieties related to problem-solving, teachers lay the necessary foundation for successful learning. Then, using an array of pedagogical and methodological strategies, instructors can promote student reflection on the problem-solving process itself, and provide critical tools for, and practice in, productive problem-solving. As a result students will become increasingly effective problem-solvers, able to solve more and more complex problems with greater and greater independence (ibid).

Comprehensive training in problem-solving includes effectively teaching students about major problem-solving strategies with which the teachers must be familiar (Malouff, 2002). These include (a) strategies that help a person understand the problem, e.g., visualizing the problem, considering the problem from different perspectives, and creating a model of a relevant process or situation; (b) strategies that help a person simplify the problem, such as solving one part at a time or redefining the problem; (c) strategies that help a person determine the cause of a problem, e.g., organizing relevant information into a chart and considering multiple cause and interactions; (d) strategies involving the use of external aids that help a person identify possible solutions, e.g., applying a theory and using a tool; (e) strategies involving the use of logic, e.g., questioning assumptions and reasoning by analogy; (f) strategies involving using a possible solution as a starting point, e.g., working backward and guess-check-adjust, (g) strategies that help a person function optimally while problem solving, e.g., thinking of a problem as a challenge and working with someone; and (h) strategies to help one solve multiple problems, e.g., applying triage and solving one problem at a time (Malouff & Schutte, 2008). In each case the teacher must employ the strategy relevant to the context, subject or topic and adjust each strategy to suit the situation.

Many different problem-solving strategies may be employed in developing problem-solving skills. Problem-solving strategies require learners to be active in their learning. For learners to produce high quality work, they need to be given the opportunity to discuss with one another and work in groups (Tomlinson, 2001). Tomlinson also emphasises that "students collaborate … and make major contributions towards solving problems" (p. 23). Benjamin (2006) as well as Cotic and Zuljan (2009) concur that when learners are working in groups, they should spend some time defining the problem first, then discuss how the problem may be solved. This is in support of McCain (2005) who deduced the 4Ds of problem-solving which are to *define* the problem given, *design* a plan for solution to the problem, *doing* which is to put the plan into action and *debriefing*. The learners need to follow a step-by-step process that will empower them to solve any sort of problem once they begin. Figure 2.1 represents the step-by-step process to deal with a given problem:

Step 1: DEFINE

- Properly define the problem given before starting to work on it
- Identify and link it with previously acquired knowledge
- Establish what the real problem is
- Nit-pick the problem so that it is well-understood so as to design an appropriate solution

Step 2: DESIGN

- Learners design a plan for the solution to a problem; in this case it will be an investigation through animal organ dissections
- Have a mental picture of the solution to the problem
- Develop a plan for bringing the vision to a reality
- Learners take responsibility of their own learning

Step 3: DO

- Learners put their plan into action
- Learners carry out animal organ dissections, exploring the organ parts, generating own knowledge
- Learn from their mistake and correct it
- Learners culminate the define and the design processes

Step 4: DEBRIEF

- Learners discuss in groups what was observed during the dissections
- Recognise the parts of the problem solved and offer constructive criticism on what could have been done better
- To assess how well a learner managed to solve the problem, learners are given ill-structured problem-solving questions
- Evaluation by the teacher essential

Figure 2.1: The 4Ds of problem-solving (Adapted from McCain, 2005, p. 51-66)

Taking McCain's opinion and the South African National Curriculum Statement (NCS) into consideration, teachers should not think that testing and passing comprises the complete set of process skills. If there is any hope of equipping young South Africans with the thinking skills that will enable them to apply their learning to real-world situations, teachers must also embrace the process of problem-solving. McCain (2005) emphasises that like teaching any skill, employing a problem-solving method of instruction is done progressively. One would start with small modest, less challenging tasks and build towards more challenging tasks, encouraging learners to employ all the steps of the 4D process. According to the 4Ds of problem-solving, learners should have the ability to *define* a given problem, linking it with some previously acquired knowledge. In the case of animal organ dissections, learners may link the given problem with the previously acquired knowledge. Once the learners understand what the problem is, they can then *design* a plan for the solution to the given problem which can be an investigation through animal organ dissections. Once the plan has been designed, the learners put the plan into action which is the third D for *do*. In this case they carry out the animal organ dissection. Lastly, d*ebriefing* takes place in which learners discuss in small groups what was observed as they investigated or dissected the organs. Teacher guidance is very essential during all the four stages towards problem-solving.

Life Sciences education in South Africa emphasises scientific inquiry and problem-solving skills. For successful development of problem-solving skills, teachers must become crafters of problems by presenting tasks as real-world problems to be solved. They should desist from presenting theory as the only way for learners to encounter course content. Another role of the teachers is to guide and begin to see themselves as an instructional resource for learners to use as they go about the task of solving problems. They must make a shift in evaluation from being a judge to being a confirmer and a challenger where they either confirm or challenge the assessments learners make of their own work, which is self-assessment. Development of problem-solving skills can take place at the same time that learners are learning the content laid out in the curriculum. For instance, the dissections of animal organs as a curriculum requirement may be used to help learners develop problem-solving skills that will empower them for lifelong success. The problems given by the teachers during the dissections of animal organs provide a context that helps learners later to remember the specific content they encountered while solving them (McCain, 2005).

The APIE (Assess Plan Implement and Evaluate) problem-solving model suggested by Beekman (2000) shows the four stages to use in problem-solving, which include:

- Assessing the problem, gathering information about the problem
- Planning to solve the problem, working out a plan of action

- Implementing the action plan, recording actions and responses
- Evaluating the effectiveness of the action plan or whether the problem has been solved.

In some cases problem-solving may not be as good as it could be because one has not been able to identify the real problem and one ends up finding a solution to the wrong problem resulting in failure to solve the problem. The APIE model incorporates rational, creative and critical thinking skills.

Another problem-solving strategy, by Lipman (1991, p. 149), summarises a systematic procedure with effective problem-solving strategies:

- Being aware of the problem
- Identifying and formulating the problem
- Setting a goal-deciding on the end result
- Formulating a hypothesis and deciding on a method
- Anticipating the consequences
- Selecting the alternative solutions
- Drawing up a plan of action
- Executing the plan
- Evaluating the effect

The above-mentioned problem-solving strategies by Beekman (2000), Lipman (1991) and McCain (2005) concur in that when learners are presented with a problem, they need to (i) analyse and understand what the problem is before they solve it. After that, they have to (ii) plan the approach or method they can use to solve the problem. When they are satisfied with the plan or method, (iii) they implement the plan, gathering information they can use to solve the given problem and record the responses, and finally they can (iv) evaluate the effectiveness of the plan implemented and discern whether it has managed to answer or give solutions to the problem given. In the case of using animal organ dissections in problem-solving, learners are given ill-structured problem-solving questions. They have to analyse each question and understand what each problem is seeking before they start answering. They plan their approach that involves the dissections of the animal organs. When ready for the dissections, they dissect and explore the organ, engaging with the dissections, seeking solutions to the given problem. The given questions guide them to engage with the dissected animal organ with a focus which will help them answer the questions or given situations. Learners may apply cooperative learning and discuss and debate their observations. They generate their own knowledge and understanding in the process, which may be helpful in acquiring problem-solving skills.

In some instances, problem-solving strategies may be promoted using certain learning styles. According to Gregory and Chapman (2002), there are many different learning styles which can be employed in a classroom. They listed five categories, which the researcher found to be relevant when using animal organ dissections in problem-solving as a teaching strategy. The five categories include: visual, auditory, tactile, kinaesthetic and tactile-kinaesthetic learning styles. Visual learners learn best through their sense of sight and they process information most effectively when they see what they are learning rather than trying to imagine what they are learning. Materials which can be given to visual learners include illustrations, demonstrations like dissections of animal organs, pictures, graphic organisers and diagrams which are preferably in colour rather than in black and white. Auditory learners can listen during the lesson as the teacher verbally presents and explains the information. They can discuss or repeat the same information to a partner or self as a way of memorising-that is how they retain their knowledge. Kinaesthetic or tactile learners perform best when they can manipulate objects or materials by doing, touching or moving (Heacox, 2002). Not only Northey (2005 p. 10), but also Gregory and Chapman (2002, p. 20), defined kinaesthetic or tactile learning as "… learning by doing or experiencing or becoming physically involved in learning activities that are meaningful and relevant in the learners' lives". According to the researcher's opinion, the afore-mentioned learning style categories are all important but they might not be effective if they are employed as stand-alone learning styles; a combination of them may result in a very effective learning outcome or result.

By way of example, for an effective use of animal organ dissections in problem-solving as a teaching strategy, it would be of utmost importance for teachers to introduce their lessons on the excretory system, in the case of this study, through the auditory and visual learning styles where the teacher can explain the important concepts regarding the system, showing the learners some pictures, models, simulations, depending on the availability of the resources in the school. The teacher may include problem-based activities in the lesson as a way of guiding the learners to engage with the concept and try to help them respond to the given problems. The teachers can then employ the tactile learning style as a way of consolidating the learnt concept for improved knowledge retention. The learners could dissect the animal organs, the kidneys in this case. Learners must be given problem-solving questions which will force them to engage with the dissections of animal organs. Through the tactile learning style, they can dissect, observe the organ and manage to answer problem-solving questions. This shows that a combination of four learning styles, visual, auditory, problem-based activities and tactile, can result in the development of many skills which include investigative or inquiry, problem-solving skills and a higher knowledge retention.

According to the Department of Education (2003) in the National Curriculum Statement, the skills that learners develop and use in the Life Sciences allow them to solve problems, think critically, make decisions, find answers and satisfy their curiosity. This dimension is mostly emphasised in the Learning Outcome 1 which states that the learner must be able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem-solving, critical thinking and other skills. Taking the above-mentioned learning outcome into consideration, the researcher explored a few principles which form the basis for problem-solving. Five instructional design principles were elaborated by Merrill (2002). Learning is promoted when (a) learners are engaged in solving real-world problems, (b) existing knowledge is activated as a foundation for new knowledge, (c) new knowledge is demonstrated to the learner, (d) new knowledge is applied by the learner, (e) new knowledge is integrated into the learner's world. The researcher mainly focuses on the first strategy because in her opinion the first principle encompasses the other four principles. For the learner to be considered capable of solving real-world problems, he or she would have managed to use existing knowledge as a foundation for new knowledge, the learner will also have managed to apply the new knowledge and integrate it into his or her world.

Bruner, in Ellis (2004), argues that the acquisition of knowledge is an active process in which meaning is only acquired by connecting incoming facts to the previously acquired knowledge. This means that before teachers can confront learners with a problem that will require prior knowledge to solve, they have to make sure that the necessary content knowledge has been covered with the learners. This enables the learners to link new knowledge to prior knowledge and ensure that further learning takes place. In the case of this study, as the learners solve the given problems by engaging in the scientific inquiry called animal organ dissections, learners must have an idea of what to look out for when they engage with the dissected organ. They can then use the new knowledge, linking it with prior knowledge, to solve the given problems.

The learners may successfully find solutions to given scientific problems if they have some theoretical background. They then derive other facts by dissecting and engaging with the organ; they observe, discuss and generate their own knowledge which they can use to answer the given problem-solving questions.

Although problem-solving is regarded by most educators (teachers, lecturers) as among the most important learning outcomes, few instructional design prescriptions are available for designing problem-solving instruction and engaging learners. The problem-solving instruction can only be effective if the teacher can distinguish between well-structured problems and ill-structured problems. “The model for solving well-structured problems is based on information-processing theories of learning, while the model for solving ill-structured problems relies on an emerging theory of ill-structured problem-solving, constructivist and situated cognition approaches to learning” (Jonassen, 1997, p. 63). However, in real life, problems are often ill-structured, which problem-solving education needs to address.

Educators must (a) identify learning goals (tangible, for example dissections, and intangible), as this is where much of the progressive thinking must occur; (b) choose learning methods that are likely to accomplish these learning goals; and (c) decide that to do no harm is a worthy pursuit. The challenge for educators is to ensure that their learners learn. Careful and realistic selection of learning goals should precede selection of learning tools; one thinks of the means to the end while choosing the end. That approach will necessarily limit one’s creativity and expectations. Taking, for instance, that the learning goal is problem-solving, the teacher then selects the learning tool based on this goal rather than starting with the tool as it can sometimes end up wasting one’s time without achieving the expected goals. Learning goals should be relatively specific. ‘Learn anatomy’ is far too broad. Anatomy of what species? In what detail? For what purpose? Furthermore, we must not ignore less tangible learning goals. Learners in the Life Sciences must recognise (and appreciate the need to recognise) detail; they must be dexterous with careful hand-eye coordination. Dissection is an active learning activity which is consistent with learner-centred strategies. It is considered an important part of teaching and learning science. It involves learners in performing experiments with concrete objects and then consolidating concepts. Not only promoting science content, it also promotes science process skills, creative thinking, problem-solving ability, and the scientific method (Hofstein & Lunetta, 2004).

According to Wellington (1998), the benefits of the laboratory activities like animal organ dissections for learners in learning science can be summarised in three domains:

a) To develop the cognitive domain (e.g. content and the nature of science).

b) To develop the affective domain (e.g. promote positive attitude toward science).

c) To develop skills (e.g. science process skills, laboratory skills, problem-solving skills, inquiry skills, and communication skills).

Many research studies have incorporated laboratory work with other teaching methods such as problem-based learning (Das & Sinha, 2000), research-based or project-based learning and inquiry-based learning (Smiley, 2002). Nakhleh, Malina, & Polles (2002) suggested that teachers should use inquiry-oriented laboratories, allow students to explore open-ended questions, and make the laboratory a link to real-world experience and up-to-date knowledge. Taking this into consideration, teachers should avoid letting learners carry out animal organ dissections just to comply with the National Curriculum Statement (NCS) requirements but it should be accompanied by questions which link the practical with the real-world experiences and as a result learners may acquire problem-solving skills.

A combination of mastering problem-solving strategies and a positive attitude towards problem-solving or challenging situations will have the following attributes:

- A tolerance for ambiguity-this ensures creative thinking and the generation of many different solutions to problems
- Respect for facts and findings-ensures sound investigations, reliable evaluations and conclusions
- An inquiring and investigative approach that will allow the collection of enough information before a decision is made-inhibits impulsiveness
- A willingness to search for alternatives-promotes critical thinking
- A willingness to re-evaluate, adjust and correct (McCain, 2005).

Besides the problem-solving strategy, emotional preparedness is necessary for problem-solving. This includes a positive perception to put the learner in a receptive frame of mind. The learner must have the inquiring mind and disposition of a critical thinker. Emotional preparedness also includes motivation, perseverance and concentration; it is not easy to concentrate when the learner is emotionally unstable. The skills one learns in the general problem-solving process will help one to solve educationally related problems. Life

Sciences teachers may also take the problem-solving strategies or models into consideration during the dissection lessons so that learners may acquire more skills than just cutting, drawing and labelling.

2.10 PROBLEM-BASED LEARNING (PBL)

Problem-based learning (PBL) is an innovative student-centred approach that was originally developed in medical teaching in 1958 in the McMaster University programs, Canada (Barrows & Tamblyn, 1980), and later adapted for use in other contexts (Barrows 2000; Barrows & Kelson 1995; Torp & Sage 2002), elementary and high school subjects (Torp & Sage 2002). In PBL, problems act as the stimulus and focus for student activity and learning (Boud & Feletti, 1991). Students learn while searching for solutions to the given problems and in the context in which knowledge is to be used. Unlike traditional teaching approaches which introduce problems only after students have acquired the relevant content knowledge and skills, problems are introduced at the beginning of a unit of instruction. This reverse *problem-first* approach in PBL helps students to understand why they are learning what they are learning (Gallagher, Stepien, Sher & Workman, 1995).

For one to be considered a good teacher, the goal should be to develop an independent young person. Unfortunately, the traditional teaching approach, which is to tell the content and test, does not foster independence in learners. Problem-based learning is a model which is student-centred and intended to develop active, motivated learning, problem-solving skills and broad field knowledge based on a deep understanding of concepts (Major, Baden, & Mackinnon, 2000). In this case, students take much more responsibility for their own learning and become independent problem solvers. The basis of problem-based learning is rooted in Dewey's work as far back as 1938, which strongly supports the *learning by doing and experiencing* principle (Dewey, 1938).

In problem-based learning, students work in small groups to investigate a meaningful problem given by the teacher, identify what they need to do and learn in order to solve the problem, and generate strategies for a solution (Barrows, 1996; Hmelo-Silver, 2004). They also implement these strategies, evaluate their results, and continue to generate new strategies as needed until they have solved the problem. The problems are realistic and have multiple solutions and methods for reaching them, rather than a single *right* approach. In all problem-based approaches, students take an active role in building their knowledge, while the teacher's role is to make thinking visible, guide the group process and participation, and to ask questions to solicit reflections. In short, the goal for teachers is to model good reasoning strategies and to encourage the students to take on these roles themselves (Barron & Darling-Hammond, 2008). A review of research on inquiry-based and cooperative learning by the same authors revealed that i) Students learn more deeply when they can apply classroom-gathered knowledge to real-world problems, and when they to take part in projects that require sustained engagement and collaboration, ii) Active learning practices have a more significant impact on student performance than any other variable, including student background and prior achievement, iii) Students are most successful when they are taught how to learn as well as what to learn which gives them a bit of independence.

Problem-based learning is an appealing instructional strategy. Authors like Visser (2002), Gallagher, Stepien and Rosenthal (1992) have argued that, according to their findings, learners who have experienced problem-based learning (PBL) are highly motivated, more proficient in *problem finding* and engage in problem-solving more successfully and more spontaneously than learners who have experienced the traditional learning environments. In broad terms, PBL describes an instructional method that uses problem scenarios as contexts for students to learn problem-solving skills and acquire knowledge (Albanese & Mitchell 1993; Barrows & Kelson 1995). PBL also offers learners opportunities to acquire knowledge through problem-solving and the use of previous knowledge. According to Culver, (2000), problem-based learning on its own may not convincingly lead to the development of problem-solving skills but problem-based learning deviated from the traditional teacher-learner interactions towards active, self-directed learning by the learner which includes giving a solution to problem-based questions through inquiry or laboratory work may result in the development of problem-solving skills. Teacher-centred approaches leave the learners unprepared for tertiary education and there are unintended consequences which can have long-lasting crippling effects on young people. The worst one is fear of failure if they have to work independently when they are used to being entirely dependent on the teacher (ibid).

There are four design principles that may be especially important in the effective implementation of PBL instruction: (a) defining learning-appropriate goals that lead to deep understanding, (b) providing scaffolds that support student learning, (c) ensuring opportunities for formative self-assessment and revision, and (d) developing social structures that promote participation (Barron et al., 1998). Providing learning-appropriate goals helps students to focus and understand the how and why of a project, while frequent opportunities for reflection promote the thinking behind the doing. These principles are not necessarily subject specific; teachers of different subjects may apply them, including the Life Sciences teachers. The teachers should bear in mind the above-mentioned principles and the characteristics of problem-based learning which include: learning needs to be learner-centred which means that the learner is at the centre of the educational activity where a problem stimulates information retrieval and the application of reasoning mechanisms (Dochy et al., 2003).

Learning has to occur in small learner groups under the guidance of the teacher; the teacher acts as the guide or facilitator; the problems encountered or given are used as a tool to achieve the required knowledge; and the problem-solving skill is necessary to eventually solve the problem. using an ill-structured problem to guide the learning agenda, having the teacher act as a metacognitive coach, and students working in collaborative groups. Ill-structured problems are those where the initial situations do not provide all the necessary information to develop a solution, and there is no one correct way to solve the problem. As facilitators of learning, teachers acquaint learners with new ideas or cultural tools, to support and guide students as they make sense of these (Driver et al., 1994). Learners also take an active role in their learning as they discuss and decide on problem-solving strategies, divide research tasks and other responsibilities among group members, discuss their findings in groups and craft a problem solution (Chin and Chia, 2004). A typical example which encompasses the above mentioned issues regarding PBL is a study carried out by Clarkeburn, Beaumont, Downie and Reid (2000) in which biology students were taught transferable skills using an educational programme which presented students with a problem-based role play, solving a challenging conservation problem. After the whole exercise the results showed statistically significant changes in the students' confidence, report making, group working skills and most importantly problem-solving skills. In the case of the current study, the learners take an active role by carrying out and engaging with the dissections of organs in small groups, discuss the observed parts linking them to real-life experiences and then answers the problem-solving questions individually. New information needs to be acquired through self-directed learning. Learners learn by investigating, analysing and solving representative problems. Learners solve realistic (albeit, simulated) problems that reflect the decisions and dilemmas people face every day rather than reading or hearing about the facts and concepts that define an academic field of study. Eng (2001) argues that problem-based learning aims to deliver a learning environment that is holistic to learner-centred education and learner-empowerment. This educational tool enhances learning as a relevant and practical experience to enable the learners to acquire problem-solving skills and to promote their independent learning skill.

A few authors have focused their PBL researches on subjects like Mathematics Science and Geography (Azer, 2009; Cerezo, 2004; Simons & Klein, 2007) but Sungur and Tekkaya (2006) carried out a cross-sectional comparison between Grade 10 Biology students at a high school in Turkey. Half the group of students received traditional teaching where students just received information from the teacher as if they were empty vessels and the remaining half of the group received instruction using a PBL approach. Timing of the instruction was one four-week unit in Biology. Learners were required to read the problem scenario, take notes and participate in group discussion to generate hypotheses and learning issues. Students were then required to independently gather information. Upon completion, the PBL group had significantly higher scores in relation to intrinsic goal orientation and task value, higher levels of critical thinking, metacognitive self-regulation and peer learning. There was also a statistically significant difference in self-reported motivation and learning. This shows that PBL is applicable across many subjects of the curriculum. However, all approaches by different researchers appeared to have had a general orientation towards a pedagogical practice that actively involved learners in the educational activity, allowed them to take ownership of their work, and their own learning process. This basically shows that irrespective of the teachers' approaches when implementing PBL, the basic principles are the same, resulting in fulfilling the same objectives.

McCain (2005) argues that, in as much as some teachers are aware that learners should be given problems to solve, the way in which the problems are presented does not prepare the learners to develop the problem-solving skill to apply if presented with a different circumstance. In most cases, the teacher explains a concept and, after that, tells the learners to read about it and then answer questions that follow. For problem-solving advocates, many questions regarding how real problems present themselves in real life come into their minds. For instance, does someone outline all the parameters and specifications for us when tasks and problems are presented in our personal and professional lives? Does someone break down the task into more easily handled subsections? The answer is *no* and yet that is exactly what most teachers do for learners every day. However, the same learner is expected to work independently and think logically once he/she is at tertiary level while the stakeholders ask why there are so many university dropouts?

According to Dochy, Segers, Van den Bossche and Gijbels (2003), real-life scenarios can be used to generate interest and teach some concepts even in Life Sciences. Learners can debate the scenarios covering the syllabus. In the process, it forces them to think beyond just receiving the theory from the teachers and memorising it for the exam. By carrying out animal organ dissections and using it to answer the given problem-solving questions, learners explore the dissected organ and focus on trying to answer the given problems with the generated knowledge. There are certain guidelines which teachers can follow when creating problems for learners to solve. These include:

- The problems must address the outcomes in the curriculum guide
- The problem should have a real-world link; scenarios could have to do with someone's health, life style or dilemmas
- The teacher has to ensure he does not give the answer when presenting the problem.

Valid assessment systems evaluate learners' competencies with an instrument based on real life. The assessment of the application of knowledge acquired when solving problems is very important in the acquisition of problem-solving skills in learners (ibid). `

2.11 CONCEPTUAL FRAMEWORK FOR THE STUDY

A conceptual framework is a set of broad ideas and principles taken from relevant fields of inquiry and used to structure research (Reichel & Ramey, 1987). The use of dissections is the main focus to encourage learners' hands-on participation and generation of their own knowledge, using observations of the organs, interaction with group members linking concepts related to the observed and acquiring problem-solving skills. The use of open-ended questions that are relevant and linked to the real-world problems associated with the structure and functions of the organ which they have dissected and observed, can also help learners to acquire problem-solving skills.

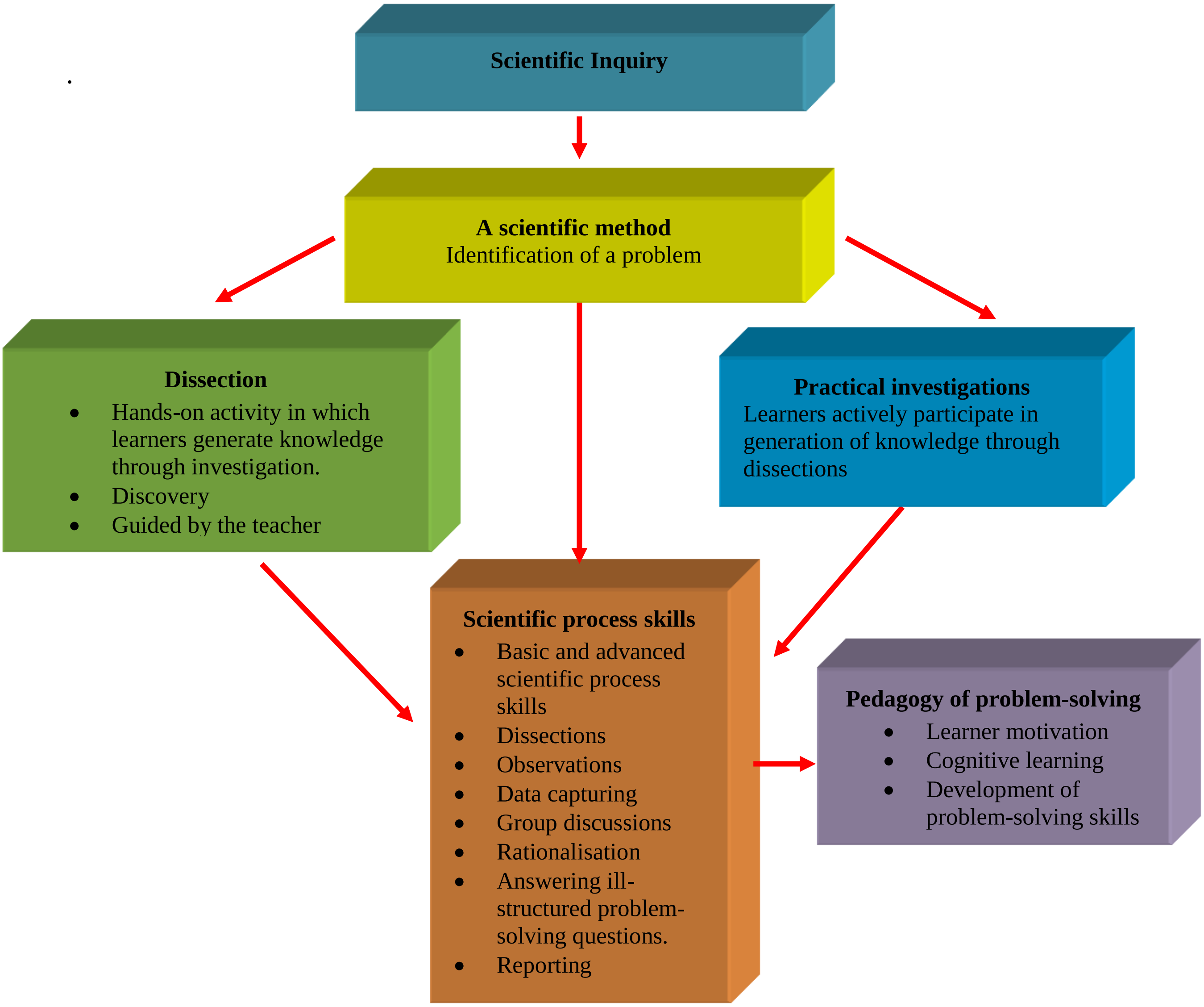


Figure 2.2: A diagrammatic representation of the conceptual framework for the study: a problem-solving model

After the literature review, the researcher summarised the concepts relevant to this study as the overall conceptual framework of the study that is presented in the diagram above (Figure 2.2). It depicts how learners, through a scientific enquiry can use animal organ dissections as a hands-on activity to generate their own knowledge. The role of the scientific inquiry according to literature is to enable learners to acquire basic and advanced scientific process skills by carrying out hands-on activities, like animal organ dissections (Bennett & Lubben, 2006). They discuss the observed in groups and capture the data which will help them to answer the ill-structured problem-solving questions. During the discussions an intense rationalisation is involved as the learners engage with the dissections of animal organs and debate until they agree as a group on the relevant generated knowledge. The challenges presented by the questions motivate the learners to explore and engage with the organ, seeking the answers that they can get from observing the organs. The knowledge generated results in cognitive learning and development of problem-solving skills as the learners strive to solve the given problems.

This study looks at how animal organ dissections can be used in problem-solving as a teaching strategy hence much emphasis is based on the animal organ dissections. Linking with the conceptual framework, this study follows the use of the inquiry method in which learners develop knowledge and understanding of scientific ideas and how scientists study the natural world. Scientific inquiry includes process skills (methods) used to study certain concepts and processes. In this study, the scientific inquiry using animal organ dissections and problem-solving are considered to be the process skills. A few authors concur that a hallmark of a successful Life Sciences learner is the acquisition of skills such as problem-solving, experimental or investigative skills, collaborative learning, oral communication and regulating one's own learning (Airey & Linder, 2009; Bao, Cai, Koenig, Fang, Han, & Wang, 2009; Brickman, Gormally, Armstrong, & Hallar, 2009; Carnegie Institute for Advanced Study Commission on Mathematics and Science Education, 2009). In the case of this study, the learners are given ill-structured problem-solving questions which they can solve through animal organ dissections, observations and group discussions. Learner motivation and cognitive learning may result from managing to solve the challenging questions and as a result may lead to the development of problem-solving skills.

2.12 SUMMARY OF THE LITERATURE REVIEW

The review of literature of Life Sciences education shows:

- Dissections are widely carried out internationally and nationally but there seems to be a dearth of literature on the use of animal organ dissections in problem-solving, especially in the South African education context. The National Curriculum Statement (NCS) of the Department of Education (DoE) and the new Curriculum and Assessment Policy Statements (CAPS) of the Department of Basic Education (DBE) require that learners carry out dissections of animal organs.

- It has also been established that the attitudes of teachers and learners towards dissections has great influence on the outcomes of the activity and in some cases on the skills that should be acquired.
- Models based on problem-solving in Life Sciences seem to be limited because most authors have linked problem-solving with Mathematics and Physical Sciences.
- Problem-solving forms an integral part of the National Curriculum Statement (NCS) of the Department of Education (DoE). Educators can use scientific inquiry like animal organ dissections to develop this skill in learners.
- This study, therefore, focuses on linking animal organ dissections with problem-solving. The researcher believes that teachers may improve their teaching strategies in problem-solving. At the same time, learners may develop problem-solving skills through the use of animal organ dissections.

The next chapter focuses on the research design and methodology used in the study. It informs the reader about the data collection methods used to gather the relevant data.

CHAPTER 3

SELECTION AND APPLICATION OF THE RESEARCH DESIGN AND METHODOLOGY

3.1 OVERVIEW OF THE CHAPTER

This chapter describes the research strategies that were used for the study that eventually developed responses to the research questions; this includes the research design, sampling procedures, data collection strategies and instrumentation, the pilot study, the main study and the ethical considerations.

3.2 RESEARCH DESIGN

A research design is a plan or strategy that moves from the underlying philosophical assumptions to specifying the selection of respondents to be studied, when, where and under what circumstances they will be studied, the data gathering techniques to be used and the data analysis to be done (Nieuwenhuis, 2010).

The decision to use a specific research design is influenced by the:

- worldview assumptions of the researcher;
- personal experiences of the researcher;
- audiences of the study;
- nature of the research problem;
- research strategy, and
- methods of data collection analysis and interpretation. (Cresswell, 2009. P. 3)

3.2.1 Research design approaches

Research design can use a (1) Qualitative approach which is “a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem” (Creswell, 2009, p. 4). It involves:

- emerging questions and procedures;
- data collected in the participant’s setting;
- inductive data analysis, building from particular to general themes;
- focus on individual meaning, and

- a description of the complexity of the situation (Creswell, 2009, p. 4).

(2) Quantitative research can be defined as "a means for testing objective theories by examining the relationship among variables" (Creswell, 2009, p. 4). These variables can be measured with the use of instruments, and the numbered data analysed with the use of statistical instruments. It involves:

- assumptions about testing theories deductively;
- the building of protections against bias, and
- generalisation and replication of findings (Creswell, 2009, p. 4).

Having taken the characteristics of both qualitative and quantitative approaches, this study adopted a multiple method approach, which is a combination of quantitative and qualitative research methods. The reason for using the multiple method approach was to ensure that both approaches complemented one another. There are three types of multiple method strategies: sequential, concurrent and transformative (Creswell, 2003). This study used the concurrent embedded strategy (qualitative/quantitative) (Creswell, 2009). Data was collected by applying both approaches within the same time frame during the study following Cresswell's (2003) concurrent strategy as illustrated in Figure 3.1:

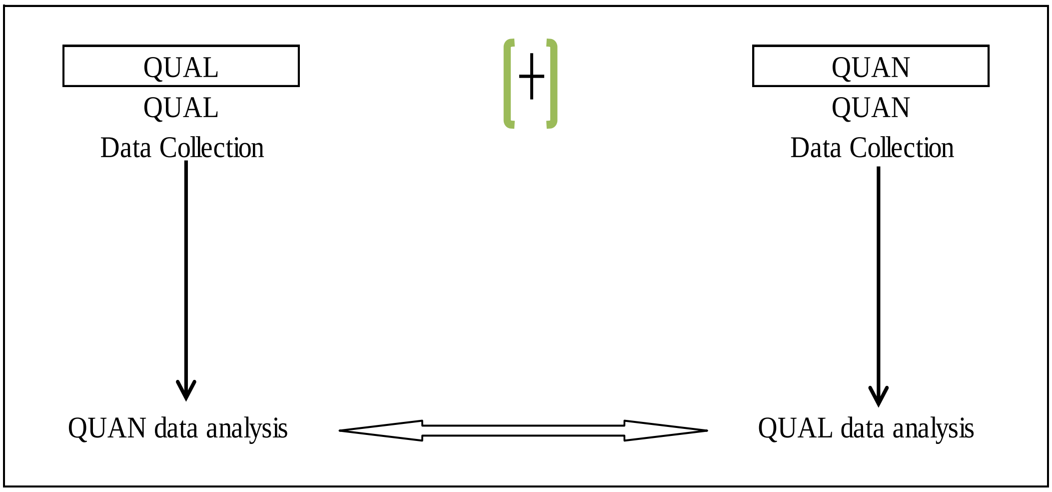


Figure 3.1: Concurrent multiple method research strategy applied in this study
Source: Creswell, (2003, p. 214)

3.2.2 Purposes of multiple method approach for this study

The multiple method approach for this study has the following purposes: triangulation, expansion, complementarity and development which shall be elaborated in the following sub-sections.

3.2.2.1 Triangulation

Triangulation seeks convergence of findings or corroboration of data. The following data collection methods were used: observation of dissections lessons and interviews with the teachers (qualitative data collection methods generated qualitative verbatim results), showing how teachers used animal organ dissections to improve the problem-solving skills; problems learners experienced as they were carrying out animal organ dissections; the extent to which the three learning outcomes were being achieved using animal organ dissections; how learners engaged with dissections and used it in developing problem-solving skills; learners' attitudes and behaviour as they were dissecting. (The teachers' interviews were used to supplement and support information obtained from the observation). Questionnaires, pre-test and post-test (quantitative data collection methods), yielded responses and data that was quantitatively transformed. This complemented the findings of the qualitative data (Sandelowski, 2000). That brought about a better triangulation.

3.2.2.2 Expansion

Expansion serves to widen the scope of study. The semi-structured interview (qualitative method) and the open-ended questions on the questionnaire (quantitative method) broadened the scope of this study. This study collected data through semi-structured interviews in which the teachers were allowed to express themselves guided by questions asked by the researcher. The researcher probed further if she felt that the information given needed to be explained and this face-to-face interview allowed the researcher to see the animal organ dissections and problem-solving issues through the eyes of the interviewed teachers. The questionnaire was also used to collect data regarding animal organ dissections, problem-solving and the attitudes of the learners. Section C of the questionnaire comprises open-ended questions in which learners expressed themselves regarding their opinions and feelings on animal organ dissections and problem-solving. The open-ended sections of the interviews and the questionnaires broadened the scope of the study because the teachers and the learners brought to the attention of the researcher some aspects that she would not have considered including had it been just a closed-ended interview or questionnaire.

3.2.2.3 Complementarity

The data collected quantitatively complemented or backed up data qualitatively collected as we shall see in the data analysis. In this study one of the objectives of the study was to establish how learners engaged with dissections and used it to develop problem-solving skills. The data collected from the lessons observations on how learners engaged with dissections was complemented with data collected from the pre-test and post-test to establish the development of problem-solving skills. Another objective was to establish teachers' and learners' attitudes towards animal organ dissections in general and its use specifically in problem-solving. In this case the lessons observations was complemented by the semi-structured interviews applied to the teachers and the questionnaire to the learners. Each one of the research sub-questions was answered using data collected from more than one data collection method, thereby increasing complementarity of the data collected.

3.2.2.4 Development

Findings of one method was used to inform another method, for instance, lessons observations showed problems faced by learners as they were dissecting and the learners in their questionnaires and tests proved that the problems really existed.

Taking into consideration the above-mentioned assumptions, the researcher considered using a multiple method approach to triangulate both broad numeric trends from quantitative research and the detail of qualitative research bringing about convergence, multiplism, complementarity, expansion, development and integration of data, and to get a better insight and understanding, as well as an explanation of the results of the study. The researcher also acknowledges that multiple methods can offset the weaknesses inherent within one method with the strengths of the other method, as mentioned by Morgan (1998).

3.3 STUDY SAMPLE AND SAMPLING PROCEDURE APPLIED IN THE STUDY

A sample is a part of a statistical population whose properties can be investigated as a means of obtaining information about the properties of the whole population or society (Porter & Hunter, 2008). A purposive stratified sampling method was used to select participating schools. "Purposive sampling, which is also known as criterion-based sampling, is a means that the enquirer selects individuals and sites for study because they can purposefully inform an understanding of the research problem and central phenomenon in the study" (Cresswell, 2007, p. 125). Merriam (1998, p. 48) adds that "purposive sampling is based on the assumption that one wants to discover, understand, gain insight, therefore one needs to select a sample from which one can learn the most". In this study it was a "deliberate selection of information-rich sources" (Lapan, 2004, p. 242) and a selection of units of analysis which were according to a specific quota (Trochim, 2006a), since these were schools representing diverse environments. Based on the above-mentioned arguments, this section discusses the criteria for selecting participants.

The study took place in Pretoria East where the researcher practises in one of the schools as this had a geographical and accessibility advantage to her. Four schools that were allocated pseudonyms A, B, C, and D in Pretoria East were selected. The criteria for the sample selection included the following:

- School A is a public school without any laboratory facilities and laboratory apparatus, in one of the Pretoria East townships.
- School B is a public school with laboratory facilities and laboratory apparatus, in one of the Pretoria East suburbs.
- School C is an independent school with adequate laboratory facilities and laboratory apparatus, in the Pretoria East suburbs.
- School D is an independent school with limited laboratory facilities and laboratory apparatus, in one of the Pretoria East townships.

Table 3.1: A summary of the criteria taken into consideration for selecting schools

Pseudonyms of Schools	School environment	Type of School	Lab facilities & apparatus	Number of teachers
A	Township	Public	Inadequate	2
B	Suburban	Public	Adequate	2
C	Suburban	Independent	Adequate	1
D	Township	Independent	Inadequate	1

- Participating schools were co-educational schools to ensure that both boys and girls are exposed to similar conditions and that the issue of gender does not cause any discrepancies in the results from the different schools.

- A sample of 224 Life Sciences learners and all six Life Sciences teachers from the four different secondary schools participated in the study.

In this study, the units of analysis included the teachers and learners at different learning environments and their engagement with dissections and problem-solving.

3.4 DATA COLLECTION STRATEGIES AND INSTRUMENTS APPLIED

The multiple-method research approach has been supported by educational psychology researchers since as far back as 1959 by Campbell and Fiske, and 1979 by Jick, as cited in Cresswell (2003). These authors argue that the multiple methods used in conjunction produce largely convergent and consistent results. Taking into consideration the arguments of these authors, this study used a multiple method research approach to ensure convergent and consistent results which greatly enriched the findings, discussions and recommendations given. This section will discuss both methods and the relevant instrumentation.

In order to address the research sub-questions of this study, several methods were used to collect both the qualitative and quantitative data. Table 3.2 shows a summary of research sub-questions, the data collection methods used to answer them and the sources of the data.

Table 3.2: Summary of the research sub-questions, data collection methods and the sources of the data

Research sub-questions	Data collection method	Data source
Question 1 What is the teachers' understanding and how well-acquainted are they with problem-solving strategies?	Semi-structured interviews using an interview schedule	Six Grade 11 Life Sciences teachers
Question 2 How do teachers use animal dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners?	Semi-structured interviews (Multiple in-depth semi-structured interviews based on dissections and problem-solving). Observations, worksheets and lesson plans	Six Grade 11 Life Sciences teachers
Question 3 How does learners' engagement with animal organ dissections aid in developing problem-solving skills?	Observations, pre-test and post-test	224 Learners
Question 4 What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?	Semi-structured interviews, questionnaires on dissections and problem-solving	Six Grade 11 Life Sciences teachers 224 Learners
Question 5 What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?	Observations of learners (to be video recorded) carrying out dissections using an observation checklist and questionnaires	224 Learners from four different secondary schools
Question 6 To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?	Document analysis, observations, pre-test and post-test (ill-structured problem-solving questions to learners before and after dissections) and semi-structured interviews	Curriculum statements 224 Learners

3.4.1 Qualitative approach followed during the course of the study

For qualitative data, the research followed a case study methodology. "A case study approach is a specific instance that is often designed to illustrate a more general principle or, alternatively, it is a study of an instance in action, one in which the case is studied in depth as it occurs in a real situation, studying real people" (Cohen, Manion and Morrison, 2000, p. 181). It is important to note that case studies may be done in multiple methods which support this research study. A case study can be a unit or group of people who are analysed and can also consist of another group(s) to reinforce the validity of the study. Nieuwenhuis (2010) argues that case studies offer a multi-perspective analysis in which the researcher considers not just the voice and perspective of one or two participants in a situation, but also the views of other relevant groups and the interaction between them. A key strength of the case study approach is the use of multiple sources and techniques in the data-gathering process. These include interviews, document analysis, and observations which were used in this case study.

A case study can be exploratory, descriptive, explanatory, interpretive or evaluative (Onwuegbuzie & Johnson, 2004). Case studies have quite a few strengths which tend to outweigh their weaknesses. The strengths include:

- Results speak for themselves, i.e. self-evident;
- Strong realities are presented;
- Results that are more readily understood by a wide audience;
- The fact that it can be undertaken by a single researcher instead of a team;
- They examine real issues in real contexts (Cohen et al., 2000, p. 184).

The nature of this case study is exploratory (Cohen et al., 2000, p. 79, 181; Edwards & Talbot, 1999, p. 53; Nieuwenhuis, 2007)

According to Cohen et al. (2000), case studies generally display several features which the researcher found very relevant to this research. These include:

- A clear description of events related to the case (behaviour of learners, hands-on work by learners, attitude of learners as they were working and discussing, teacher's role);
- Provision of chronological sequence of events (to avoid reader confusion);
- Focusing on individuals or groups of people (Life Sciences teachers, Life Sciences classes and learners);

- Involvement of researcher (observation, setting of pre-test and post-test, setting up of the dissections practical, interviewing the teachers);
- Attempting to portray the richness of the study in the write up (verbatim responses from some learners and teachers, quantitative and qualitative methods used, descriptions on how learners approached the dissections practical and exercise given afterwards);
- Examining issues in real contexts (research done in the Life Sciences laboratory or classroom, dissections activity done as per the curriculum requirements, activity done by the Life Sciences learners)

3.4.1.1 Data collection methods applied

Several methods were used to collect data during this study in order to provide in-depth vital information. The methods were used to triangulate data, for data convergence and to verify data. According to Mouton (2001, p. 108), "data come in different formats and have different properties: interview schedules, direct observations, audiotapes, videotapes, questionnaires were all not only data collecting methods but also techniques of triangulation".

The methods of data collection for the qualitative part of the study are discussed in this section. The qualitative part of the study took place in two phases.

Lessons observations during which animal organ dissections was carried out

The first phase which is observation is an essential data-gathering technique which allows the researcher to hear, see and begin to experience reality as participants in the research group do (Nieuwenhuis, 2010). It also helped to gain an insight into the learners' cognitive, affective and psychomotor behaviour in a natural or real class setting (Ary, Jacobs, & Razavieh, 2002). Cohen et al. (2000, p. 185) are of the opinion that case studies are typified by observations as the purpose of observations is "to probe deeply and to analyse intensively the multifarious phenomena that constitute the life cycle of the unit with a view to establishing generalizations about the wider population to which that unit belongs". Some of the advantages of classroom observation include:

- Allows researchers to study the process of education in naturalistic settings;
- Provides more detailed and precise evidence than other data sources;
- Stimulates change and verifies the change that occurred;

- Findings have provided a coherent, well-substantiated knowledge base about effective instruction;
- Video recorded observations avoid any recall biases on the part of the researcher;
- Observer records information as it is revealed;
- Observation schedules provide specific and easily identifiable behaviours that the observer can easily code (Cohen et al., 2000).

There are different observation types which can be: (a) Observer as a complete participant i.e. the observer conceals the observer role; (b) Observer as a participant and in this case the role of the researcher is known; (c) Participant as observer, the observer role is secondary to participant role; (d) Complete observer: researcher observes without participating.

Each observation type has its own advantages and limitations. For the purpose of this study, the type of observation was that of the observer as participant where the researcher did not directly influence the teaching process in the class situation but her role was known (Nieuwenhuis, 2007). The researcher observed the learners carrying out the dissections, having group discussions about the observed dissected organ and answering the ill-structured problem-solving questions. The results of the observations were then analysed quantitatively and qualitatively as shall be discussed in Chapters 4 and 5. The researcher used an observation checklist which was compiled in advance as the researcher already knew what she was looking for (Cohen et al., 2000) see Appendix I. The researcher created detailed outlines of what she intended to focus on during the observation. These outlines helped her to "systematically record particular information, behaviour patterns and analytically focus on particular events of interest during the observation period" (Hartas, 2010, p.62).

The lessons observations of the animal organ dissections and the discussions by learners were video-recorded and the video recording was used by the researcher to back up and capture information, behaviour patterns or any other events of interest which the researcher might have missed or had not captured on her observation checklist. The observation checklist and the video recording were then used to establish: the problems faced by learners as they dissected; the attitude of learners towards animal organ dissections and answering of the problem-solving questions; the skills development of the learners, and their understanding through the group discussions; and the role the teacher played during the lesson. The benefit of video recording was that the researcher was able to view it more than once focusing on the information which helped her to answer some of the research questions. The fact that the lessons were video recorded also authenticated the lessons observations. The video analysis was carried out in conjunction with the observation checklist and the researcher made a lessons observations coding using information from both the checklist and the video recording as shall be discussed in Chapter 5.

The lessons observed were scheduled as part of the ordinary teaching time in schools B and C since they had scheduled double periods to accommodate the dissections practical and the writing of the problem-solving test but in the other two schools A and D, they had to be scheduled in the afternoon since the school timetables did not have double periods. The video camera was stationed at an angle in the laboratories or classrooms where it was as unobtrusive as possible and least distractive.

In observing the teachers and their learners carrying out dissections, the researcher's intention was to be able to answer some of the research questions which focused on: (a) How teachers used animal organ dissections as a teaching strategy in problem-solving; (b) Problems learners experienced as they were carrying out animal organ dissections; (c) The extent to which the three Learning Outcomes in Grade 11 Life Sciences were being achieved using animal organ dissections and; (d) How learners engaged with dissections and used it in developing problem-solving strategies.

Observing the lessons before interviewing the teachers was very helpful because the teachers carried out their lessons as they would normally do without being conscious of what the researcher was looking for, which made the results of the observation more valid. According to Patton (2002, p. 264), "Interviews present the understandings of the people being interviewed … interviewees are always reporting perceptions – selective perceptions … By making their being perceptions part of the data – a matter of training, discipline, and self-awareness - observers can arrive at a more comprehensive view of the setting being studied …"

Interviews with the Life Sciences teachers

The researcher acknowledges that the classroom observation gave an insight on: the behaviour of learners; problems experienced by learners during the animal organ dissections;

group discussions carried out by learners; answering of problem-solving questions; and role of the teachers during the animal organ dissections. However, this study required more than just the observed behaviour, hence the need to interview the teachers. According to Patton (2002, p. 341), “We cannot observe feelings, thoughts, and intention … nor how people have organised the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things”. During the second phase of the qualitative part of this study, the researcher conducted interviews with the six Life Sciences teachers, whose lessons she had observed between April and May 2012. Interviews involved collection of data from direct verbal interaction between the researcher and the respondents (Cohen & Manion, 1997).

Advantages of interviews

Interviews have quite a few advantages when compared with other instruments. When well conducted, they provide in-depth data because they allow both the respondents and the researcher to ask for clarification, thereby increasing the chance of obtaining valid information from the respondents (Cohen & Manion, 1997). Fraenkel and Wallen (1990) argue that interviews are the most effective means of eliciting cooperation from respondents, as rapport can be established between the researcher and the interviewee. If there is rapport between the interviewer and the interviewee it may be possible to get sensitive information that would not be easy to get otherwise (Gall, Borg, & Gall, 1996).

There are different types of interviews: structured, semi-structured and unstructured interviews. According to Opie (2004), structured interviews involve a series of fixed questions that do not allow the researcher to follow up on a question and obtain information of greater depth. Semi-structured interviews involve a pre-existing set of questions, but allow the interviewer the flexibility to deviate from the interview schedule and probe further if the need arises (Gall et al., 1996). In unstructured interviews there are few prepared questions, usually with no set order, and the interviewer will phrase questions during the interview according to the responses of the interviewee. The problem of unstructured interviews is that they make it difficult for the researcher to focus the respondent on the issue, and as a result a lot of unusable data may be collected. The unstructured interview data is also hard to analyse and draw several conclusions from. (Gall et al., 1996).

After an intense literature review on the types of interview, the researcher decided to use the semi-structured interviews in this study because they allowed for carefully prepared questions which ensured that all the areas of interest were covered, and nothing was left out. Furthermore, they allowed the researcher (the interviewer) to deviate and probe further and in this way more detailed information was obtained as the teachers (interviewees) could express themselves, thereby expanding their responses. The researcher wanted to see the worldview through the eyes of the teachers she was interviewing. The use of the semi-structured interview allowed her to focus on collecting usable data by following the semi-structured interview schedule but at the same time allowing the interviewees to express themselves without diverting too much from the area of focus which was animal organ dissections and problem-solving.

Developing the interview schedules

Interview schedules are well structured lists of questions that will be asked during an interview, to ensure that the interview goes well (Opie, 2004). The interview schedule was constructed by the researcher after an extensive literature review on how to develop and conduct interviews. The interview schedule was developed using guidelines from the literature (see Table 3.3) on criteria considered for the development and conducting of interviews.

Table 3.3: A summary of the criteria considered for the development and conducting of interviews

Suggestion	Reasons	Author(s)
Developing the interview schedule		
Consider what information is required to answer the research questions.	To avoid asking interview questions which do not contribute to the research, collecting unusable data.	Coleman and Briggs (2003)
Decide on the structure of the interviews, i.e. (structured, semi-structured or unstructured).	The interview format must be carefully considered to match what one wants to achieve.	Opie (2004)
Translate research questions into specific questions and more probing questions to be asked in the interview.	Questions should cover all the information one wants to get.	Coleman and Briggs (2003); Opie (2004)
Determine the order in which questions will be asked.	It would be easier to conduct interviews if you have a schedule so that questions can flow naturally, in a logical sequence.	Opie (2004)
Word questions so that they encourage respondents to give more detail with "greater richness and spontaneity" (what they think and do).	To avoid questions that will give non-committal answers like Yes or No, with little or no detail.	Coleman and Briggs (2003); Opie (2004)
Language is important and researchers must avoid using terminology the interviewee is not familiar with (e.g. professional jargon should be avoided).	To ensure that questions are clearly understood by the interviewees.	Coleman and Briggs (2003)
Do not ask leading questions that are suggestive and direct interviewee's response.	Interviewees may give you the responses they think you would like to hear, thus decreasing validity of the responses.	Posner and Gertzog (1982); Opie (2004)
Do not use ambiguous questions	They may cause confusion, and the respondent will find it difficult to answer or the answer will not be what the question intended to seek.	Gall et al. (1996); Opie (2004)
Carry out a pilot study interview using the schedule.	To detect ambiguous and confusing questions, so that they can be rephrased.	Opie (2004)
Conducting the interviews		
Be appropriately dressed.	Appearance is important, so you do not offend or intimidate the interviewee.	Coleman and Briggs (2003)
Establish rapport by greeting respondents and engaging in small talk to put the respondent at ease and drop their guard. Find a balance between friendliness and objectivity.	Makes respondents comfortable and encourages honest answers later in the interview.	Coleman and Briggs (2003)
Inform the respondent of the purpose of the interview at the start.	So that respondents are aware of the kind of information they have to give and how that information will be used.	Schumacher and McMillan (1993); Opie 2004)
Assure respondents of confidentiality before starting the interview and that data will be used solely for educational research.	To gain their trust and encourage them to give truthful answers.	Gall et al. (1996)
Use clear, simple language meaningful to respondents.	Asking complex questions may lead to questions not being answered, or misunderstood.	Coleman and Briggs (2003)
Aim to talk less and allow the respondent to talk more. Careful not to allow interviewee to deviate much from your focus.	To get rich, detailed answers.	Posner and Gertzog (1982)

A good interviewer must provide concentrated attention, be a good listener.	Listening attentively promotes further information from the interviewee.	Posner and Gertzog (1982)
Do not interrupt the respondent's response.	You may cut off important information.	Thompson (1978)
Do not appear to be cross-examining or judgemental to the respondents. If they feel threatened by some questions skip these and move on to others.	You need to be sensitive and sympathetic to respondents' standpoints. Your attitude may stop them answering (if they feel threatened).	Coleman and Briggs (2003)
Know when to probe, and when you do probe you must probe to elicit responses.	Probes must never favour a particular answer. They must be neutral.	Fraenkel and Wallen (1990)
Stick to the wording of the planned questions where possible.	Changing the question wording may change a question you spent a lot of time designing to achieve your research goals.	Schumacher and McMillan (1993); Babbie (2005)
Check if your audio-recording equipment is recording clearly before commencing the interview.	This ensures that all the information is captured accurately and to avoid recall bias if every data is not recorded.	Fraenkel and Wallen (1990)
At the end of the interview ask if there is anything the respondent would like to ask, and thank them.		Coleman and Briggs (2003)

Content – validation of the interview schedule used to interview the teachers

Designing the interview schedule was followed by content-validation. This validation involved asking a science education expert, asking supervisors, and carrying out a pilot interview to see if the questions were appropriate for answering the research questions, if they were worded clearly using language respondents would understand, to check that they were sequenced in a logical way and to check whether the developed schedule would measure what it was intended to measure. The validity of the interview schedule was modified and improved taking into consideration the opinions suggested by the individuals consulted. The researcher was of the opinion that the more valid the interview schedule was the higher the chances of gathering the required information. The interview schedule was divided into Section A which sought to establish the biographical data of the teachers, and Section B which consisted of 25 questions seeking to establish the teachers' opinions regarding animal organ dissections, problem-solving, problems faced by their learners when dissecting, the attitudes of the teachers and the learners towards animal organ dissections and problem-solving (see Appendix III). The questions guided the interview and collectively provided information to answer research questions one, two, three, four, five and six, which are outlined in Section 1.4 of Chapter 1. Table 3.4 shows the interview items and the research sub-questions they helped to answer:

Table 3.4: A summary of the interview questions and the relevant research sub-questions answered

Semi-structured questions	
Question	**Research sub-questions**
1. Please tell me what the dissections in Life Sciences curriculum in Grade 11 are?	2, 6
2. How many other opportunities are there for dissections in the current Life Sciences curriculum?	2, 6
3. How easy/difficult are the dissections of different organs on the part of your learners?	2, 4, 5
4. At which point of the topic do you carry out dissections with your learners?	2, 6
5. How do you ensure that the intended Learning Outcomes are fulfilled?	2, 6
6. To what extent does dissections fulfil all the 3 NCS Learning Outcomes for the Grade 11 curriculum?	1, 6
7. What is the source of organs you use for dissections?	2
8. Any reservation on dissections in terms of time consumption/constraints?	2, 4
9. What are advantages of hands-on group work during dissections?	4
10. What problems do learners experience in doing animal organ dissections?	5
11. How do you handle situations where some learners, for some reason, are not willing to participate in actual dissections e.g. religious, cultural, moral, and ethical or being vegetarian?	4, 5
12. Please recall and describe your reactions/feelings when you first carried out dissections.	4
13. Please describe your feelings whenever you have to carry out dissections with your learners.	4
14. What are the financial implications of dissections – actual versus virtual?	2
15. How do you manage discipline during dissections?	4
16. What is your preference in dissections: a demonstration or that they do it themselves, in groups or one by one?	4
17. Are there instances where you as a teacher do not want to dissect; do you just let them do it without your involvement?	4
18. If the school does not have the necessary infrastructure for dissections, how do the dissections take place in the school?	2
19. How significant is the use of virtual/online dissections?	1, 2
20 What is your understanding of problem-solving strategies?	1
21.In which topics in Life Sciences do you develop this skill in learners?	1, 2
22. Is the dissections of organs important or significant in problem solving?	2, 3
23. Do you think animal organ dissections have any contribution to the development of problem-solving skills of Grade 11 Life Sciences learners? Please explain your view.	1, 2, 4
24. What are the learners' attitudes towards the use of animal organ dissections on problem-solving?	4
25. How do you use animal dissections to improve the problem-solving skills of Grade 11 learners?	2, 5

Conducting the interviews

The semi-structured interviews, using an approved interview schedule with each one of the Grade 11 Life Sciences teachers in each participating school, was carried out after the learners carried out the dissections. The aim of qualitative face-to-face interviews was to see the world through the eyes of the participant in order to obtain rich descriptive data that would help to understand the participant's construction of knowledge and social reality (Nieuwenhuis, 2010). The interview also revealed the fine reactions, facial expressions, gestures and feelings that could never have been represented on paper and the researcher took note of the above-mentioned body language during the interview.

Six teachers that teach Grade 11 Life Sciences at the selected schools were interviewed. The aim of the interview was to determine: what the teachers thought was meant by the concept *problem-solving* skill and how they used dissections, if at all, to develop this skill; to explore their opinion on dissections and problem-solving and to determine their attitudes towards the practical. Interviews with teachers were used to supplement data collected from the lessons observations, questionnaires, pre-tests and post-tests so as to get more in-depth information. Once the interview schedule had been approved, the researcher's role was to:

- Suggest and schedule dates for interviews with each of the six teachers at their earliest possible convenient dates;
- Each was allowed to choose a convenient venue as long it was quiet enough for audio-recording purposes;
- A day before the interview date, the researcher called the teacher to confirm the appointment;
- The researcher met with the teacher at the agreed venue;
- Before the commencement of the interview, the researcher checked the recording equipment and set it ready to record with the permission from the interviewee;
- The researcher gave a brief explanation of the purpose of the study and assured the interviewee of confidentiality;
- The interviews were audio-recorded for the following reasons:
    - (a) To make sure that all the information was accurately captured;
    - (b) To avoid recall bias on the part of the researcher;
    - (c) So that the flow of the interview was not interrupted by the researcher taking notes or asking the respondent to repeat some statements, a problem which Fraenkel and Wallen (1990) warn about;
    - (d) Literature also advises that audio-recording reduces the interviewers' bias or tendency to make an unconscious selection of data that support their study, if they are taking notes.
- During the interview the researcher controlled the focus of the interview by asking questions from the interview schedule and follow-up questions when there was need for further probing;

- Finally, the audio-taped interviews were transcribed verbatim and coded afterwards by the researcher. A summarised report was then compiled based on the responses of the interviewees.

Transcribing the recordings allows a second person to check the accuracy of the transcription, thus increasing validity (Gall et al., 1996).

Problem-based lessons

Taking into consideration work done by Major et al. (2000) and Dewey (1938) on Problem-Based Learning, an intense literature review on how to design problem-based lesson plans and in consultation with the Life Sciences teachers of the selected schools, the researcher developed problem-based lesson plans for the urinary system topic and the dissection lesson plan (see Appendix V), which teachers used to teach the topic during their normal teaching lessons.

The problem-based lesson plans consisted of eleven forty-five minute lessons covering three main objectives:

- Describe the structure of the urinary system
- Analyse the function of the urinary system
- Analyse characteristics and treatment of common urinary disorders

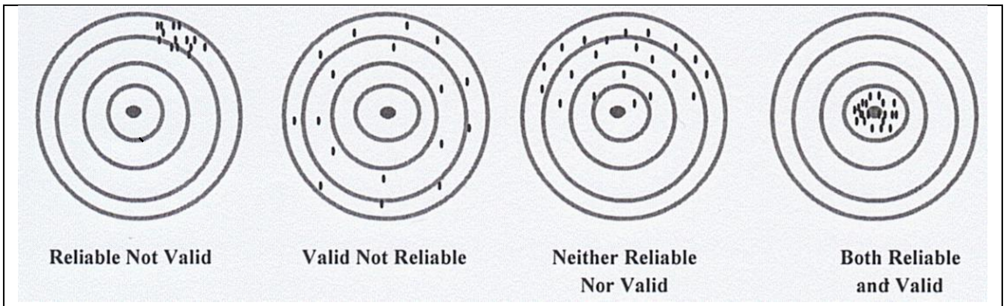
The twelfth lesson was the actual hands-on dissection which was done after writing a pre-test. After the dissections, the learners then wrote the post-test.

Importance of using problem-based lessons

The reason for encouraging the teachers to use the problem-based lessons was to ensure that the learners had been sufficiently prepared to carry out the animal organ dissections, bearing in mind the challenges they faced during the theoretical lessons. The learners would then use the dissections to answer some of those challenges. As a result of the challenges in the lessons, they would be driven to engage more with the practical and the group discussions before they wrote the post-test.

Measures taken into consideration to ensure trustworthiness of quantitative and qualitative approaches

It is important in any study to ensure that the research is valid and reliable. The analogous criterion in naturalistic inquiry to establish validity and reliability is trustworthiness (Lehman, 2003). Silverman (2004, p. 283) argues that: "Validity and reliability are two important concepts to keep in mind when doing research, because in them the objectivity and credibility of research are at stake". This study used both qualitative and quantitative approaches to produce valid and reliable knowledge. The relationship between validity and reliability as they contribute to trustworthiness is illustrated in Figure 3.2 according to Trochim (2001**)**:



Consistently and systematically measuring the wrong value for all respondents	On average getting the right answer for the group	Hits are spread across the target consistently missing the centre	Consistently hitting the centre of the target and measuring the concept perfectly

Figure 3.2: Relationship between validity and reliability which contributes to trustworthiness of a research. Adapted from: Trochim (2001, p. 1-2)

In this study, the validity and reliability of the resulting data was improved by the multiple method approach which strengthened the causal inferences by providing the opportunity to observe data convergence which results in perfect measurement of the concept as illustrated by Trochim (2001) in Figure 3.2. According to Nieuwenhuis (2010), trustworthiness is of the utmost importance in qualitative research. The qualitative data being collected from this study is in the form of observations and interviews. The observations and interviews were electronically recorded and transcribed (video-taped and audio-taped respectively). Participants had the opportunity to review these transcriptions at the end of the data collection period to ensure accuracy and to provide additional research data. This convergence of data enhances the validity and reliability of the knowledge produced. To enhance the trustworthiness of the qualitative approach, Nieuwenhuis (2010, p. 113-115) suggests that the following steps be taken into consideration: use of multiple data sources; verification of raw data; keeping of notes on research decisions taken; ensure trustworthiness in coding data; stakeholder checks; verification and validation of findings; control for bias, avoid generalisation; choosing of quotes carefully; maintaining confidentiality and anonymity and stating the limitations of your study upfront. To ensure the trustworthiness of this study, data from multiple sources was used to help the researcher verify the findings. For example, data collected through interviews was verified with information gathered from the observations, pre-test, post-test and questionnaires. In addition, the transcripts and field-notes were submitted to the participating teachers to correct factual errors.

Figure 3.3 indicates strategies which can be applied to ensure trustworthiness so as to enhance the worth of both qualitative and quantitative approaches:

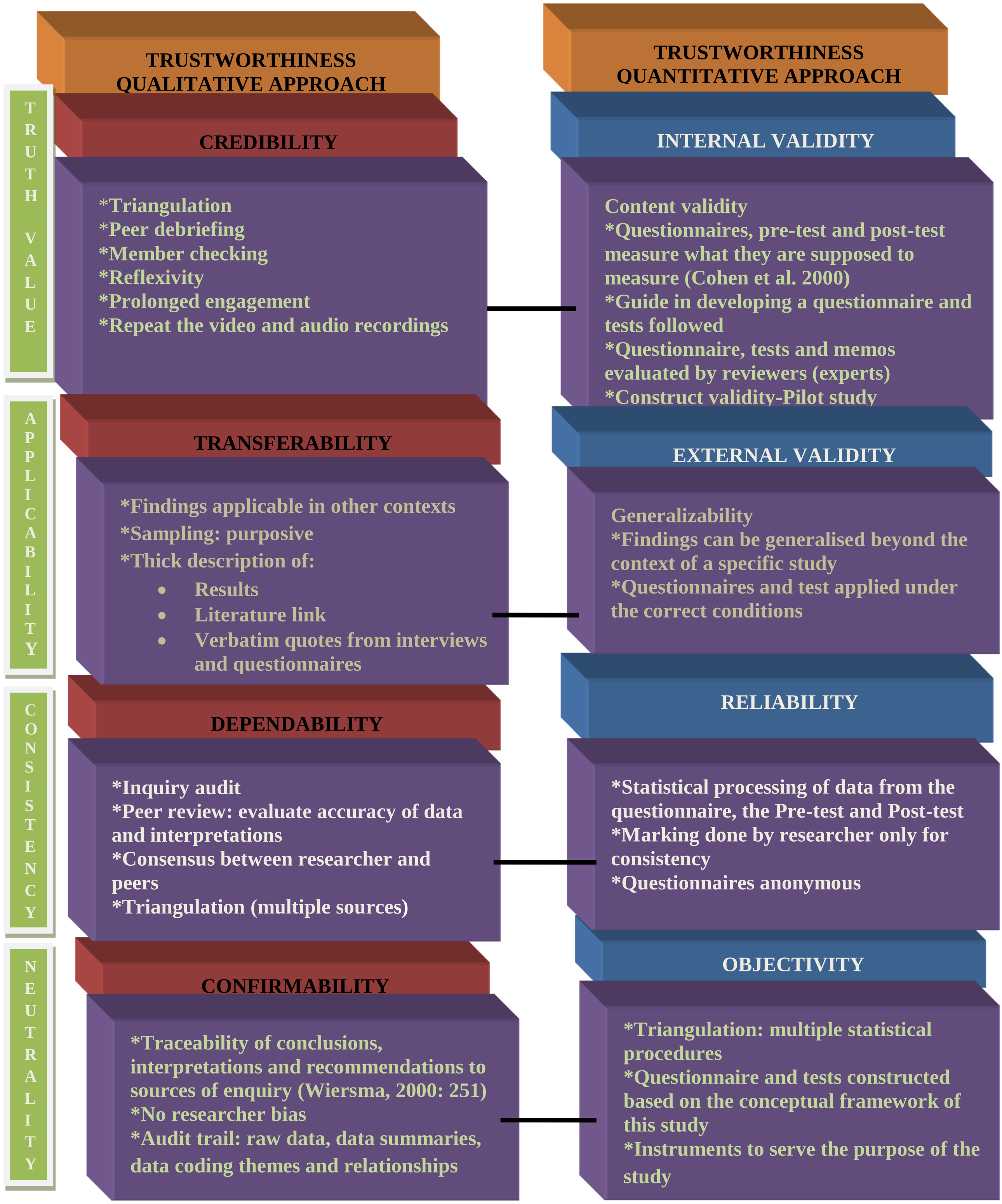


Figure 3.3: Strategies applied to ensure trustworthiness of quantitative and qualitative approaches. Adapted from: Lincoln and Guba trustworthiness model (in Morse & Field, 1996, p. 118)

Since this study is a multiple method approach, it adopted criteria based on the following: *truth value* which gives credibility to the qualitative approach and internal validity to the quantitative approach; *applicability* promotes transferability to the qualitative approach and external validity to the quantitative approach; *consistency* gives dependability to the qualitative approach and reliability to the quantitative approach; and *neutrality* which promotes confirmability to the qualitative approach and objectivity to the quantitative approach. The strategies applied by the researcher in terms of the criteria are depicted in Figure 3.3. To concur with the trustworthiness model on the qualitative aspects, during the observations the researcher made field notes and the dissections practicals were video-taped to further ensure credibility as she could refer back to them, repeat watching them and for cross referencing with data from the observation checklist and what the teachers had said in the interviews. Before the interview started, the researcher built a rapport with the interviewee to ensure that honest and open responses were given as this would enhance reliability in the interviews. The data from the interviews was triangulated with the practical observations. The same interview schedule, including the same questions and sequence, was used for all interviews. The questions were short and precise.

Crystallisation

Crystallisation refers to the practice of *validating* results by using multiple methods of data collection and analysis (Maree & Van der Westhuizen, 2009). Different perspectives that all reflect the unique reality and identity of participants are necessary to provide for a complex and deeper understanding of the phenomenon (Nieuwenhuis, 2010). Crystallisation offers a more appropriate lens for viewing components which can be achieved by applying different methods of data collection to increase the trustworthiness of the study. It also increases a more deepened, complex understanding of the topic (Janesick, 2003). Taking into consideration the arguments of different authors, the researcher used multiple methods of data collection for both qualitative and quantitative approaches to ensure crystallisation. These included interviews, lessons observations, pre-test, post-test and questionnaires. The data from the different instruments brought about multi-dimensionality which were then correlated and converged to give a deeper understanding and meaning of the study.

The researcher also invited comments from experts with divergent views, peer debriefing from *critical reader friends* to confirm or refute categories and themes which she had established from the data and to check her evolving interpretations of the study. The crystallisation and credibility of this study was then brought about by: 1) correlation and themes established by the researcher from the data collected from the many instruments, 2) the expert and peer criticism. Two of my fellow PhD students were my peer or *critical reader friends* who provided the peer criticism.

3.4.2 Quantitative approach followed during the course of the study

Since this study assumes a multiple method approach, it was deemed necessary to look at the qualitative and the quantitative approaches followed during the study. The purpose of this phase was to triangulate the data. The multiple-data collection instruments used appropriately assured triangulation and increased the validity and reliability of the study which shall be discussed later in the chapter

3.4.2.1 Data collection methods applied

Several methods were used to collect data during this study in order to provide in-depth vital information. The methods were used to triangulate data, for data convergence and to verify data. The data promoted multi-dimensionalism which would help to make sense of the data. The quantitative data was drawn from questionnaires, pre-tests and post-tests applied to learners.

The methods of data collection for the quantitative part of the study are discussed in this section. The quantitative part of the study took place in two phases: a questionnaire for learners was administered and a quasi-experimental pre-test-post-test design was applied.

The questionnaire for learners

A questionnaire is a research tool through which people are asked to respond to the same set of questions in a predetermined order. Questionnaires can either be in the form of a self-administered questionnaire, that is, the respondents complete the questionnaire in their own time, or in the form of a structured interview, where the researcher writes down the responses of the respondent during a telephone or face-to-face interview. Irrespective of which method is used, the formulation of the questions and the structure of the questionnaire are critical to the success of the survey. The type of questionnaire used in this study is the *self-administered* questionnaire. In this type of questionnaire the learners complete it in their own time but they were given specific time frames by their teachers to ensure all questionnaires were returned before they got lost.

Strengths of a self-administered questionnaire

When the researcher considered applying the questionnaire to learners as one of the data collection methods, she consulted literature to establish the strengths and the limitations of using a questionnaire. The strengths include the following:

- The researcher is able to contact large numbers of respondents quickly, easily and efficiently (identify target group and take the questionnaires to them);
- It is a relatively inexpensive way of getting information from large samples; it can be administered by one researcher on a single occasion thereby reducing travelling expenses (Neuman, 1994);
- Questionnaires are relatively quick and easy to design code and interpret. In addition, the respondent, not the researcher, uses own time to complete the questionnaire;
- A questionnaire is easy to *standardise*. For example, every respondent is asked the same question in the same way. The researcher, therefore, is sure that everyone in the sample answers exactly the same questions, which makes this a very *reliable* method of research;
- Questionnaires can be used to explore potentially embarrassing areas (such as sexual and criminal matters, attitudes) more easily than other methods. In the case of this study, the questionnaire was both *anonymous* and completed in privacy. This increased the chances of learners answering the questions honestly as they were not intimidated by the presence of the teacher or the researcher (Gall et al., 1996; Opie, 2004).

Limitations of questionnaires

Just like any other instruments, questionnaires also have some weaknesses which include:

- Poor returns when they are mailed, which can lead to biased data which should not be generalised (Oppenheim, 1966). Fortunately for this study the issue of poor returns was not experienced since the questionnaires were issued by the teachers who persuaded them to bring them back within a specified time frame. The teachers helped the researcher to collect all the questionnaires;

- Questionnaires do not allow further probing like face-to-face interviews; the researcher cannot explore any of the given answers in more detail. This denies researchers the type of data that gives research its richness and value (Gall et al., 1996; Opie, 2004);
- Since questionnaires are usually completed during the respondents' own time, the researcher will not be there to clarify questions or instructions not understood by the respondents. To minimise this, the researcher went through the questionnaire with the respondents explaining each instruction and some terms like 'morphology' which the pilot study students had indicated were unclear.

The researcher established that the strengths of the questionnaire outweighed the limitations and there were some measures she could take to minimise the limitations, which encouraged her to apply the questionnaire to learners.

Developing the questionnaires

Opie (2004) and Schumacher and McMillan (1993) argue that questionnaires are one of the most convenient methods of obtaining research information, but construction of a good questionnaire is not easy. Taking the above argument into consideration, a thorough literature review was conducted on the planning and designing of a good questionnaire and the common mistakes to avoid when writing the questionnaire questions. Table 3.5 shows the summary of the guidelines the researcher took into consideration when she was planning and designing the questionnaire for the learners:

Table 3.5: A summary of the criteria considered for the development of a questionnaire

Planning stage		
Guideline	**Reasons**	**Authors**
Make a list of specific objectives that one expects to achieve by the questionnaire. Take into consideration the research question you want answered by the questionnaire.	Gives one clear focus on what information one hopes to get. Helps one to decide on an appropriate form of questions to use.	Gall et al. (1996)
If possible locate an existing questionnaire, which you can use as a template. If one develops new questionnaires, they must justify the use.	Reliability and validity have already been established, which saves time. It is not easy to develop a good questionnaire and to ensure rigour, it needs energy and time.	Schumacher and McMillan (1993)
Design stage		
Both open-ended and closed-ended questions must be formulated.	The weaknesses of each form of question are complemented by the strengths of the other, and benefits of each are maximised.	Neuman (1994)
Start with simple items and include more complicated items near the end of the questionnaire.	Difficult questions may discourage the respondents and they may abandon the questionnaires as a result.	Oppenheim (1966); Opie (2004)
Include brief, clear, conspicuous instructions.	Guarantees that respondents are clear on what they must do and how the questionnaire should be completed.	Opie (2004)
Ensure suitable spacing between questions. Allow sufficient spacing for open-ended questions to be answered.	Enhances readability. Gives an indication of how much information one expects for open-ended questions.	Gall et al. (1996); Opie (2004)
Use simple language, avoiding the use of technical complicated terms.	Target the vocabulary level of the learners by using the language they will understand.	Neuman (1994);
Format and layout of questionnaire should be attractive and professional.	Gives a good impression and encourages learners to take the questionnaire seriously.	Schumacher and McMillan (1993); Opie (2004)
Common mistakes to avoid when writing questions		
Avoid ambiguous and vague questions. Avoid asking questions that are beyond respondents' capabilities	Ambiguity causes inconsistencies in terms of the meanings different learners assign to the questions, and thus affects the validity of their answers. They frustrate respondents and lead to poor quality responses.	Neuman (1994)
Avoid biased or leading questions, and make respondents feel that all responses are legitimate.	Leading questions influence respondents' tendency to give the responses they think researchers want.	Neuman (1994); Gall et al. (1996)
Avoid double-barrelled items. Make each question about one topic.	Respondents may agree with one and not the other, but they are forced to respond to two questions with one answer; could cause validity problems.	Neuman (1994); Gall et al. (1996)

Since the questionnaire was self-administered, the researcher designed a questionnaire consisting of three parts:

- *Section A* asked for biographical details including age, gender, religion, cultural groups.
- *Section B* with item numbers 5.1 to 5.24 consisted of statements requiring learners to tick the relevant box (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree) on a Likert scale, to indicate the extent of their agreement or disagreement with each statement. A Likert scale is a self-reporting instrument in which a respondent replies to a series of statements by indicating the extent of agreement (Gay and Airasian, 2000, p. 625). This section consisted of closed-ended statements regarding dissections and problem-solving, how the learners felt about it and problems they faced during dissections. The learners were instructed to indicate the extent of their agreement regarding the statements in the questionnaire.
- *Section C* consisted of item numbers 6 to 13. This was the open-ended part which allowed learners to freely express themselves, without providing them with options or predefined categories from which to choose. Their only guide was the space left for them to write in, to avoid unnecessary data (Hartas, 2010). Open-ended questions are useful when it is important to avoid influencing respondents by providing a list of possible answers to choose from, for example, reasons for a particular behaviour or an opinion. This section also "allowed them to share their views relatively unconstrained by the researcher's perspective" (Cresswell, 2005, p. 197).

The developed questionnaire was administered to all the Grade 11 Life Sciences learners in each participating school. This was meant to determine the attitude and feelings of learners towards dissections and the difficulties that learners experience when using dissections for problem-solving.

Management of the quasi-experimental design

A quasi-experimental pre-test-post-test design (Gall et al., 1996) was applied. According to Shadish and Luellen (2006), there are five types of quasi-experimental designs which are presented by Hartas (2010, p. 251):

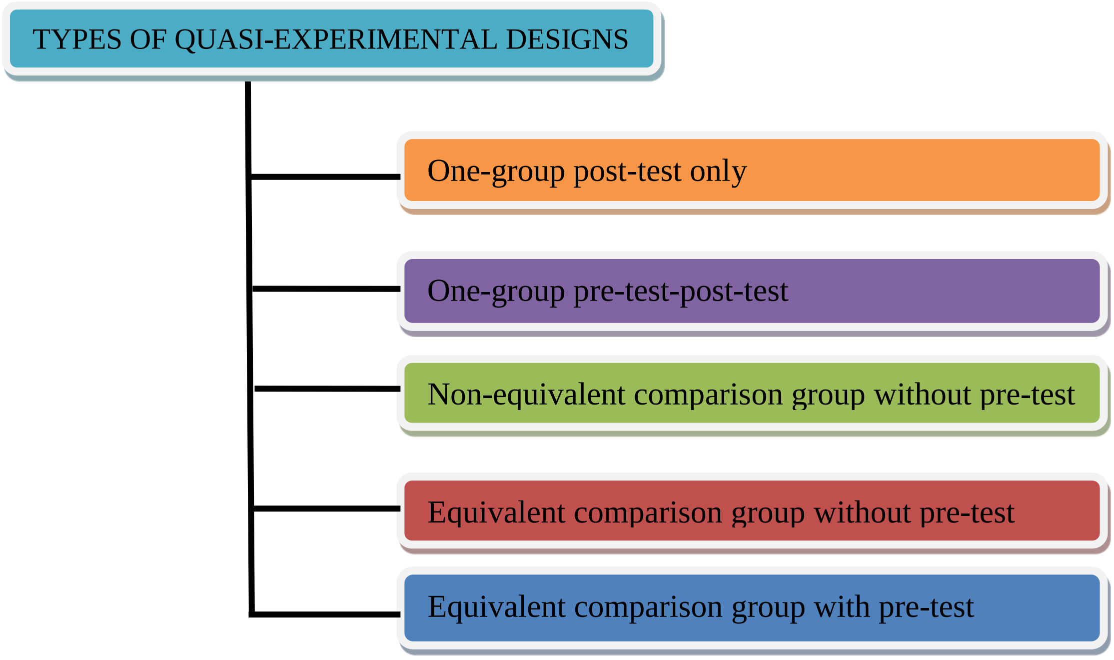


Figure 3.4: Types of quasi-experimental designs. Source: Hartas (2010), p. 251

Generally the quasi-experimental designs have an important advantage due to the fact that one will be comparing naturally occurring groups (e.g. intact classrooms, schools). The groups represent the real world classrooms better, thereby maximising the generalisability or external validity of the findings and good applicability. The main weakness of quasi-experimental designs is the possibility that a selection bias is high because persons are not randomly assigned to the experimental and the control groups, thereby compromising the internal validity of the group. To minimise this limitation, this study adopted the one-group pre-test-post-test quasi-experimental design (see Figure 3.4) where the whole group is pre-tested before intervention and then post-tested after the intervention to observe whether any changes would have occurred as shown in Figure 3.5:

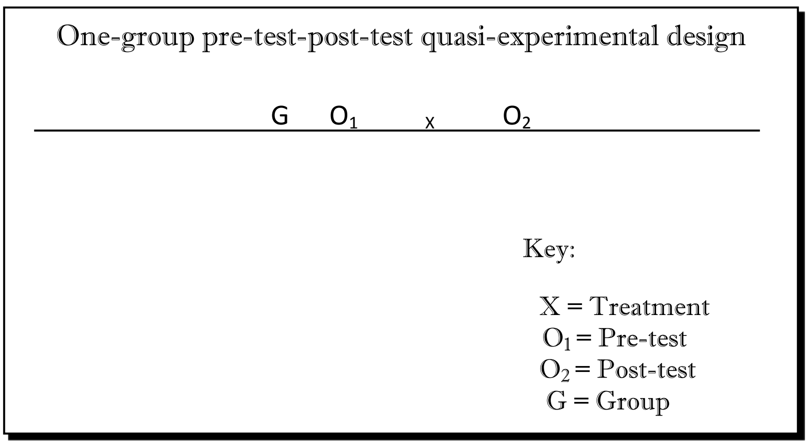


Figure 3.5: Symbolic representation of one-group pre-test-post-test quasi-experimental design

The pre-test-post-test was planned and designed by the researcher after a thorough policy document analysis on Life Sciences education according to the Department of Education National Curriculum Statement (NCS) and literature review on Life Sciences. The set test and memo was moderated by one of the most experienced Life Sciences subject specialists in the same district as the selected schools. Figure 3.6 depicts the summary of the process followed before, during and after the intervention.

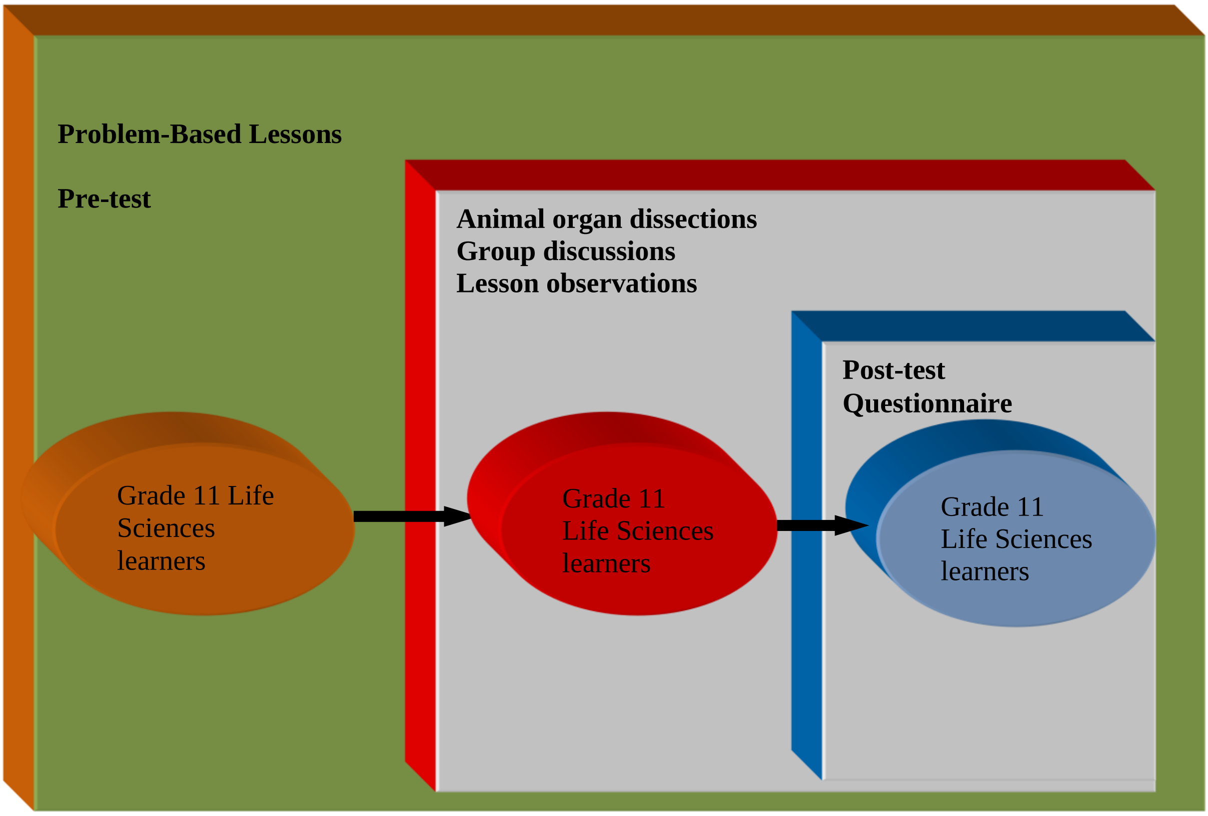


Figure 3.6: Summary of the process followed before, during and after the intervention

The structure of the test included both rote learning and predominantly problem-solving questions following Bloom's Taxonomy. Both types of questions were closely related to the dissections of the kidney which the learners carried out after writing the pre-test. The test had more emphasis on the third to the sixth levels of Bloom's Taxonomy which include Application, Analysis, Synthesis, Evaluation involving process-skills, Activities in problem-solving and Scientific enquiry. Duch, Groh and Allen (2001) argue that the problem-solving questions challenge learners to develop higher-order thinking skills, thereby developing problem-solving skills which were the aim of the animal organ dissections activities in conjunction with problem-solving tests. As a way of ensuring reliability over time, test-retest reliability was obtained by giving the identical test as both the pre-test and post-test (Salkind, 2010). The ill-structured problem-solving questions were written as a pre-test by all the Grade 11 Life Sciences learners. The intervention was for all the learners to carry out animal organ dissections under the guidance of their teacher with the researcher as the observer. The reason why all learners carried out the dissections was to avoid disadvantaging one group of students by using them as the control group which is ethically and professionally not permissible. After the intervention the same learners wrote the post-test. Popham (2003, p. 151) supports this by stating:

> "The virtue of the classic pre-test-post-test evaluative model is that, for the most part, it does measure the same group of students before intervention and after, meaning that a comparative analysis of the two sets of test data provides a clearer picture of the teachers' interventional impact on student mastery levels than do post-test data alone".

The pre-tests were collected before the learners started carrying out the dissections. After the dissections and group discussions were guided by the teacher just to make sure that they were discussing issues relevant to what they were observing, the same learners were given enough time (25 minutes) to write the same ill-structured problem-solving questions as a post-test. The aim was to find out if there were any significant changes in the performance of the learners in terms of their test scores after carrying out animal organ dissections. The post-tests were collected towards the end of the lesson. All the scripts were collected and marked by the researcher to ensure consistency of the data by avoiding marker discrepancies and subjectivities on the part of the teachers.

Validity of the instruments

Validity is an important aspect in all research to ensure that a particular instrument measures what it was supposed to measure (Cohen et al., 2000). The content validity of each instrument was determined by estimating the degree to which the items were a representative sample of the relevant content as determined by the specific objectives of the instrument. Please refer to the trustworthiness model in Figure 3.3. After an intense literature review, to ensure content validity a proper guide in developing a questionnaire and tests was followed. Initially the questionnaires, tests and memos were evaluated by the supervisors who ensured that the items for each instrument were consistent with the objectives and research questions set for them. Secondly, the instruments were given to reviewers/experts (experienced Life Sciences teachers) who matched the instrument items with the specific objectives. The extent, to which the reviewers agreed with the instrument developer on the assignment of items to the respective objectives, provided the content validity of the instrument (Dillashaw & Okey, 1980).

For the achievement instruments (pre-test and post-test), the reviewers were also asked to provide answers or responses to test items, so as to verify the accuracy and objectivity of the expected responses to the items. Comments from reviewers were used to revise and modify the instruments. Inappropriate items were discarded, replaced or re-worked accordingly. This method of validating instruments was used by a researcher (Kazeni, 2005) in her study for the development of the test of integrated science process skills, and other test developers, such as Dillashaw and Okey (1980), as well as Onwu and Mozube (1992). In order to establish the construct validity of the instruments, a pilot study was carried out which shall be discussed later in this chapter. The achievement tests were given to both Grade 10 learners who were likely to be less competent and Grade 11 learners from another school not participating in the study that were likely to be more competent in the content and skills under investigation (Brown, 2000). The results from the two groups of learners were compared and used to determine the construct validity of the respective instruments. To prove that the instruments measure what they purported to measure, Grade 11 learners performed better in the test than Grade 10 learners.

The researcher set the pre-test and post-test and the questionnaire in line with the research sub-questions which needed to be answered by the tests and the questionnaire thereby enhancing its content validity of the instruments. Research sub-questions four and five were to be answered by the questionnaire, even though some items in the questionnaire might seem not to give a direct answer to the research question. They were essential to give a broader understanding of the data in terms of learners' experience with dissections which could have an influence on their attitudes and even problems that they experienced during the dissections the researcher observed. Some items helped to answer both research sub-questions as shall be described in Chapter 4. Tables 3.6 and 3.7 show the questionnaire and test items respectively that helped answer the relevant research sub-questions:

Table 3.6: Questionnaire items that helped answer the relevant research sub-questions

Questionnaire items that answered research sub-question four: *What are the learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*	**Questionnaire items that answered research sub-question five:** *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?*
4) What cultural group do you belong to?	5.1) I understand what dissections is
5.4) Dissections is useful in the learning of animal organ structure and function	5.2) I have been exposed to animal organ dissections through demonstrations
5.5) Dissections helps me to understand structure and function of the animal organ	5.3) I have carried out animal organ dissections in previous Grades
5.6) Animal organ dissections helps me to improve my investigative skills	5.12) I find it difficult to manipulate (handle) dissections instruments
5.7) Animal organ dissections helps me develop skills which I can use to solve real life problems	5.13) Animal organ dissections is the only way to help me develop manipulative (handling skills)
5.8) I feel comfortable with the idea of doing animal organ dissections myself	5.18) It is compulsory for me to carry out animal organ dissections
5.9) I would rather use alternatives like artificial organs to carry out dissections	5.19) I prefer to dissect an animal organ rather than the whole body
5.10) I would rather observe others doing animal organ dissections than doing dissections myself	5.20) Dissections is necessary because textbook information is generally limited
5.11) I find it emotionally difficult to dissect a fresh animal organ	5.21) The idea of dissecting animal organs increases my respect for animals
5.14) My religion restricts me from dissecting real tissue animal organs	5.22) I can learn more about my own body by dissecting mammalian organs
5.15) My culture restricts me from dissecting real tissue animal organs	5.23) The use of additional information resources helps me understand more of the animal organ morphology
5.16) I find animal organ dissections disgusting	5.24) To test my knowledge, I prefer to be given a test after animal organ dissections rather than just drawing and labelling
5.17) I will do animal organ dissections because I am interested in finding out first-hand about the anatomy of the organ I am studying	6) Tick the animal organs that you have dissected in school during Grade 1 to Grade 10
7) Are you morally for or against organ dissections?	8) What other experiences have you had with animal organ dissections?
10) Do dissections help you in developing as a Life Scientist?	9) What problems do you as a learner face when carrying out animal organ dissections?
11) Describe and explain your feelings when carrying out animal organ dissections.	12) How did animal organ dissections help you clarify any confusion?
	13) How did the problem-based learning approach help you to clarify confusion or misconceptions relating to organ morphology?

Table 3.7: Summary of pre-test and post-test questions with relevant research sub-questions and Learning Outcomes

Pre-test and post-test question	Research sub-question	Learning category	Acquired skills	Learning Outcomes
1.1 Label the parts 1-17 as observed on the kidney organ you dissected. Use the provided blank flags on a toothpick. Write the names of the observed parts of the kidney you have dissected and stick the toothpick onto the correct part.	**Question 3:** How does learners' engagement with dissections aid in developing problem-solving skills?	Rote learning	Hands-on activities, learners generate knowledge discovery, acquire practical skills, observation, identifying parts of organs, and critical thinking	LO 1
1.2. Relate the structure to the function of each of the parts you observed on the kidney organ you dissected	**Question 3**	Rote learning	Observations, analysis and cognitive, recall, explaining and application	LO 2
1.3. Why is there difference in colour between the cortex and medulla?	**Question 6:** To what extent are Learning Outcomes 1, 2 and 3 of the NCS being achieved by animal organ dissections in Grade 11?	Rote learning	Observation and analysis	LO 1
1.4. How many pyramids can you identify in one half of the kidney?	**Question 3** (1st part)	Rote learning	Observation and analysis	LO 1
1.5. Using the hand lens identify and name the tiny dots in the cortex region.	**Question 3 and 6**	Problem-solving	Science process skills, laboratory skills, observation and analysis	LO 1 & LO 3
1.6 (a) What is the purpose of the renal artery and (b) what results if there is blockage in this vessel?	**Question 3 and 6**	Problem-solving	Creative thinking, problem-solving ability and investigative skills	LO 2 & LO 3
1.7 According to your observation of the dissected kidney, what differences did you notice between the human and that animal's kidney?	**Question 6**	Rote learning	Observation and analysis of the organ	LO 1
1.8. On the dissected organ, identify the ureter. What results if there is blockage in this vessel?	**Question 3 and 6**	Problem-solving	Critical thinking, creative thinking, problem-solving ability and investigative skills	LO 1 & LO 3
1.9. Pretend you are a metabolic waste molecule. Use the provided kidney and red colored and numbered flags already glued on toothpicks. Illustrate on the dissected kidney the route through the excretory system within the kidney until urine is formed and sent to the bladder. Make sure you include all the important parts of the kidney that you will come into contact with as you make your journey. Then write a paragraph describing this journey which includes the nephron.	**Question 3 and 6**	Problem-solving	Problem-solving skills, inquiry-based skills, and communication skills	LO 2

2.1. Label parts A – D and relate the structure to its function.	**Question 6**	Problem-solving	Identifying parts of organs, and critical thinking	LO 2
2.2. People with severe renal failure can be treated by **dialysis**, using a kidney machine, to purify the blood. a) What are the signs of a failing kidney b) Which part of the kidney causes this problem?	**Question 3** **Question 6**	Problem-solving	Critical thinking, problem-solving skills, inquiry-based skills, recall	LO 3
2.3. When a person takes a drug, the drug will eventually be eliminated from the body. One of the primary mechanisms for this removal is tubular secretion. What problems would produce the greatest reduction in the ability of our kidneys to remove drugs?	**Question 3**	Problem-solving	Science process skills, inquiry-based skills, critical thinking and problem-solving skills.	LO 3
3. Urinalysis: 1) Interpretation of the meaning of each urine test strip 2) The renal problem linked to the result and 3) How it could be treated.	**Question 3 and 6**	Problem-solving	Science process skills, inquiry-based skills, critical thinking and problem-solving skills	LO 3
4. Match the following words in column A with those terms in column B.	**Question 3 and 6**	Problem-solving	Investigation and problem-solving skills. Inquiry-based skills and communication skills	LO 2
4.1 Of the diseases above choose one that directly affects one of the parts you have observed on your dissected kidney and answer the following: - Background information on the disease and treatment. - Economic impact. - Social impact. - Lifestyle change needed to improve overall health.	**Question 3 and 6**	Problem-solving	Relate knowledge acquired to technology, culture and society. Scientific thinking, problem-solving skills	LO 3
4.2 Discuss multiple possible lifestyle modifications that could be achieved to improve the overall health of the individual suffering from a kidney disease, and helping disease prevention.	**Question 6**	Problem-solving	Relate knowledge acquired to technology, culture and society and scientific thinking	LO 3

Reliability of data

“Reliability refers to the consistency of an instrument in measuring what it purports to measure” (Krathwohl, 1998, p. 435) and according to Altheide and Johnson, (1998, p. 287), it is “the stability of methods and findings” in research. This includes providing a similar score for a similar amount of evidence. A study may be declared reliable if findings from a particular group are replicated when a similar group in a similar context is investigated. Reliability then refers to the “precision and accuracy, consistency and re-applicability over time, over instruments and over groups of respondents” (Cohen et al., 2000, p. 117).

The same questionnaire, pre-test and post-test was applied to all the learners. Since accuracy is one of the important aspects of reliability, the questionnaire was given to experts who have been involved in the development of questionnaires, for evaluation on relevance of the questionnaire items. These experts judged the adequacy of the content as well as language suitability for the intended learners and to identify any ambiguity to avoid multiple interpretations of the same question. Cronbach’s Alpha reliability test was done with the assistance of the Department of Statistics at the University of Pretoria and the questionnaire, pre-test and post-test reliability coefficients were ranging from 0.6 to 0.8 which show that they were reliable as shall be discussed in chapter 4. Cronbach’s Alpha reliability coefficient normally ranges between 0 and 1. However, different authors consider different ranges of reliability coefficients as reliable based on arguments which include the number of items in the test. According to George and Mallery (2003), the closer Cronbach’s Alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale. Based upon the formula: $rk /[1 + (k -1)r]$ where k is the number of items considered and r is the mean of the inter-item correlations the size of alpha is determined by both the number of items in the scale and the mean inter-item correlations. George and Mallery (2003, p. 231) also provide the following rule of thumb: “_ >0.9 – Excellent, _ >0.8 – Good, _ >0.7 – Acceptable, _ >0.6 – Questionable, _ >0.5 – Poor and _ <0.5 – Unacceptable”. According to Tavakol, Mohagheghi and Dennick (2011), the number of test items, item interrelatedness and dimensionality affect the value of alpha. This means that a low value of alpha could be due to a low number of questions, poor interrelatedness between items or heterogeneous constructs. They also acknowledge that there are different reports about the acceptable values of alpha, ranging from 0.70 to 0.95 depending on the factors mentioned earlier which can affect reliability of a test item. The questionnaires were reviewed based on comments from these experts. Other aspects that the researcher took into consideration to increase the reliability of the instruments used in this study include:

- the use of simple and clear technical terms;
- standardising the administration procedure as much as possible;
- scoring procedures standardised using test scores and codes for the questionnaire;
- each item of the instruments focused on the same outcome to avoid ambiguity;
- appropriate level of difficulty.

The marking of the pre-test and post-test was done only by the researcher only for consistency. To ensure that respondents gave honest answers, the questionnaires were anonymous with just a code number. The pre-test and post-test also had code numbers assigned to each learner and recorded on the class list.

Objectivity-Neutrality

Objectivity refers to "data collection and analysis procedures from which only one meaning or interpretation can be made" (McMillan & Schumacher, 2001, p. 596). An objective measure is "any measure that requires little or no judgement on the part of the person making the measurement. Objective measures are more resistant to experimenter biases than subjective measures" (Graziano & Raulin, 2004, p. 421). The researcher took into consideration *pitfalls* to avoid that could have led to bias and error according to Mouton (2002, p. 13). These include: avoiding untested/unpiloted questionnaires, leading or biased questions in questionnaires, biased instruments and biased sampling that would influence the objectivity of the research. This means that the data was collected and analysed free from bias on the part of the researcher. Statistical processing of data from the questionnaires, pre-test and post-test was essential for objectivity (refer to trustworthiness model in Figure 3.3). Triangulation of quantitative approach was ensured by convergence, multiplism and multi-dimensionalism of the statistical data from the questionnaire, the pre-test and the post-test.

3.5 THE PILOT STUDY APPLIED TO VALIDATE THE INSTRUMENTS

Before the data collection, the reliability of the questionnaires and the problem-solving pre-test and post-test was determined during the pilot study. A pilot study is a process whereby the research design for the prospective study is tested to gain information which could improve the major study (De Vos et al., 2002; Wiersma & Jurs, 2005). The purpose of the pilot study was:

- To ensure clarity of the questions;
- To test the feasibility of the test instruments, and to identify possible logistic problems before conducting the main study;
- To determine the effective duration for the administration of the instruments;
- To improve the quality and sensitivity of the instruments by collecting data for item analysis, so as to determine their test characteristics, followed by revision of items, where there was need.

Twenty learners from Grade 10 and Grade 11 classes from a school that was not one of the participating schools took part in the pilot study. A consent letter was written and signed by the researcher and the principal of the respective school asking for permission from the learners and their parents to take part in this study.

On the questionnaire the respondents were asked to time themselves as they were filling in the questionnaire so that the researcher could be certain that it was feasible to complete it between 30 and 45 minutes. They were also asked to comment in writing on the items on the questionnaire which they thought were not clear, ambiguous or irrelevant. The respondents pointed out some items which were a repetition and that was rectified; they also pointed out some concepts/terms which they said they were not familiar with, like “morphology, real-life problems”. The researcher took note to explain such terms to the actual respondents as she was going through the questionnaire with them before they took it home. They even pointed out a grammatical error which was rectified as well. The questionnaire was also handed to two fellow PhD students for peer evaluation and constructive criticism.

The same 20 learners wrote the pre-test-post-test so as to check if the test was of the right standard. The researcher determined the average time it took the learners to write the test to be between 25-30 minutes, which is what she considered as she planned the lesson. The learners also pointed out some items of the test which were not clear, the researcher rephrased them and the issue of the term morphology also came up. As expected, the performance of the Grade 10 learners was considerably lower than that of Grade 11 learners which validated the content of the tests. The questionnaire and the pre- test-post-test were handed to the

Department of Statistics at the University of Pretoria, where advice was given on the proper layout of both instruments so as to be compatible with the statistical programmes that were used to analyse data.

A pilot study interview was carried out with the Life Sciences teacher of the learners who participated in the pilot study and with her informed consent the interview was audio-recorded. The teacher was asked to point out if there were any questions on the interview schedule which were not clear, ambiguous or a repetition. The researcher also took note of the time it took interviewing, which was 28 minutes. This meant that the interview schedule was not too long as the expected interview time was approximately 30 minutes. Some interview questions which would lead to the same answers were considered as repetition and were removed from the interview schedule or were rephrased. The teacher as a Life Sciences expert was asked to evaluate the pre-test and post-test and the memo to determine if it was the right standard. She made a few suggestions on the memo on how some learners would explain certain concepts and they were taken into consideration.

As a result of the above-mentioned procedures the well-revised and modified interview schedules, questionnaire, pre-test and post-test were printed as final drafts (Appendix III, VII-IX). The final drafts were used for data collection.

3.6 VARIABLES THAT WERE USED IN THE STUDY

It was deemed necessary to establish the variables used in the study so as to guide the researcher throughout the study. A variable may be defined as “Any entity that can take on different values” (Trochim, 2006b, p. 1). There are two types of variables:

- An independent variable is what the researcher manipulates which can be a treatment or an intervention.
- A dependent variable is the effect or outcome caused by the intervention (independent variable). (Trochim, 2006b). Table 3.8 shows the variables that were used in the study:

Table 3.8: The variables that were used in the study

Type of variable	Variables
Independent	1.1 Dissections as a hands-on approach 1.2 Problem-based activities
Dependent	2.1 Problem-solving skills. 2.2 Learner performance 2.3 Inquiry or investigative skills 2.4 Learner and teacher attitudes

The independent variables in this study were the problem-based activities and the animal organ dissections which the learners carried out in their lessons at each of the four schools. These two independent variables were manipulated to bring about effects or outcomes on the dependent variables. The dependent variables which were as a result of the manipulated variables were: the change in learner performance, the development of problem-solving skills, the development of inquiry or investigative skills and the establishment of the learners' and teachers' attitudes. There are some variables which were not necessarily interventions but could have an effect on the dependent variables, for instance the teacher influence could possibly affect the learners' attitudes, which would have an overall effect on the other dependent variables.

3.7 ETHICAL ISSUES CONSIDERED IN THE STUDY

Ethics involves the moral issues implicit in the research work with respect to people directly involved in or affected by the project. It focuses on the subject matter and methods of research in so far as it affects the participants and "in the appearance of regulatory codes of research practice formulated by various agencies and professional bodies" (Cohen et al., 2000, p. 49).
"Educational research is also advocacy research. A set of values, and hence a moral and ideological position of some kind, informs all research" (Adler & Lerman, 2003, p. 452). Researchers should strive to avoid doing harm to individuals involved in their study, as well as avoiding harming the educational system. Researchers must be able to care for and care about the respondents.

The researcher acknowledged that her responsibility was to strive to adhere to ethical principles and standards guiding research. To ensure that the study adheres to the research ethics requirements, she applied for permission from the Ethics Committee, Faculty of

Education at the University of Pretoria for clearance of research involving human subjects, adhering to all their guidelines about doing research involving humans, and permission was granted. The research design, methodology and participants' information was provided in the Ethics application form.

According to Cresswell (2002), the researcher develops an informed consent form for participants to sign before they engage in the research and Cohen et al. (2000) argue that the rights of respondents as human beings should be respected at all times. This implies that the above-mentioned consent form must include the following:

- The right to take part is voluntary and they have the right to withdraw at any time, so that the individual is not coerced into participation;
- The purpose of the study, so that the individuals understand the nature of the research and its likely impact on them;
- The procedures of the study, so that the individuals can reasonably expect what to anticipate in the research;
- Assurance that they will not be coerced into providing information, especially not information that may be perceived as sensitive or incriminating;
- Assurance that their responses will remain anonymous and that the information they provide will be treated as confidential at all times;
- The right to ask questions, obtain a copy of results, and have their privacy respected;
- Signatures of both the participant and the researcher must be on this consent form or letter.

Gaining the permission of individuals in authority (e.g. gatekeepers) to provide access to study participants at research sites is of utmost importance. This involves writing a letter that identifies the extent of time, the potential impact and the outcomes for the research (Cresswell, 2003). Firstly, the researcher asked for permission from the Gauteng Department of Basic Education and the principals to do research in the respective schools. In addition, written consent from parents of all participating learners and the learners was obtained. She also solicited informed consent of the teachers to participate in the study and guaranteed their anonymity, even though they were to be audio-taped. Only code names were used to identify them, as recommended by Schumacher and McMillan (1993) and Cresswell (2003), and permission was given to use their responses in the study. These applications were submitted after the proposal was successfully defended at Faculty level and before fieldwork began. Issues addressed in the application involved the sensitivity level of the research activities, the research design and methodology including full details regarding the participants, voluntary participation, informed consent, confidentiality, anonymity and risk. Minimum disruption of classes was ensured through the involvement of learners in instruments application like questionnaires outside the normal school timetable (see Appendix XI-XVI).

The study had a medium level of sensitivity as the participants were video-taped during the dissections practical to gather data through the video analysis regarding the learners' dissections skills, attitudes and how they use dissections with regard to problem-solving. The information collected was, however, not regarded as sensitive. The researcher acknowledged that she could not force some individuals who were uncomfortable or objected to dissections and she advised them to watch other group members dissect and participate in the discussions. Taking into consideration the different religious backgrounds of the learners like Muslims, Hindus, Jewish, Seventh Day Adventists, some of which would find it problematic to handle pig kidney, lamb kidneys were used for the dissections. Even though the lamb kidney is a bit smaller in comparison with the human kidneys, most of the structures are similar which makes it an ideal representative of the human kidney. The lamb kidneys are readily available at abattoirs and even ordinary butcheries at a low cost of R30 per kilogram.

The researcher was open to, and honest with, the teachers and learners and disclosed fully the purpose of the study. The participants were then invited to take part in the study after the purpose of the study and their participative roles had been explained to them so that they would make an informed decision. They were not coerced or forced to take part in the study but instead they had a choice whether to take part or not and they were allowed to withdraw at any stage. The teachers and learners, who decided to participate, signed a letter of informed consent containing the purpose of the study, the procedures to be followed during the investigation, the possible advantages and disadvantages as well as information regarding confidentiality, anonymity and possible risks involved in taking part in the study. An anonymous respondent is a participant whose responses cannot be identified as his, by the researcher (White, 2005). Confidentiality means "that although researchers know who has provided the information or are able to identify participants from the information given, they will in no way make the connection known publicly; the boundaries surrounding the shared secret will be protected" (Cohen et al., 2000, p. 62).

To ensure anonymity and confidentiality during the sample selection phase of the study, the participants were not asked to identify themselves publicly and in the cases where names were known, they were kept confidential at all times. The signed consent letters served as a further guarantee to the participants regarding the anonymity and confidentiality of the study. During the data collection phase in the questionnaire they were asked to reveal their personal or biographical information anonymously. The laboratory work observations were video-taped while the researcher also made field notes and the interviews were audio-taped. The interviews took place in low noise environments, for audibility reasons. Their knowledge and attitudes and behaviour captured during the observations and interviews were kept confidential and were not disclosed to anyone. No names were mentioned of any participant during the dissemination phase, in this main study, but instead pseudonyms or coded names were used. They were also informed that the data collected during the study would be destroyed after a period of 15 years but it would be kept at the Department of Science, Mathematics and Technology for that duration. This information was given to the participants to assure them that the information they had disclosed was safe and not for public consumption. Permission to use any of the statements or pictures of participants, in the dissertation or products thereof, was obtained from the relevant authorities. The teachers interviewed were asked to review the summary of the interview transcription before it was finalised. During this study none of the participants was physically or psychologically harmed. The only possible harm participants experienced was the invasion of their privacy by video-taping them, but fortunately in the case of this study, none of the participants seemed to have any problems with this kind of invasion.

3.8 DATA ANALYSIS APPLIED IN THE STUDY

Since this study is a multiple method study which used both quantitative and qualitative methods, the data analysis was also done quantitatively and qualitatively. Mouton (2002, p. 161) defines *quantitative data* analysis as "… the stage where the researcher, through application of various statistical and mathematical techniques, focuses separately on specific variables in the data set".

3.8.1 Analysis of quantitative data

The researcher, with the assistance and guidance of experts from the Department of Statistics at the University of Pretoria, used different statistical procedures to analyse the data quantitatively. The data collected from the pre-test, post-test and the questionnaires were statistically analysed. Descriptive and inferential statistics were used to analyse the quantitative data.

3.8.1.1 Descriptive statistics

Descriptive statistics is concerned with describing or summarising data from the sample (Gay & Airasian, 2000, p. 437). It also enables the researcher to describe data with numerical indices or in graphic form (Fraenkel & Wallen, 1996, p. 629). The analysis of data in descriptive statistics involves calculating and interpreting the statistics which include frequency distribution, measures of central tendency, measures of variability, measures of relative position and measures of relationships (Gay & Airasian, 2000, p. 437). Frequency distribution, as one of the descriptive statistics showing all the scores in each item, was used to tabulate data. Frequency data was presented both numerically and as a percentage indicating the number of learners who had marked a particular item in the questionnaires in relation to the total number of learners in the four schools. Frequency tables, histograms or pie charts were used to indicate the biographical data of the learners, the interviewed teachers and to indicate responses to dissections and problem-solving items. Measures of central tendency are mostly used to determine the average score of a group of scores including mean, median or mode. Mean is the most commonly used measure for distribution that has no extremely high or low marks, median is usually highly skewed, and both measures of distribution were reported in this study.

3.8.1.2 Inferential statistics

a) Reliability Test: Reliability and consistency of the pre-test and post-test were assessed by using Cronbach Alpha standardised test. The reason for considering the standardised test was because the different questions were weighed differently. Reliability of the questionnaire was assessed by using Cronbach Alpha since the Likert scale was applicable to all the questions in Section B of the questionnaire. Consistency in answering for the learners who are morally *for* and *against* dissections of animal organs was also assessed using the Cronbach Alpha. The reliability coefficients showed that the tests and the questionnaire were reliable as shall be discussed in Chapter 4.

b) The statistical analysis was done using the SAS v9.3 and BDMP release 8.1 statistical software. Matched T-test according to the BMDP statistical software, Inc 1993 edition was used to compare the scores of the pre-test and the post-test to establish the impact or influence of the intervention which was the animal organ dissections.

c) The GLM/ANOVA according to the SASV 9.3 statistical package was used to compare the learning gain between the four schools according to the following factors: the learners who are morally *for* and *against* animal organ dissections, gender and culture and to compare learning gains between questions that were categorised as rote learning, problem-solving, LO1, LO2, and LO3 questions between schools for the same factors as well. The whole point was to determine if the learning gains between the means for the various factors were significant. The ANOVA was used because multiple factors were being considered for comparison, the residuals were normally distributed and the sample size was big enough for the procedure.

d) Scheffe's test was used to compare the differences between the learning gain between paired schools using the overall test learning gain and also to compare the learning gain differences between questions that were categorised as rote learning, problem-solving, LO1, LO2, and LO3 questions in paired schools

3.8.2 Analysis of qualitative data

Two types of coding were used for analysing the qualitative data in this study, namely, closed coding and open coding.

- Closed coding: This was used where instruments had pre-identified categories, as was the case with the lessons observations checklist and some closed-ended questions from the questionnaire. Frequencies of teachers giving certain responses were recorded.
- Open coding: Open coding involves reading through the data, picking up the patterns or trends arising from the results, categorising and naming the trends (Cohen and Manion, 1997). Coding was used for categorising answers from the interviews and from the open-ended questions from the questionnaires. The researcher read through

the data and looked for emerging patterns and trends. The categories were then allocated abbreviated codes to distinguish them from each other for easy analysis. Categorising and coding helped in extracting information relevant to the study with the purpose of addressing the research questions. The codes were only used during analysis and not for reporting data. A science education expert was asked to face-validate the coding system developed by checking if the categories covered all the data collected. The expert also checked if the categories developed were logical and mutually exclusive.

3.8.2.1 Analysis of lessons observations and the video recording

The lessons observations, video recordings and the interviews with the teachers were analysed qualitatively. Bogdan and Biklen (1992, p. 153) define *qualitative data* analysis as the "process of making data more manageable by organising the collected data into categories and interpreting data, searching for recurring patterns to determine the importance of relevant information. McMillan and Schumacher (2001) argue that in qualitative research the collection of data and analysis takes place simultaneously to build a coherent interpretation of the data. To make sense of the data, the researcher followed the steps for data analysis as set out by Cohen et al. (2000, p. 148).

Step 1 Established units of analysis of the data, indicating how they are similar and different.

Step 2 Created a *domain analysis*.

Step 3 Established relationships and linkages between the domains.

Step 4 Made speculative inferences.

Step 5 Made a summary

Step 6 Sought negative and discrepant cases.

Step 7 Made a summary and a theory was generated.

The lessons observations analysis which was recorded on an observation checklist was carried out in conjunction with the analysis of the video recorded during the lesson. The researcher made a lessons observations coding using information from both the checklist and the video recording as shall be discussed in Chapter 5. The data was coded and summarised showing in terms of frequencies what was happening in the different classes of the different teachers.

3.8.2.2 Analysis of the interviews with the Life Sciences teachers

The data analyses started by coding each aspect into many categories and as the lesson continued more categories were added and some data was placed into the already existing categories, some categories were modified as more data was gathered. Without continuous analysis, data can be overwhelming, unfocused and repetitious. To avoid the previously mentioned problem, the researcher started interview data analysis as the data was being gathered. She first listened to the audio-recorded interview and read the transcribed interview repeatedly to gain a sense of the whole and to make the interpretation of smaller units of data much easier. The texts segments were compared and contrasted naming and classifying categories (McMillan & Schumacher, 2001). After interview data collection the following steps were followed:

1) *transcribing:* converting the audio-recorded interview into a text verbatim;
2) *analysing:* determining the meaning of the gathered information or data in relation to the purpose of the study;
3) *verifying:* checking the reliability and validity of the information; and
4) *reporting:* providing themes and categories and interpreting and converging it with data from other data collection methods like lessons observations, questionnaire, pre-test and post-test.

The above-mentioned points are discussed in detail in Chapters 4 and 5 under the presentation and description of results.

3.9 LIMITATIONS OF THE STUDY

Every research may have inhibiting factors in carrying it out which can include: the human factor, legislative policies, attitudes by gate keepers or the respondents. Merriam (1998, p. 20) supports this by stating: “The human instrument is as fallible as any other research instrument”. Factors like human mistakes, opportunities missed or personal bias interfere. McMillan and Schumacher (2001) add that institutions such as schools are public enterprises influenced by the external environment which can lead to change of programmes or policies.

In the case of this study, the limitations included last minute or upon arrival cancellations of scheduled appointments due to change of programmes within the school. This meant that the researcher had to be very flexible and in some cases it was inconvenient. Another limitation was the teachers' personal or problems which resulted in postponement of lessons observations or an interview appointment and the researcher had no choice but to wait for the rescheduled time. Cultural diversity brought degree of challenge as some learners in some schools were more comfortable to discussing in their small groups in the vernacular or Afrikaans, which the researcher did not understand. Use of English in interviews, which was a second language to four of the six teachers, may have been a prohibiting factor as they would struggle to express themselves and the interviewer had to keep on probing the interviewee until it was clear. Another limitation was costs, since the researcher was self-sponsoring, in some instances the cost of printing material, printer toners, fuel were prohibitive to the progress of the study.

3.10 SUMMARY OF THE RESEARCH DESIGN AND METHODOLOGY APPLIED IN THE STUDY

The chapter described the research design and methodology used in this study. The use of multiple method approach was discussed and substantiation was given for choosing this particular research approach. The strategies taken into consideration to ascertain trustworthiness were pointed out. It gives an explanation of where the study was carried out and how the samples were selected. It also provides a description of the instruments and strategies used to collect data, why and how they were used, and steps taken to improve validity of the results obtained using the instruments. It also outlined the ethical issues which were taken into consideration during the study. The data analysis processes for both quantitative and qualitative methods were outlined. The limitations of this study were also presented.

CHAPTER 4

FINDINGS DRAWN FROM THE QUANTITATIVE DATA

4.1 OVERVIEW OF THE CHAPTER

The next two Chapters, 4 and 5, deal with data retrieved from the field work. The findings drawn from quantitative and qualitative data will be presented and discussed in the two chapters respectively. The findings from the questionnaire completed by the learners, pre-test and post-test written by the learners, interviews with the teachers and lessons observations will be presented and discussed in the format presented in Figure 4.1:

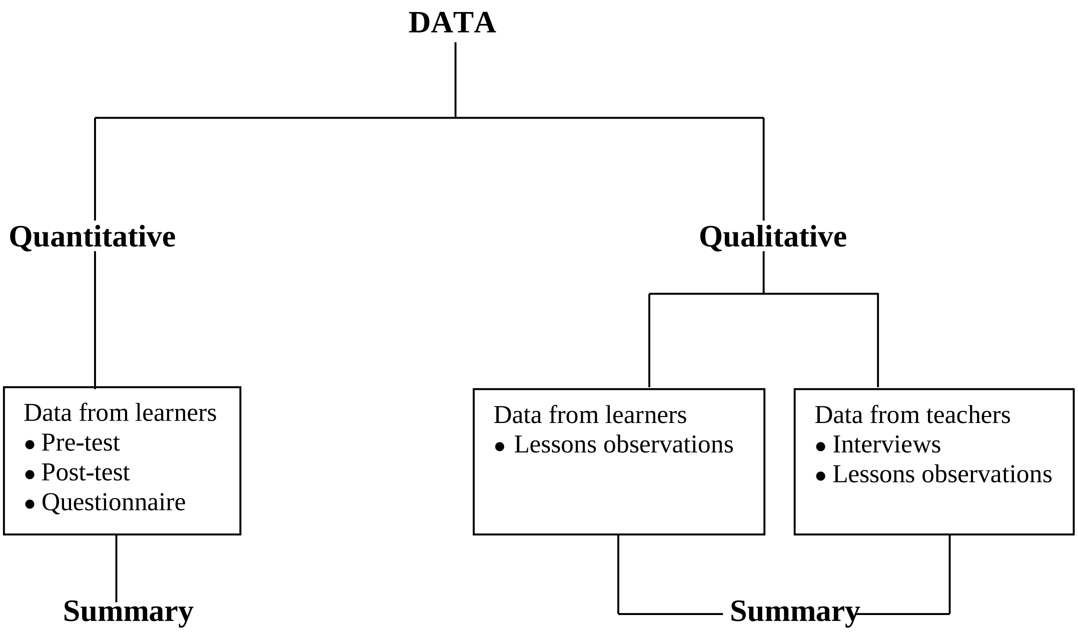


Figure 4.1: Graphical presentation of how data will be presented in Chapters 4 and 5

This chapter presents and discusses quantitative data for this study, which set out to explore the use of animal organ dissections as a teaching and learning strategy in problem-solving. The study also investigated the attitudes of teachers and learners, problems faced by learners in animal organ dissections and problem-solving and to what extent Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) are covered during animal organ dissections and in the tests written. The data presentation and discussion of this chapter has been divided into two sections. The first section presents data drawn from the learners' questionnaire and the second section of this chapter presents data drawn from the learners' pre-test and post-test. This chapter presents and discusses the findings drawn from the quantitative data but the in-depth analysis, triangulation and convergence of the findings will be discussed in Chapter 6.

It is important to note that all participants were included even when there was no response which means that the missing values were considered as zero in the pre-test and post-test which is what happens in a normal test. In the questionnaire the missing data is also highlighted so that the researcher can make an inference regarding non-responses.

4.2 QUANTITATIVE DATA PRESENTATION AND DISCUSSION

The quantitative data was gathered through the administration of a questionnaire, the pre-test and post-test applied to the Grade 11 Life Sciences learners. The data from the questionnaire, pre-test and post-test was captured and processed by the Department of Statistics at the University of Pretoria. Descriptive and inferential statistics were used to analyse the data (see Chapter 3).

A thorough review of literature on research methodology indicated that generally researchers want three questions answered once they finish collecting and analysing quantitative data. These are:

a) Is this effect real or was it as a result of chance (coincidence)?
b) If this is real, how large is it?
c) Is it large enough to be generalisable or to be useful? (Ellis & Steyn, 2003; Vaske, 2002; Winkleman, 2001)

These three questions were also applied to this study by the researcher. Question (a) is answered using significance testing, differences between the scores of the pre-test and post-test using the matched T-test and Analysis of Variance (ANOVA) procedure for multifactor including gender, culture, moral support for dissection. The results showed whether or not the observed effect was as a result of chance. Question (b), which is about the size of the effect, was addressed using descriptive statistics and reliability tests, which in this study were the Cronbach's Alpha reliability test (Kirk, 2001). The last question on whether the effect would be of practical usefulness can be very subjective depending on factors which affect the judgement of the researcher. These include societal concerns, feasibility in terms of costs and benefit as per the researcher's experience and the value system of the researcher in the particular context. Kirk (2001) argues that the researcher, as the person who will have collected and analysed the data, has an obligation to make a judgement on whether the effect would be of practical use depending on the researcher's context. Taking into consideration Kirk's argument, the researcher also analysed the factors that affected her context and her judgement shall be discussed in Chapter 7.

This study comprises *descriptive statistics* reported as frequencies, means, median and standard deviations. *Inferential statistics* reported using the matched T-test, General Linear Model (GLM)/ ANOVA, Scheffe's test, Chi-square test for association between school and culture group and finally the Chi-square test for association between gender, school and the learners who were morally *for* or *against* dissections of the animal organs. As mentioned in Chapter 3, the statistical analysis was done using the SAS v9.3 and BDMP release 8.1 statistical software. Parametric statistical tests used assume that the distribution of the data is normal. The distribution of the data was assessed and approximated a normal distribution, this in combination with the assumption of normality for sample sizes above 30, in terms of the Central Limit Theorem, was the motivation for using parametric statistical tests. A 5% level of significance was used for all statistical tests i.e. a p-value of <0.05 was considered statistically significant. This means that there is less than a 5% chance of accepting the alternative hypothesis when there is in fact no difference between scores (or no association between factors in the case of the Chi-square test).

The parametric matched t-test was used to compare Pre-test and Post-test scores under the assumption of the normal distribution of the data. BMDP also provides the results of the non-parametric Wilcoxon signed-rank test and these results agreed with those of the T-test. Having established that there were statistically significant differences between the pre-test and post-test scores further analysis was done to investigate the effect of school, culture, gender and moral position on the use of animal organ dissections on the learning gains (Post-score minus Pre-score). ANOVA (Analysis of variance) in the SAS GLM procedure was used to compare the learning gains for these factors. The associations between the four explanatory factors were investigated using the Chi-square test. Due to the statistically significant association between school and culture it was decided to omit the culture factor because its' association with school would violate the assumption of independence. The distribution of the data and of the residuals was assessed and considered to meet the normality assumptions for ANOVA.

The Cronbach's Alpha reliability test is also presented in this chapter to show reliability levels of the questionnaire, the pre-test and the post-test with reliability scale ranging from 0–1. The closer the reliability level is to 1, the higher the reliability of the instruments. According to Maree (2007), different degrees of internal reliability are required depending on what an instrument has to be used for: reliability estimates of 0.80 are regarded as more acceptable in most applications while values lower than 0.60 are regarded as unacceptable. In the case of this study the reliability coefficients which were considered as acceptable were between 0.60 and 0.85.

4.2.1 The reliability tests applied to the questionnaire, pre-test and post-test

Reliability is concerned with the ability of an instrument to measure consistently (Tavakol, Mohagheghi & Dennick, 2011). It should be noted that the reliability of an instrument is closely associated with its validity which means that an instrument cannot be valid unless it is reliable. However, the reliability of an instrument does not depend on its validity (Nunnally & Bernstein, 1994). It is possible to objectively measure the reliability of an instrument using the Cronbach's Alpha, which is the most widely used objective measure of reliability, that is Cronbach's Alpha is a commonly employed index of test reliability. It is mainly used in the reliability evaluation of assessments and questionnaires. Taking this into consideration, the Cronbach's Alpha was used in this study to assess the reliability levels of the questionnaires, pre-test and post-test which were applied to learners.

Alpha was developed by Lee Cronbach in 1951 to provide a measure of the internal consistency (reliability) of a test or scale. It is expressed as a number between 0 and 1; the closer Cronbach's Alpha coefficient is to 1.0 the greater the internal consistency (reliability) of the items in the scale (Tavakol, Mohagheghi & Dennick, 2011). When using Likert-type scales it is imperative to calculate and report Cronbach's Alpha coefficient for internal consistency reliability for any scales or subscales one may be using. The analysis of the data then must use these summated scales or subscales (Tavakol, Mohagheghi & Dennick, 2011).

Standardised Item Alpha was applicable to the pre-test and post-test of this study because the individual scale items are not scaled the same. The questionnaire used the Raw Item Alpha since it was a four-point Likert scale in Section B; the individual items are scaled equally. The reliability test results of the three instruments are represented in Table 4.1:

Table 4.1: The Cronbach's Alpha reliability test for the questionnaire, pre-test and post-test

Variables	Cronbach Alpha coefficient for the questionnaire	Cronbach Alpha coefficient for the pre-test	Cronbach Alpha coefficient for the post-test
Raw	0.614149	0.652912	0.784942
Standardised	0.626100	0.781984	0.831900

From the explanation and substantiation from the literature by Maree (2007) stated earlier in the chapter, the Alpha scale ranges from 0 to 1 and the closer the Alpha coefficient is to 1.0, the higher the reliability of the instruments. The questionnaire of the learners has an Alpha coefficient of 0.61 which shows that it was reliable. Another factor that can affect the coefficient level is the length of the instrument or a few individual questionnaire items which had very low correlation coefficients. For example, item 5.5 has a coefficient of 0.16 and item 5.17 has a coefficient of 0.11 which lowered the overall Alpha coefficient of the questionnaire. The two questionnaire items will be focused on in the discussion exploring the possible reasons for the low coefficients. A Standardised Item Alpha coefficient reliability test was carried out for the pre-test and the post-test as shown in Table 4.1. The pre-test written by learners has an Alpha coefficient of 0.78, which shows that it is highly reliable. As for the post-test written by learners; the Alpha coefficient is 0.83, which also shows that it is highly reliable.

The Cronbach's Alpha test showed that the learners who were morally *against* dissections and who also said that animal organ dissections did not help as Life Scientists, showed a more consistent answering than those who were morally *for* animal organ dissections, but the responses were not necessarily always negative. This might justify why there was no statistically significant difference between the mark differences for those morally *for* and *against* animal organ dissections when the ANOVA was used to compare the pre-test and post-test learning gain differences of these groups of learners.

4.2.2 The questionnaire data presentation and discussion

This section presents and discusses data from 224 questionnaires completed by Grade 11 Life Sciences learners from the four selected schools in Pretoria East. The purpose of this questionnaire was to answer research sub-questions four and five:

- *What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*
- *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?*

As mentioned in Chapter 3, the questionnaires were given to the Grade 11 learners soon after carrying out animal organ dissections and writing the post-test which predominantly had problem-solving questions. The data gathered from the questionnaire to the learners was coded and summarised logically. Coding is the process of converting questionnaire data into meaningful categories to facilitate analysis (Williams, 2003). Section A of the questionnaire explored the biographical data of learners. The coding of Section B which was closed-ended was done using the Likert scale. Section C which comprises open-ended questions was coded by examining all the responses to a question then devise categories for the answers. The data was coded the same way as closed response questions, but the categories covered a broader spectrum. Interesting responses were quoted verbatim in this report.

4.2.2.1 Section A: Biographical data of the learners

In Section A the distribution of data will be described in terms of:

- gender,
- age,
- religion,
- culture group, and
- animal organ dissections done from Grades 1 to 10.

Although some of the biographical data was not central to the study, it helped to contextualise the findings and in the formulation of appropriate recommendations.

Gender of learners at the four selected schools

Since the selected schools were co-educational, it was deemed essential to establish the male to female ratio.

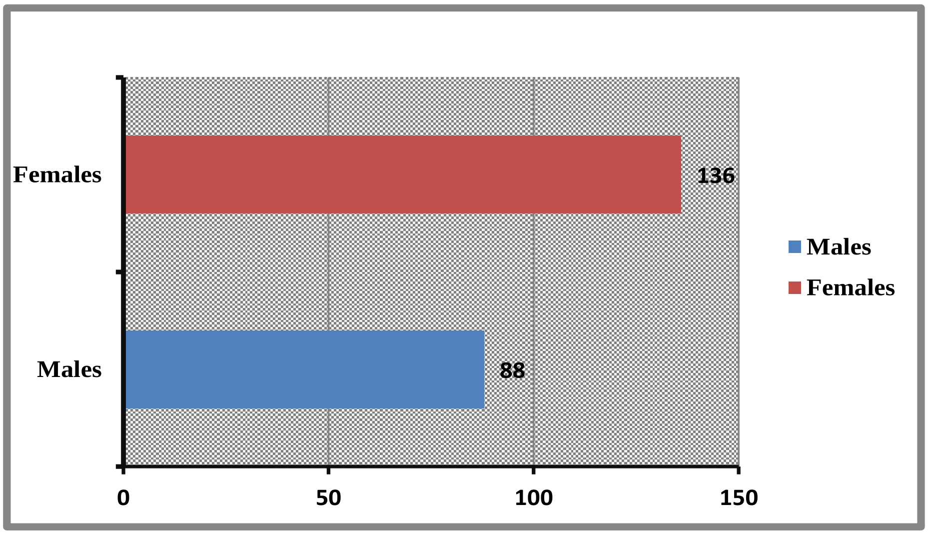


Figure 4.2: Gender profile of the sample of learners who participated in the study

Taking Figure 4.2 into consideration, it is evident that the majority (136) of the 224 participants were female. The ratio of male to female learners in the four schools is almost 1:1.5. The number of female learners in this sample does not reflect the male to female ratio in the South African population, where according to the 2011 Census data, the ratio for the 15 to 24 age groups is almost equal at a ratio of 1:1.05 (Statistics South Africa, 2011). According to the Department of Education: Education statistics (2009), the discrepancies on ratios may have been caused by the following factors: (a) from Grades 10 to 12 some learners may decide to follow a different path included in the Further Education and Training (FET) band. (b) repetitions of various Grades within the secondary school system could also cause the significant discrepancy in numbers, for example, repetition of males in Grade 10 is 20,7% as compared to 16.6% in females (National Income Dynamics Study (NIDS), 2010).

Age of the learners at the time of completing the questionnaire

Since the learners in the sample are in the same grade, the age range of the Grade 11 learners was 15 to 20. Table 4.2 depicts the age of the learners at the time they completed the questionnaire:

Table 4.2: Age of the learners at the time of completing the questionnaire

Age	Frequency	Percentage
15 years	2	0.89
16 years	87	38.84
17 years	99	44.20
18 years	24	10.71
19 years	11	4.91
20 years	1	0.45
TOTAL	224	100.00

Most learners start school at six or seven years; that is why the majority of Grade 11 learners are aged 16 and 17 (83%). The few outliers like 15 year olds might be the few exceptional cases where the learner started school at 5 years, and the 19 and 20 year olds could be due to repetitions as indicated by the National Income Dynamics Study (2010).

Religion profile of learners

The issue of dissections has been controversial for ages; different sectors have debated for or against dissections and one of the sectors which has been involved in these debates is the religious group. Taking that aspect into consideration, it was deemed important to find out the religious groups to which the learners belong and then deduce whether they had any influence on their attitudes towards carrying out animal organ dissections. Figure 4.3 depicts the respondents' religion:

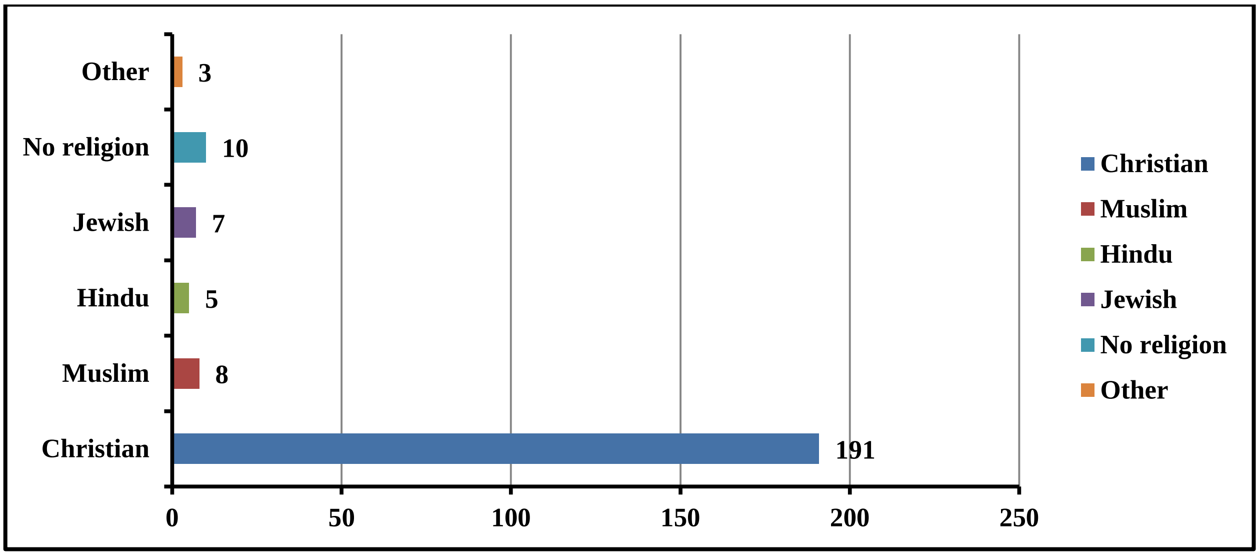


Figure 4.3: Religion profile of learners who participated in the study

South Africa is a country with freedom of worship and no religion is discriminated against. From Figure 4.3, it is evident that the sample group was predominantly Christian (85.27%) and 14.67% is divided amongst the other religions.

Culture groups of the learners

South Africa as a rainbow nation consists of a wide range of cultural groups. The cultural background of an individual can influence how one perceives the world around oneself. Collecting the data on the cultural groups of learners was considered important so as to explore the effect of culture on using animal organ dissections in problem-solving as a teaching strategy in diverse school environments. Since the aspect of school environment was considered in this study, the data presented in Table 4.3 shows the number of learners per school belonging to each culture group, and the total number of learners per culture group.

Table 4.3: Culture group profile of learners

Culture Group	**Frequency per School**				
	A	**B**	**C**	**D**	**Total**
Afrikaans	4	4	4	1	13
English	6	34	8	0	48
Ndebele	14	2	1	3	20
North-Sotho	35	3	17	12	67
South-Sotho	0	1	3	2	6
Swazi	5	1	3	0	9
Tsonga	7	0	1	1	9
Tswana	13	1	4	2	20
Venda	4	0	0	1	5
Xhosa	2	1	1	1	5
Zulu	7	2	3	5	17
Other	0	4	1	0	5
Total	97	53	46	28	224

Looking at the culture distribution of the sample of 224 learners, the majority of the learners belong to the North-Sotho cultural group (29.91%) which does not really come as a surprise because, in terms of the black South Africans in Pretoria, North-Sotho is the predominant cultural group followed by Tswana, Ndebele then Zulu. In terms of the European language, English was the predominant culture group (21.43%) the reason being that the selected schools were English medium since the researcher is an English speaker. Five non-South African learners indicated their cultural groups as *other*, of which two of the five learners were from Rwanda, two were Portuguese and one was Shona. This showed how culturally diverse the schools were. However, if one takes a closer look at the culture group distribution per school, it is evident that the culture group predominant in a school depends on the school environment. This is why School A, which is a township school, is predominantly North-Sotho and School B, which is a former Model C school (former whites only school under apartheid), is predominantly English. A Chi-square test was run to explore the association between school environment and culture. The test results showed that there is a statistically significant association between the school environment and culture at a confidence interval of 95% with the p value < 0, 0001. The high significance of association between the school environment and culture justified the use of the diverse school environment as a significant variable rather than both variables. Another Chi-square test was run to explore the association between the culture, gender and the opinion on being morally for or against animal organ dissections and there was a very low level of association between them, hence the group was looked at as a whole not in terms of culture or gender regarding dissections of animal organs.

The culture group profile of School A is displayed in Figure 4.4. It shows that the culture group predominant at School A is North-Sotho with frequency of 35 which represents 36% of School A learners. This does not come as much of a surprise because North-Sotho is the most predominant language in Gauteng; therefore it is being reflected in the schools as well. This school is also situated in one of the Pretoria East townships. It was noted that there were some learners belonging to Afrikaans and English culture groups in the township schools, but they represent less than 5%. Ndebele is the second most predominant culture group followed by Tswana. The other culture groups are in existence in very small numbers but South-Sotho was not represented at this school.

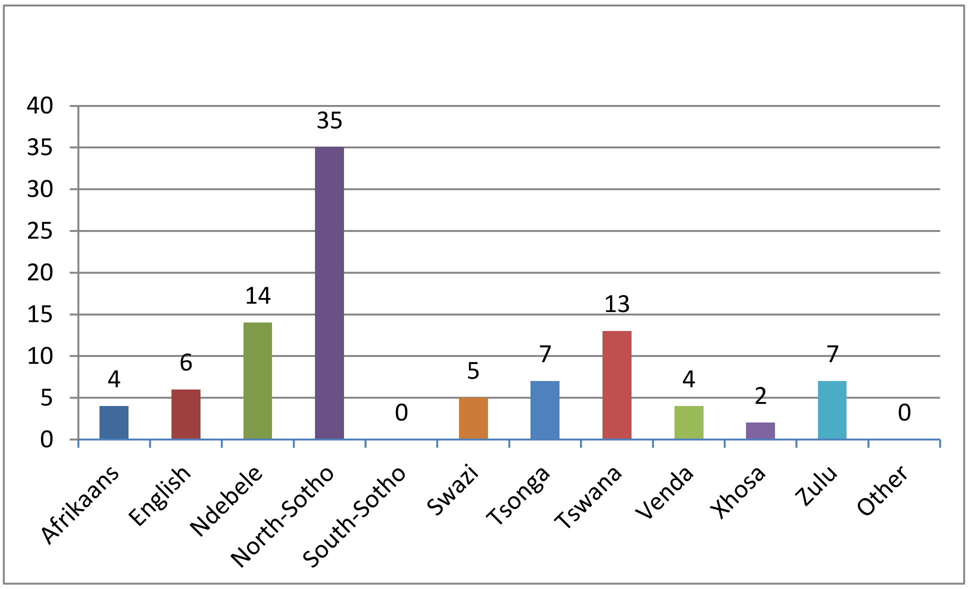


Figure 4.4: Culture group profile of School A

Figure 4.5 displays the culture group profile of School B. It clearly shows that the predominant group culture is English with 64%, followed by Afrikaans and other culture groups which are non-South African, like Portuguese or Rwandan. The reason why English is the most predominant group is because School B is a former Model C school which is predominantly attended by white learners and it is an English medium school. It is also situated in one of the Pretoria East suburbs.

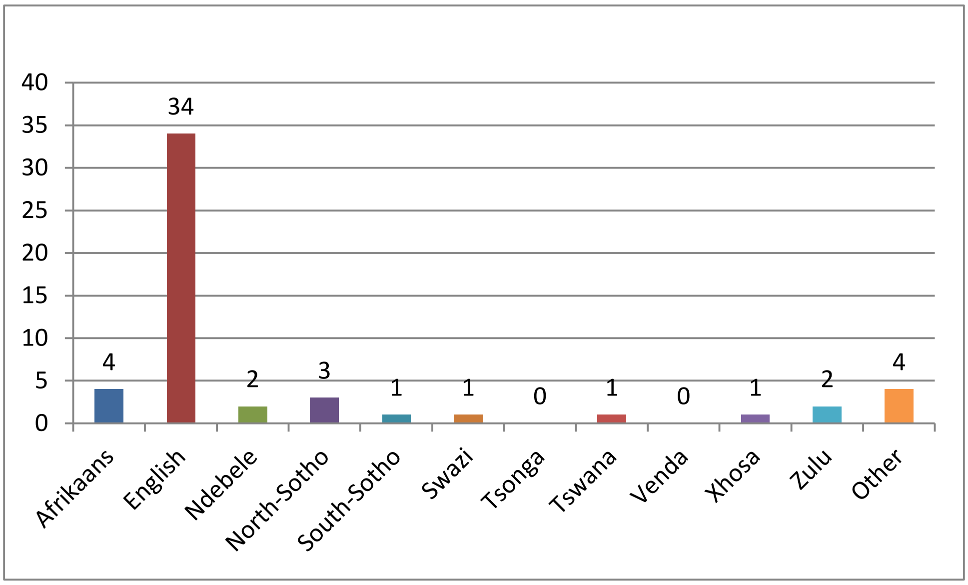


Figure 4.5: Culture group profile of School B

Figure 4.6 below depicts the culture group profile of School C. It shows the predominance of the North-Sotho culture group (37%), followed by Afrikaans (17%) and English culture groups. This is a well-resourced, high-fee independent school and it shows that almost all the culture groups are represented except Venda.

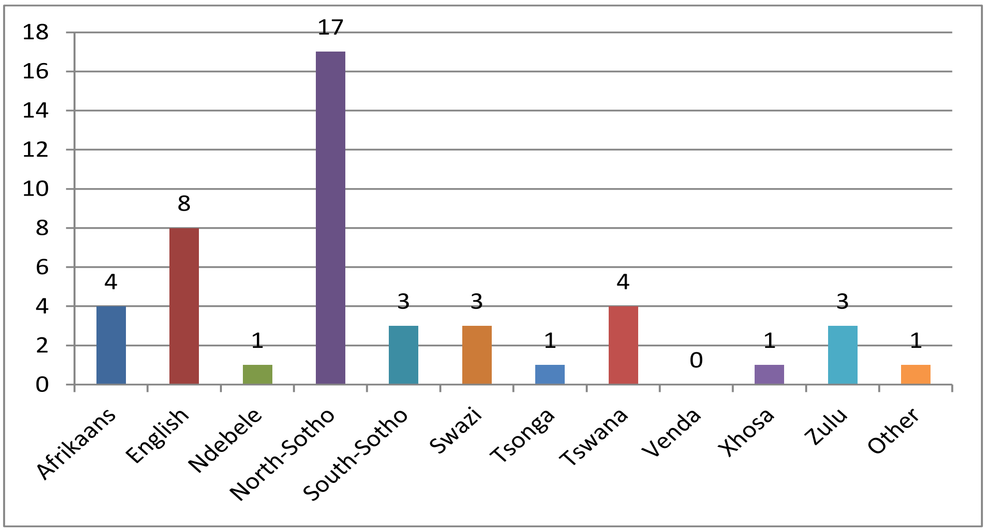


Figure 4.6: Culture group profile of School C

Figure 4.7 displays the culture group profile of School D which shows a 43% predominance of North-Sotho followed by Zulu and Ndebele. Other culture groups like English and Swazi are not represented at all. This pattern concurs with the predominant culture groups in the province on the part of black South-Africans.

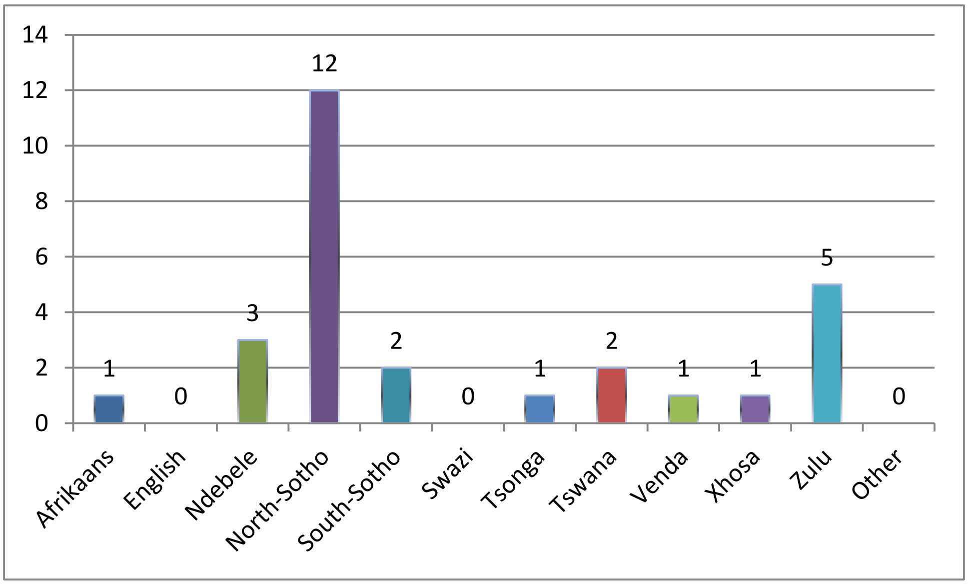


Figure 4.7: Culture group profile of School D

Summary of the profile of learners

The biographic data of the learners can be summarised as follows: The majority (60.71%) of the learners were female but the imbalance in gender did not seem to present discrepancies which could be deduced as being caused by gender differences. The predominant age group as expected is 16 and 17 since most learners start Grade 1 at the age of six or seven. This sample group in terms of religion is predominantly Christian (85.27%). The culture group which has the most students is North-Sotho followed by English but each of the 11 culture groups is represented in smaller frequencies.

4.2.2.2 Data presentation and discussion of Section B of the questionnaire

Section B of the questionnaire consisted of 24 statements, 5.1 to 5.24, that consisted of statements requiring learners to tick the relevant box (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree) on a Likert scale to indicate the extent of their agreement or disagreement with each statement. The statements were developed by the researcher to establish the attitudes and opinions of learners regarding animal organ dissections and problem-solving. The data gathered was subjected to measures of central tendency, specifically frequency, cumulative frequency, percentage and cumulative percentage to find the frequency of occurrence of a particular response. The summary was presented in tabular form as a frequency and as a percentage.

Table 4.4 shows the frequency distribution of responses for the 24 statements.

Table 4.4: Frequency distribution of the responses on animal organ dissections

Statements	Level of agreement							
	Strongly agree		Agree		Disagree		Strongly disagree	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1. I understand what dissection is	90	40.18	122	54.46	10	4.47	2	0.89
2. I have been exposed to animal organ dissections through demonstrations	76	33.93	120	53.57	21	9.38	7	3.13
3. I have carried out animal organ dissections in previous Grades	42	18.75	54	24.11	80	35.71	48	21.43
4. Dissection is useful in the learning of animal organ structure and function	112	50.00	104	46.43	6	2.68	1	0.45
5. Dissection helps me to understand structure and function of the animal organ	137	61.16	82	36.61	4	1.79	1	0.45
6. Animal organ dissection helps me to improve my investigative skills	136	60.71	83	37.05	5	2.23	0	0
7. Animal organ dissection helps me develop skills which I can use to solve real life problems	67	29.91	116	51.79	31	13.84	10	4.46
8. I feel comfortable with the idea of doing an animal organ dissection myself	75	33.48	115	51.34	26	11.61	8	3.57
9. I would rather use alternatives like artificial organs to carry out dissection	25	11.16	37	16.52	108	48.21	54	24.11
10. I would rather observe others doing animal organ dissection than doing dissection myself	15	6.70	42	18.75	103	45.98	64	28.57
11 I find it emotionally difficult to dissect a fresh animal organ	13	5.80	41	18.30	110	49.11	60	26.79
12. I find it difficult to manipulate (handle) dissection instruments	19	8.48	68	30.36	75	33.48	62	27.68
13. Animal organ dissection is the only way to help me develop manipulative (handling skills)	53	23.66	91	40.63	66	29.46	14	6.25
14. My religion *restricts* me from dissecting real tissue animal organs	8	3.57	23	10.27	69	30.80	124	55.36
15. My culture *restricts* me from dissecting real tissue animal organs	7	3.13	11	4.91	81	36.16	125	55.80
16. I find animal organ dissection disgusting	18	8.04	34	15.18	102	45.54	70	31.25
17. I will do animal organ dissections because I am interested in	121	54.02	87	38.84	12	5.36	4	1.79

finding out first-hand about the anatomy of the organ I am studying								
18. It is compulsory for me to carry out animal organ dissection	30	13.39	72	32.14	94	41.96	28	12.50
19. I prefer to dissect an animal organ rather than the whole body	64	28.57	99	44.20	48	21.43	13	5.80
20. Dissection is necessary because textbook information is generally limited	88	39.29	101	45.09	30	13.39	5	2.23
21. The idea of dissecting animal organs increases my respect for animals	75	33.48	105	46.88	36	16.07	8	3.57
22. I can learn more about my own body by dissecting mammalian organs	104	46.43	98	43.75	18	8.04	4	1.79
23. The use of additional information resources helps me understand more of the animal organ morphology	103	45.98	105	46.88	14	6.25	2	0.89
24. To test my knowledge, I prefer to be given a test after animal organ dissection rather than just drawing and labelling	83	37.05	82	36.61	38	16.96	21	9.38

Firstly, the researcher wanted to establish the number of learners who understood dissections as this would have implications on how the learners would carry out the animal organ dissections and their attitudes towards it. The responses reflected that a cumulative percentage of 5.36% of the learners did not understand what dissections is while a cumulative percentage of 94.64% agreed with the statement which shows that the majority of the learners understood what dissections is. Even though the majority of the learners indicated that they understood what dissections is, the issue of whether or not the learners had carried out animal organ dissections or not in previous grades was explored. The learners were asked if they had carried out animal organ dissections themselves from Grade 1 to 10. Prior knowledge (learner experience) influences the self-report rating of mental effort (Ayres, 2006) and learning performance (Ginns, 2005). Figure 4.8 depicts the learners who have experienced hands-on animal organ dissections and those that have never dissected.

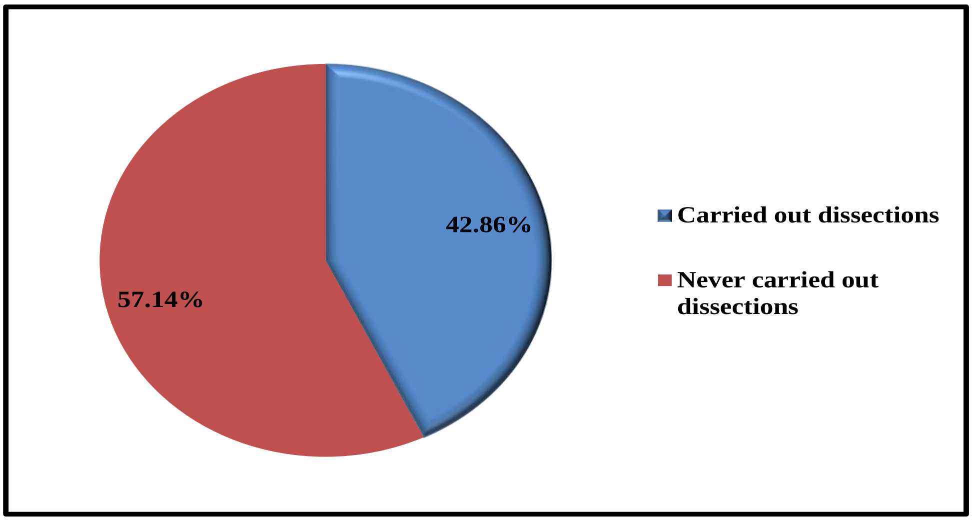


Figure 4.8: Prior experiences of learners with dissections

The figure 4.8 shows that 42.86% of the sample of 224 learners had experienced animal organ dissections in previous grades while 57.14% of them had never carried out animal organ dissections. This means they had their first hands-on animal organ dissections experience in Grade 11 during this study. Since animal organ dissection is a requirement which must be complied with even in Grade 10, the researcher could not help but wonder how the 57.14% of the learners proceeded to Grade 11 Life Sciences without having fulfilled one of the requirements of the National Curriculum Statement which is the animal organ dissections. A further analysis to prior dissection experience per school showed School A prior dissection experience was about 32 %, while School B was 53%, School C and D were 57% and 40% respectively. These discrepancies between the schools could possibly have been due to insufficient laboratory facilities and apparatus at schools like A and D which would make it difficult to arrange dissections in lower grades. This implies that the learners' understanding of animal organ dissections did not necessarily mean that they have carried it out. Some might have understood dissections by reading about it in textbooks or magazines or experienced it through demonstrations in class, on television or the internet as confirmed by 87.49% of the learners who said they had been exposed to animal organ dissections through demonstrations while 12.51% revealed that they had not had any form of exposure to dissections. According to the National Curriculum Statement, It is a requirement that a learner must conduct a minimum of five dissections each year from Grade 10 to Grade 12 (Isaac, 2002). The 87.49% of the learners includes the learners that have carried out the hands-on animal organ dissections (See Table 4.4). These findings show that some teachers are just exposing learners to dissections through demonstrations without letting them carry it out themselves. The same explanation given for a lower percentage of prior experience at the schools with insufficient laboratory facilities and apparatus is applicable as to why such schools when they could, just carried out demonstrations.

The researcher also wanted to establish the opinions of learners regarding the usefulness of animal organ dissections in the learning and understanding of the structure and function of the organ. A cumulative percentage of over 90.00% of the learners are of the opinion that animal organ dissections are useful in learning and understanding of the structure and function of the organ. Most of the learners (97.76%) acknowledged that animal organ dissections helped them to improve their investigative skills while less than 2.24% of the learners were in disagreement with this acknowledgement. Just over two-thirds (64.29%) of the learners are of the opinion that animal organ dissections are the only way to develop manipulative skills and 35.71% disagree with the statement. The learners' responses helped the researcher to establish if they acknowledged other practicals that lead to the development of manipulative skills besides animal organ dissections. Over 80.00% of the learners did not only acknowledge the usefulness of animal organ dissections in terms of developing investigative and manipulative skills only but also in the development of skills to solve real life problems. A low percentage (18.30%) of the learners did not see how animal organ dissections would help them to develop real life problem-solving skills. Besides animal organ dissections being considered useful to improve the skills like investigative, manipulative and problem-solving, the majority of learners realised the importance of carrying out animal organ dissections for other reasons.

For instance, 84.38% of the learners are of the opinion that dissections are necessary because textbook information is limited, hence the need for the animal organ dissections so as to complement the theoretical knowledge acquired. The integration of the acquired theoretical and practical knowledge results in a more in-depth understanding of the excretory system and the acquisition of the skills mentioned earlier. Very few (15.62%) of the learners do not agree with this statement and are either of the opinion that textbook information is adequate or that animal organ dissections are not necessary. According to the observations done by the researcher, one of the reasons why the learners were so excited about carrying out animal organ dissections was because they believed that through dissecting the organ they can learn more about their own bodies. This was confirmed by 90.18% of the learners who echoed the sentiment that they could learn more about their bodies through animal organ dissections while 9.82% disagree with that opinion. For about 92.86% of the learners, the understanding of the animal organ morphology was also enhanced by the use of additional information given by the teachers during their lessons. This opinion serves to confirm that the majority of the learners acknowledge animal organ dissections as a powerful method of learning to complement the theory and consolidate topics at a higher level of understanding and acquisition of skills. To prove that they have understood the animal organ morphology after carrying out animal organ dissections, almost three-quarters (73.66%) of the learners prefer to be given a test to assess their knowledge rather than just drawing and labelling the dissected organ while just over a quarter (26.34%) would rather just draw and label the dissected organ than to be tested.

Animal organ dissections and dissections in general are issues with a lot of controversy internationally. The controversies surrounding dissections can bring about different attitudes towards animal organ dissections by the learners, hence the need to establish what attitudes the learners had towards animal organ dissections. More than 80.00% of the learners feel comfortable with the idea of doing the animal organ dissections themselves while 15.18% were not comfortable with the idea of doing the dissections themselves. More than a quarter (27.68%) expressed that if given a choice they would rather use alternatives like online or artificial animal organ dissections, especially in the schools which are technologically equipped to do so, while some from financially disadvantaged schools would rather watch others dissect the organs. The learners that expressed preference to alternative dissections did not come as a surprise to the researcher because almost the same percentage (24.1%) of the learners expressed that they find it emotionally difficult to dissect fresh animal organs.

Almost the same percentages of learners who find it emotionally difficult to dissect fresh animal organs also find animal organ dissections disgusting, that is about 23.22% of the learners. Above 75.00% of the learners did not express any disgust or being emotionally affected by dissecting fresh animal organs. A further analysis was carried out to establish if there was an overlap of learners between those choosing to use alternatives to dissections, those who find it emotionally difficult to dissect fresh organs and those who find fresh animal organ dissections disgusting and it was interesting to note that there was an 82% overlap, which shows that these learners felt strongly against fresh organ dissections.

In as much as almost a quarter of the learners expressed a negative attitude towards animal organ dissections for different reasons ranging from being emotionally affected to being disgusted, three-quarters of the learners showed positive attitudes and a lot of interest towards animal organ dissections. Almost 80.00 % of the learners are of the opinion that animal organ dissections increases their respect for animals and almost 20.00% of the learners did not think so. Great interest was also expressed by 92.86% of learners who said they would do animal organ dissections because they are interested in finding out first-hand about the anatomy of the organ they are studying but 7.14% of the learners showed no interest. A small group (27.23%) of the learners showed more eagerness to dissect the whole body rather than the animal organs dissections, whereas the rest of the learners (72.77%) prefer to dissect the animal organ rather than the whole body.

For some learners the scepticism regarding dissections is caused by the influence of their religions or cultures. A few (13.84%) of the learners expressed that in as much as they would like to dissect, their religion was against it. Only 8.04% of the learners acknowledged that culture restricted them from participating in dissections of animal organs but the majority were not restricted by religion or culture. This shows that religion and culture did not have much of an impact on the attitudes of the majority of the learners towards animal organ dissections. The issue of animal species was avoided by using the lamb kidney because not all religions can handle the pig kidney. Some religions like the Muslim learners expressed the problem with how the animal was slaughtered, which rather makes it difficult to eradicate the religion barriers to animal dissection.

Besides attitude problems the learners might have, almost 40.00% of the learners find it difficult to manipulate the dissections instruments and from the researcher's observations, some of the manipulations problems were due to lack of adequate and efficient dissecting instruments at the disadvantaged schools where improvised alternative dissecting instruments were used. However, 61.16% of the learners did not find it difficult to manipulate the dissections tools. Almost half of the learners (45.53%) think that it is compulsory to carry out dissections while 54.47% of the learners think that it is not compulsory to carry out dissections of animal organs. Their opinions basically depended on what their teachers told them. In Schools A and B, they were told that they had to do it because it was compulsory according to the National Curriculum Statement (NCS) of the Department of Education while in schools C and D, they were made to understand that they were not being forced to carry out animal organ dissections as there were other alternatives like online dissections, watching others dissect or taking photos of the dissected organ with their phones.

4.2.2.3 Data presentation and discussion of Section C of the questionnaire

Section C of the questionnaire was comprised of open-ended questions or statements. It consisted of ten questions or statements. Some of the statements consisted of two, parts for example 7.1 and 7.2 as shown in Table 4.6 and Table 4.7. Learners were requested to write their opinions in the spaces that were provided regarding the given statements. The data was coded by examining all the responses to a question. The researcher then devised common categories for the answers and the data was numerically coded the same way as a closed response question but the categories covered a broader spectrum. Interesting responses were quoted verbatim in this report. In most cases one statement brought about different responses as expected with open-ended sections. To avoid data overload and for logical data analysis, it was summarised into the common categories.

Learners were requested to tick the animal organs they have dissected in school during Grade 1 to Grade 10. The learners were allowed to tick more than one option and as a result the cumulative frequency was not the same as the number of learners and those learners that have not dissected did not respond. Table 4.5 shows the frequencies of the responses given by learners regarding the animal organs they had dissected during Grade 1 to Grade 10 and the percentage of the responses based on the total number of the responses.

Table 4.5: Animal organs dissected by learners during Grade 1 to Grade 10

Organ	Responses (n=187)	Percentage
Heart	47	25.13
Lung	47	25.13
Kidney	36	19.25
Liver	27	14.44
Eye	11	5.88
Brain	9	4.81
Wing	6	3.21
Thigh	2	1.07
Not applicable	2	1.07

Table 4.5 indicates the different organs that have been dissected by learners in previous grades. Less than half (42.86%) of learners indicated that they have carried out animal organ dissections during Grade 1 to Grade 10 which means that organs listed in the table are the ones they dissected. Some learners dissected more than one organ and the two learners whose dissections have been categorised as not applicable are because they dissected the whole animal like a foetal pig and the other one a mouse. The organs which were dissected the most are the hearts and the lungs with 25.13% of the responses. According to the National Curriculum Statement, learners in Grade 10 are required to dissect the lungs but apparently only 47 learners dissected the lungs in previous grades. This shows that only 20.98% of the learners complied with this requirement and the rest of the learners proceeded to Grade 11 without complying with this curriculum requirement.

The researcher asked learners if they were morally *for* or *against* animal organ dissections and they were requested to give their reasons for their choice. A Chi-square test was used to establish the level of association between schools and the learners who were morally *for* or *against* animal organ dissections. It was established that $p = 0.472$ at a significance level $p < 0.05$ which showed the level of association between the school and their opinion regarding animal organ dissections was not significant, it depended on the individual learners. The learners were allowed to give more than one reason and as a result the cumulative responses were 343 in total. The researcher asked this question to establish what attitude the learners have, taking into consideration their moral views towards animal organ dissections. The learners' positive responses were classified into nine categories (See Table 4.6). Table 4.6 shows the responses of the learners who are morally in support of animal organ dissections.

Data is only presented in terms of frequency of responses and percentage of the 343 responses.

Table 4.6: Summary of the moral views of learners supporting animal organ dissections

Categories elicited from the responses of learners	Responses (n=343)	Percentage
Promote more learning and understanding of animal organ morphology	120	34.99
Links knowledge taught from textbooks with the real organ	54	15.74
Motivation towards a career choice	40	11.66
Helps get hands-on experience	30	8.75
Improves the investigative and practical skills	29	8.45
Textbooks or artificial organs restrict/limit information	21	6.12
Makes studying the topic more interesting	21	6.12
Organs are obtained from dead animals so it is not being cruel to animals	19	5.54
It is not murder because it is for a good cause	9	2.62

When learners were asked if they were morally *for* or *against* animal organ dissections, 186 learners responded that they were in support of animal organ dissections, only 31 learners were *against* it while seven were listed as missing values. Almost 35.00% of the responses justified animal organ dissections because it promotes more learning and understanding of animal organ morphology and more than 15.00% acknowledged that it links knowledge taught from textbooks with the real organ. Interestingly, despite all the complaints about the smell, the disgust and the squeamishness, 11.66% of the responses deemed it important because it motivated them towards their career choices which showed a very positive attitude towards animal organ dissections. Guilt can be one of the issues that can make learners feel that animal organ dissections are morally wrong. However, 5.54% of the responses suggested that it was not being cruel since organs were obtained from dead animals while 2.62% of the responses suggested that it was not murder because it was for a good cause.

The learners who had said they were morally *against* animal organ dissections were also asked to state their reasons. Table 4.7 shows the reasons why the learners were against animal organ dissections. The learners' negative responses were classified into six categories.

Table 4.7: Summary of the moral views of learners against animal organ dissections

Categories elicited from the responses of learners	Responses (n=46)	Percentage
Against the religion or beliefs to dissect animal organs	11	23.91
Cruel to the animal	10	21.74
Many animals had to die for the purpose of dissections	9	19.57
Animals should only be used as a food source	6	13.04
Being vegetarian	5	10.87
Strong respect for animals	5	10.87

Even though only 31 learners were against animal organ dissections, the responses are more than the learners because some learners gave more than one reason why they were morally against dissections. More than 20.00% of the responses indicated that animal organ dissections was against their religion and considered it cruel to the animals. Almost 20.00% of the responses are against the idea that many animals had to die for the purpose of animal organ dissections. This shows that as far as these learners are concerned animal organ dissections are not worth the death of the animals from which the organs were obtained unless if the animals were killed as a source of food. More than a tenth of the responses (10.87%) argued against animal organ dissections because of being vegetarians and also due to their strong respect for animals. The researcher realised that the moral values of learners which can be based on religion, culture, being vegetarians or just animal lovers can have a great influence of their attitudes towards animal organ dissections.

The researcher deemed it necessary to establish the ways in which the learners had experienced animal organ dissections as this would help in finding out the different ways in which learners can be exposed to animal organ dissections and the extent of impact they can have on a learner’s understanding. The learners were instructed to tick the statements on which their experience was based and if it was not included in the given statements, they were asked to specify. The learners were allowed to tick more than one option; as a result the cumulative frequency is more than the number of learners who have had experiences with animal organ dissections. Figure 4.9 depicts the different ways through which the learners experienced animal organ dissections.

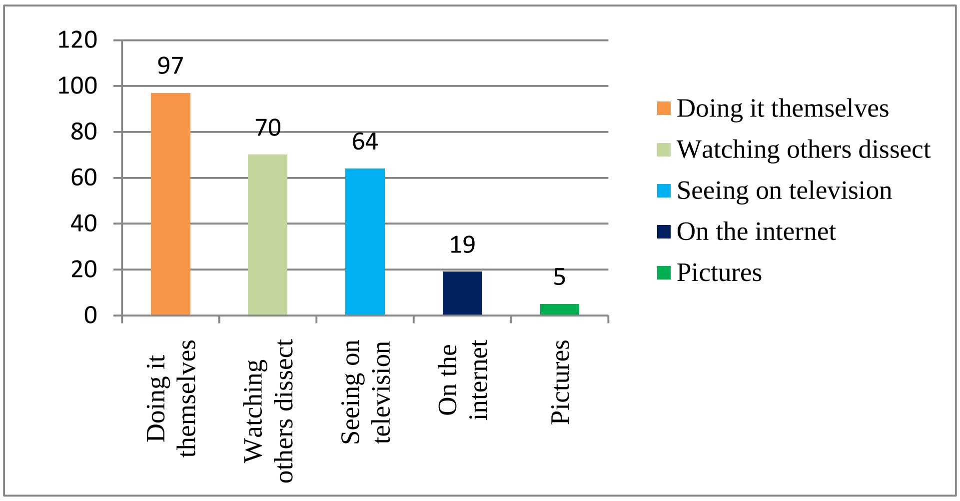


Figure 4.9: The experiences of learners with animal organ dissections

Almost 40.00% of the 255 responses indicated learners have had experience with animal organ dissections through doing the animal organ dissections themselves. More than 30.00% of the responses indicated that they had watched animal organ dissections being done by others or watched it on television. It was interesting to note that the use of technology was indicated by almost 8.00% of the responses through the use of the internet. From the researcher's observations, it is not always financially feasible for all learners to carry out hands-on animal organ dissections due to inadequate laboratory facilities and apparatus. In cases like that, alternative ways of experiencing animal organ dissections can be followed, although it will not be the same as carrying out the actual animal organ dissections.

The researcher also wanted to establish problems experienced by learners as they were dissecting animal organs. The learners were allowed to state more than one problem and as a result the total responses were 304. Table 4.8 is a summary of the problems experienced by learners as they were dissecting. The learners' responses were classified into nine categories (See Table 4.8).

Table 4.8: Problems experienced by learners when carrying out animal organ dissections

Categories elicited from the responses of learners	Responses (n=304)	Percentage
Risk of cutting oneself - Instrument handling problem	99	32.57
Constant urge to vomit, nausea, squeamish, smell and blood phobia	66	21.71
Sometimes it is difficult to identify parts of organ	36	11.84
No problems	24	7.89
Confusion between picture in textbook and the real tissue	19	6.25
Found group work difficult	18	5.92
Dissections tools old, blunt, inadequate, and ineffective	18	5.92
Difficult for teacher to guide too large groups	16	5.26
Putting vegetarian beliefs aside	8	2.63

According to the responses of the learners the main problem experienced by the learners is the handling of the instruments used for animal organ dissections. Nearly a third of the responses (32.57%) echoed the fear of cutting oneself on the part of those learners at the schools with adequate dissections instruments. For those learners at disadvantaged schools, the instrument handling problems were due to the inadequacy and ineffectiveness of the dissections tools, some of which were blunt which made the dissection process difficult. Some were scared of cutting themselves with the improvised razor blades in some cases. The issues of disgust, nausea, squeamishness and blood phobia were also expressed in 21.71% of the responses. Some could not stand the smell of the fresh kidney or the sight of blood and they felt squeamish because of the kidney texture. Group work does not always give positive outcomes. About 5.92% of the responses indicated that some learners found it difficult to work in a group. In some classes (5.26%) the groups were too large; this made it difficult for the teachers to manage and guide. Only about 2.63% of the responses expressed their struggle with putting aside their vegetarian beliefs and handling the fresh animal organs; they only did the animal organ dissections to fulfil the curriculum requirements.

The researcher deemed it necessary to find out from the learners if animal organ dissections help them as Life Scientists. It was encouraging to discover that 91.52% said *YES*, animal organ dissections help them as Life Scientists, while only 7.14% of the learners said it did not help them as Life Scientists and 1.34% was missing data. Table 4.9 shows the reasons given by the learners who said animal organ dissections help them as Life Scientists. The learners' responses were classified into nine categories. Learners were allowed to give more than one reason and as a result 365 reasons were given.

Table 4.9: Reasons why animal organ dissections help learners as Life Scientists

Categories elicited from the responses of learners	Responses (n=365)	Percentage
My knowledge regarding animal organs was broadened	84	23.01
First-hand experience/hands-on experience	70	19.18
Preparation for my career as a medical practitioner or Life Scientist	60	16.44
Learn dissecting skills	53	14.52
Teaches me real life situations or diseases	36	9.86
Remember a lot more information	31	8.49
I have come to enjoy dissections	14	3.84
Dissecting animal organs increases the respect for animals	13	3.56
Getting over blood phobia	4	1.10

The learners that believed that animal organ dissections helped them as Life Scientists had varied reasons and some had more than one reason. About 23.01% of the responses confirmed that knowledge regarding animal organs was broadened by animal organ dissections thereby developing the learners as Life Scientists. More than 16% of the responses indicated the gaining of hands-on experience which prepared them well for their careers as medical practitioners or Life Scientists. It was interesting to note that some learners started pondering ideas of career choices prompted by doing the animal organ dissections. This mind-set could generate more interest and help the learners to focus on the subject. Almost 15% of the responses confirmed that animal organ dissections helped them acquire the dissecting skill which is essential for a Life Scientist. Even though some learners did not aspire to be medical practitioners, they still believed that animal organ dissections teaches them real life situations related to the dissected organ including the health, social and lifestyle aspects, as echoed by 9.86% of the responses. In as much as some were sceptical about animal organ dissections after doing it, almost 4.00% of the responses indicated that they had come to enjoy the dissections of the organ and the respect for animals by the learners had increased. One percent of the responses acknowledged getting over the blood phobia thereby becoming true Life Scientists. The researcher assumes that if learners acknowledge the usefulness of animal organ dissections, then they will engage more with the practical to acquire those skills and knowledge which they expect to gain from the animal organ dissections.

The 7.14% of the learners who said that animal organ dissections do not help them to develop as Life Scientists were also asked to state their reasons. Table 4.10 shows the reasons given by the learners who said animal organ dissections does not help them as Life Scientists. Their responses were classified into six categories.

Table 4.10: Reasons why animal organ dissections do not help learners as Life Scientists

Categories elicited from the responses of learners	Responses (n=23)	Percentage
I did not learn much in the dissections lesson	5	21.74
It does not go hand in hand with the aspired career	5	21.74
Disagree with the slaughtering of animals	5	21.74
I find it disgusting to work with organs	3	13.04
Use of artificial models preferred	3	13.04
All the information and diagrams are found in the books	2	8.70

Not many learners were of the opinion that animal organ dissections did not help them as Life Scientists but those few gave their reasons. Almost 22% responses indicated that learners did not see how animal organ dissections help them as Life Scientists because they did not learn much in the dissections lessons and for some (21.74%), it did not go hand in hand with the careers they aspired to do. The moral issues tend to overshadow the importance of animal organ dissections as 21.74% of responses indicated disagreement with the slaughtering of animals for their organs and 13.04% of the responses focused on the disgust of working with fresh animal organs. The learners who disagreed with slaughtering of animals for moral issues will definitely find it difficult to acknowledge that animal organ dissections could help them as Life Scientists because according to them it is just not acceptable.

It was deemed important to find out how the learners were feeling when they were carrying out animal organ dissections as this would help the researcher to establish what the attitudes of the learners were as they were carrying out animal organ dissections. Table 4.11 summarises the feelings of the learners as they were carrying out animal organ dissections. The learners' responses were classified into eight categories.

Table 4.11: Learners' feelings when carrying out animal organ dissections

Categories elicited from the responses of learners	Responses (n=352)	Percentage
Exciting, enjoyable, fascinating, amazed, curious and motivating to see the organ parts on the real tissue	123	34.94
Life Sciences not just theory but real, practical and broadens knowledge	60	17.05
It was smelly, gross and nauseating	44	12.50
Felt guilty, cruel and disrespectful towards the dead animals	38	10.80
Felt like a doctor or real Life Scientist	30	8.52
Respectful of the animal from which the organ came because it died for learners' benefit	25	7.10
Nervous and scared to cut wrongly and damage the organ	21	5.97
Prefer watching others carry out the dissections since its part of the curriculum	11	3.13

It was interesting to note that the majority of the responses (34.94%) indicated that the learners found animal organ dissections exciting, enjoyable, fascinating, amazing, arousing their curiosities and motivating to see the organ parts on the real tissue. This was encouraging because it showed a positive attitude towards animal organ dissections. There is an extent of novelty reaction for some learners since it was a first experience and it is acknowledged that the reactions will not necessarily be the same for all of these learners as they carry out more dissections. For some learners (17.05%), the carrying out of animal organ dissections was an eye opener because they realised that Life Sciences was not just the theory they were taught in class but it was real, practical and broadened their knowledge on the link between theory and reality. Almost 9.00% of the responses supported the fact that animal organ dissections helped to link theory with reality because they felt like real doctors or Life Scientists, while only 7.10% of the responses indicated that learners felt respectful of the animal from which the organ came because it died for their benefit. Even though the majority of the learners had positive feelings as they were dissecting the organs, there were quite a few learners who felt it was nauseating, smelly and gross as indicated by almost 13.00% of the responses. The influence of the religion and moral values was evident again in how the learners felt as they were dissecting the organs; almost 11.00% of the responses echoed the feeling of guilty, cruelty and being disrespectful towards the dead animals. About 6% of the responses indicated that the learners were scared to touch the animal organ and they were also nervous to cut wrongly and damage the organ. This inexperience in dissecting animal organs is attributed to the fact that some learners were dissecting for the first time and therefore lacked the animal organ dissections skills, a skill that they should have acquired in the previous grades.

It was important to find out from learners if animal organ dissections had helped them to clarify any confusion which they might have had after their lessons on excretion. Table 4.12 shows the kind of confusion learners had after the theoretical lessons. The learners' responses were classified into seven categories (See Table 4.12).

Table 4.12: Confusions learners had which were clarified by animal organ dissections

Categories elicited from the responses of learners	Responses (n=319)	Percentage
Clarified the confusion between the real organ and the textbooks diagrams	72	22.57
It clarified how animal organ morphology works	61	19.12
Discovered different colours and shapes of different sections of the organs	45	14.11
Hands-on experience with texture	44	13.79
Link the theory with reality	40	12.54
Better understanding of how the body works	38	11.91
It clarified that animal organs are very similar to human organs	19	5.96

Most of the learners had only seen the kidney in textbooks and dissecting the animal organ helped them by clarifying how the real organ looks in terms of texture and colour. This cleared the confusions that had been caused by the textbook diagrams which are not clear, as acknowledged through almost 23.00% of the responses. Learners could not manage to establish the texture of the kidney, the different colours and shapes of different sections of the kidney by merely observing the diagrams of the kidneys in textbooks. Almost 14% of the responses indicated how animal organ dissections had helped learners to discover different colours and shapes of different sections of the organs, hands-on experience with texture and to link the theory with reality. The clarifications of what the structure of the kidney was like in real life helped learners to have a better understanding of the animal organ morphology as indicated by 19.02% of the responses. Only 5.96% of the responses indicated that the learners realised how similar the animal organs are to human organs they had been taught theoretically in class even though the similarity between animal and human organs is not applicable to all animals.

Learners were also asked how the problem-based activities they had in class had helped them clarify any confusion or misconceptions relating to organ morphology. The learners' responses were classified into five categories (See Table 4.13).

Table 4.13: Confusions learners had which were clarified by problem-based activities

Categories elicited from the responses of learners	Responses (n=286)	Percentage
Improved understanding of functions of different parts related to structure	109	38.11
Knowledge on excretion and kidney functions broadened	86	30.07
The link between the dissected organ and textbook diagrams clarified	35	12.24
It helped to clarify the differences between the excretory organs	34	11.89
Clarity on disease implications to the system	22	7.69

Table 4.13 reflects that the problem-based activities learners had in class helped some of the learners (38.11% of the responses) to improve their understanding of functions of different parts related to structures and to broaden their knowledge on excretion, as indicated by more than a third (30.07%) of the responses. The problem-based activities also helped to link theory with real life situations as learners worked on implications of diseases on the excretory system organs, as echoed by almost 8.00% of the responses.

4.2.3 Data presentation and discussion of the pre-test and post-test

This section presents and describes data from the pre-test and post-test which were written by the 224 Grade 11 Life Sciences learners from the four selected schools in Pretoria East. The purpose of these tests was to answer research sub-questions three and six:

- *How does learners' engagement with animal organ dissections aid in developing problem-solving skills?*
- *To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?*

As mentioned in Chapter 3, the pre-test was given to the Grade 11 learners before carrying out the animal organ dissections and the post-test was written soon after carrying out animal organ dissections. The test was based on Bloom's Taxonomy; it included rote learning questions, predominantly problem-solving questions, Learning Outcome 1 questions which required investigation and problem-solving skills, Learning Outcome 2 questions which required recalling of scientific knowledge and Learning Outcome 3 questions which required learners to relate knowledge acquired to technology, culture and society. All three learning outcomes were based on the National Curriculum Statement of the Department of Basic Education.

The total mark was 75 and all tests were marked by the researcher for consistency. The pre-test and post-test scores were presented in the form of means of the pre-test and post-test, these means were score summary statistics which were used to compare the pre-test and post-test scores. The means were categorised into six variables which were:

(a) The means for the total marks for all the 224 learners.

(b) The means for the rote learning questions.

(c) The means for the problem-solving questions.

(d) The means for the Learning Outcome 1 questions.

(e) The means for the Learning Outcome 2 questions.

(f) The means for the Learning Outcome 3 questions.

The means of the six variables were calculated as an overall for all the 224 learners and then also calculated per school for both the pre-test and post-test.

The researcher also considered measuring the effectiveness of the intervention based on the culture of learners and school learning environment separately but the Chi-square test for association between the school learning environment and culture showed that there was a statistically significant association between the culture and the school environment as shown in Table 4.14.

Table 4.14 Association of learners' culture and the school environment

Statistic	DF	Value	Prob
Chi-Square	12	92.9142	<.0001
Likelihood Ratio Chi-Square	12	95.7142	<.0001
Mantel-Haenszel Chi-Square	1	0.2417	0.623
Phi Coefficient		0.644	
Contingency Coefficient		0.5415	
Cramer's V		0.3718	
Sample Size = 224			

As a result of this significant association the researcher considered it more logical to use diverse school environments than both variables since they were reflecting the same pattern of results.

4.2.3.1 T-test procedure comparing the means of the pre-test and post-test scores for the whole group.

The T-test procedure was used to establish if there was a significant difference between the means of the pre-test and post-test scores for the whole group. This would help to determine if the intervention had any effect on the results. In hypotheses testing for the T-test, the null hypothesis $-H_0$ stated that the means of the pre-test were equal to the means of the post-test (A = B) with the alternative hypothesis $-H_1$ stating that the means of the pre-test were not equal to the means of the post-test ($A \neq B$). If the p-value was small ($p<0.05$) it implied that there was a significant difference between the pre-test and post-test scores summarised by the means, that is, the null hypothesis would be rejected. If the p-value was large ($p>0.05$) then the null hypothesis would be accepted.

Data presentation for the pre-test and post-test means and the T-test for the overall marks.

It was considered essential to analyse the knowledge or learning gain (post-test mean – pre-test mean) for each variable as a percentage before looking at the T-test results which then established if the learning gain for each variable was significant.

Table 4.15: Comparison of the percentage learning gains between the variables

Variable	Pre-test %	Post-test %	% Knowledge gain
Total	31.21	60.85	29.64
Rote	41.88	65.39	23.51
Problem-solving	25.55	58.47	32.92
LO1	55.65	85.35	29.70
LO2	31.63	63.46	31.83
LO3	20.35	52.12	31.77

Table 4.15 shows that the rote learning pre-test scores were relatively high while relatively low for problem-solving and the knowledge gain is proportionately higher for problem-solving after the intervention which was animal organ dissection. The greatest impact of the intervention was evident on the problem-solving variable because it addressed the aspect of learning which was lacking in the learners. Over 57% of the learners had never carried out dissections and the intervention improved the skill which needed them to investigate and

solve relevant problems. This may be interpreted to mean that practicals like animal organ dissections possibly enhanced their problem-solving capabilities.

Table 4.16: Comparison between pre-test and post-test medians, means and standard deviation

Variable	N	Median		Mean		Standard Deviation	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Total	224	23	46	23.41	45.64	10.84	14.17
Rote	224	11	17	10.89	16.99	4.83	4.49
Problem-solving	224	13	29	12.52	28.65	8.40	10.97
LO1	224	10	15	9.46	14.51	3.35	2.80
LO2	224	11	23	11.07	22.21	6.69	7.77
LO3	224	4	13	5.29	13.55	4.73	6.96

Table 4.16 is a summary which shows the medians, means, standard deviations of the pre-test and the post-test for all the 224 learners

The medians, means and the standard deviations (SD) of the pre-test and the post-test were used to calculate the differences between the medians, means and standard deviations for all the 224 learners as shown in Table 4.17.

Table 4.17: Differences between the pre-test and post-test medians, means and standard deviation

Variable	N	Median	Mean	Standard Deviation
Total Differences	224	23	22.23	11.74
Rote Differences	224	6	6.10	4.39
Problem Differences	224	16	16.13	10.07
LO1 Differences	224	5	5.05	3.53
LO2 Differences	224	12	11.14	7.81
LO3 Differences	224	9	8.26	6.09

When the researcher completed the marking of the pre-test and post-test, the first summary of the data was to calculate the medians, means and the standard deviations of the whole group in terms of the pre-test and the post-test as shown in Table 4.16 which reflects that the mean for the total which was marked out of 75 was 23.41 for the pre-test and 45.64 for the post-test. Table 4.17 shows that the difference between the means for the total marks was 22.23. Matched T-test was used to establish if the difference between the means of the total mark was statistically significant.

Table 4.18: Comparison of the means and medians of the pre-test and post-test for the total mark

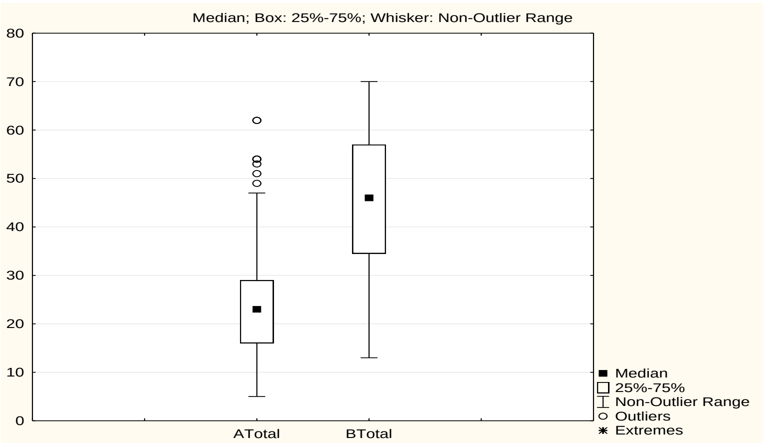
	Matched T-test
Test Statistic	-28.33
DF	223
P- values	0.0000
	***p< 0.0001

H_0: A = B H_1: A ≠ B ($\alpha = p < 0.05$)

The T-test used to compare the means of the pre-test and the post-test scores for the total mark resulted in the p-value < 0.0001. This showed that there was a statistically significant difference between the means of the pre-test and the post-test; therefore the null hypothesis was rejected. The change in the test scores was not by chance but possibly due to the effectiveness of the interventions which were the animal organ dissections which were carried out by learners.

The box and whisker plots were deemed essential to give a visual representation of how the pre-test and post-test data was distributed for the whole group and between schools. In these graphic representations the learning outcomes are abbreviated as LO while the pre-test is symbolised with an *A* and post-test is symbolised with a *B*.

The median calculated and presented in Table 4.16 was used to draw the box and whisker plots shown in Figure 4.10:



A: pre-test; B: post-test

Figure 4.10: Box and whisker plots showing data distribution of the pre-test and post-test scores for the totals

The median for the pre-test was 23 and the median for the post-test was 46. In the pre-test there were five scores that were numerically distant form the rest of the scores (outliers) but the post-test had no outliers. Looking at the five outliers of the pre-test which were above 40, it may be assumed that these were generally above average performers. The magnitude of gain was much higher owing to the intervention for the low-scorers thus clustering the post-test scores resulting in no outliers on the post-test.

Data presentation for the pre-test and post-test means and the T-test for the rote learning questions

The second variable considered for analysis was rote learning whose data was presented on Table 4.16 which reflects the medians, means and standard deviations of the pre-test and post-test. The rote learning questions contributed to 26 marks. The table reflects that the mean for the pre-test was 10.89 and the mean for the post-test was 16.99; the median was 11 for the pre-test and 17 for the post-test. The difference between the means of the rote learning scores was 6.10.

Table 4.19: Comparison of the means and medians of the pre-test and post-test for the rote learning

	Matched T-test
Test Statistic	-20.82
DF	223
P- values	0.0000
	*****p< 0.0001**

H_0: A = B H_1: A ≠ B ($\alpha = p < 0.05$)

The T-test was used to compare the means of the pre-test and the post-test scores showed a p-value < 0.0001, which means that there was a statistically significant difference between the means of the pre-test and the post-test. The null hypothesis was therefore rejected. It may be argued that the change in the test scores was not by chance but possibly due to the effectiveness of the interventions which were the animal organ dissections carried out by learners.

The distribution of the pre-test and post-test scores for the rote learning questions was illustrated by the box and whisker plots in Figure 4.11.

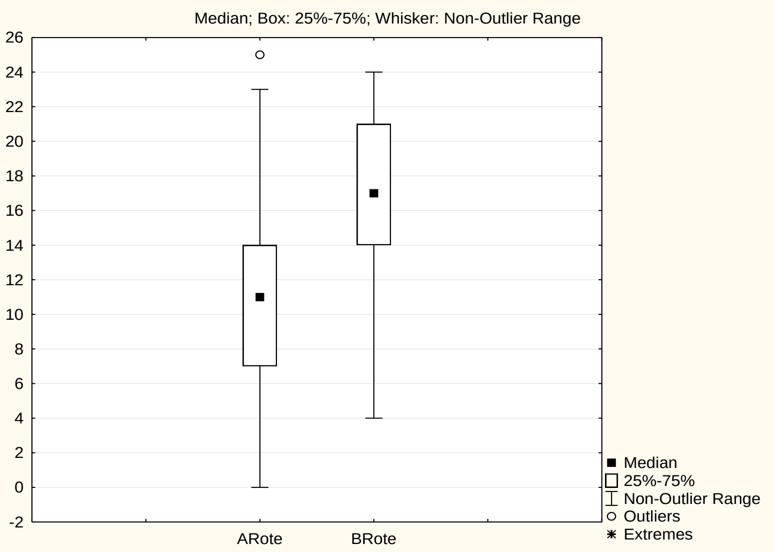


Figure 4.11: Box and whisker plots showing data distribution of the pre-test and post-test scores for rote learning questions

Figure 4.11 shows that the median for the pre-test was 11 and the median for the post-test was 17. The pre-test had about one outlier but the post-test had no outliers.

Data presentation for the problem-solving questions

The third variable considered for analysis was problem-solving whose data was presented on the Table 4.16 which reflects the medians, means, and standard deviations of the pre-test and post-test. The problem-solving questions contributed to 49 marks. The table reflects that the mean for the pre-test was 12.52 and the mean for the post-test was 28.65; the median was 13 for the pre-test and 29 for the post-test. The difference between the means of the problem-solving scores was 16.13. Matched T-test was used to establish if the difference between the means of the problem-solving scores was statistically significant.

Table 4.20: Comparison of the means of the pre-test and post-test for problem-solving

	Matched T-test
Test Statistic	-23.95
DF	223
P- values	0.0000
	*****p< 0.0001**

H_0: A = B H_1: A ≠ B ($\alpha = p < 0.05$)

The T-test used to compare the means of the pre-test and the post-test for problem-solving scores resulted in a p-value < 0.0001, showing that there was a statistically significant difference between the means of the pre-test and the post-test scores; therefore the null hypothesis was rejected. The change in the means of the test scores for the problem-solving questions was not by chance but due to the effectiveness of the interventions which were the animal organ dissections carried out by learners.

The distribution of the pre-test and post-test scores was illustrated by the box and whisker plots in Figure 4.12.

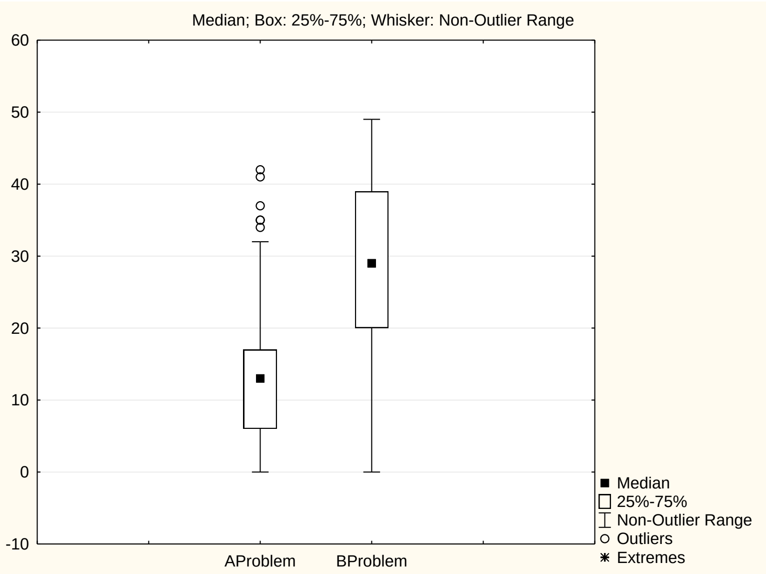


Figure 4.12: Box and whisker plots showing data distribution of the pre-test and post-test scores for problem-solving questions

Figure 4.12 shows that the median for the pre-test was 13 and the median for the post-test was 29. The pre-test had about five outliers but the post-test had no outliers. Looking at the five outliers of the pre-test which were above 40, it may be assumed that these were generally above average performers. The magnitude of gain was much higher owing to the intervention for the low-scorers thus clustering the post-test scores resulting in no outliers on the post-test.

Data presentation for the Learning Outcome 1 questions

The fourth variable considered for analysis was Learning Outcome 1 (LO 1). The LO 1 questions which required investigation and problem-solving skills of the learners contributed to 17 marks of the total mark. The table reflects that the mean for the pre-test was 9.46 and the mean for the post-test was 14.51; the median was 10 for the pre-test and 15 for the post-test. The difference between the means of the LO 1 scores was 5.05.

Table 4. 21: Comparison of the means of the pre-test and post-test for LO 1 questions

	Matched T-test
Test Statistic	-21.39
DF	223
P- values	0.0000
	*****p< 0.0001**

H_0: A = B H_1: A ≠ B ($\alpha = p < 0.05$)

The T-test resulted in a p-value < 0.0001. This means that there was a statistically significant difference between the means of the pre-test and the post-test; therefore the null hypothesis was rejected. It is therefore assumed that the change in the means of the test scores for the LO 1 questions was not by chance but due to the effectiveness of the interventions which were the animal organ dissections carried out by learners.

The distribution of the pre-test and post-test scores was illustrated by the box and whisker plots in Figure 4.13. The ALO1 represents the distribution of LO 1 scores for the pre-test and the BLO1 represents the distribution of LO 1 scores for the post-test.

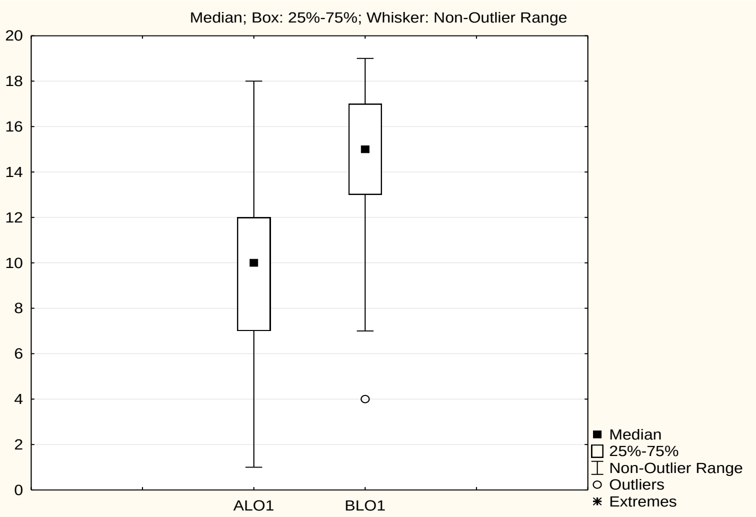


Figure 4.13: Box and whisker plots showing data distribution of the pre-test and post-test scores for Learning Outcome 1 questions

Figure 4.13 shows that the median for the pre-test was 10 and the median for the post-test was 15. The pre-test had no outliers but the post-test had one outlier. It may be argued that the one outlier below the 25^{th} percentile on the post-test was one of those learners who were sceptical about carrying out animal organ dissections but had no problem in responding theoretically during the pre-test.

Data presentation for the Learning Outcome 2 questions

The fifth variable considered for analysis was Learning Outcome 2 (LO 2) whose data was presented on the Table 4.16. It reflects the medians means and standard deviations of the pre-test and post-test. The LO 2 questions contributed to 35 marks. The table reflects that the mean for the pre-test was 11.07 and the mean for the post-test was 22.21; the median was 11 for the pre-test and 23 for the post-test. The difference between the means of the LO 2 scores was 11.14.

Table 4.22: Comparison of the means of the pre-test and post-test for LO 2 questions

	Matched T-test
Test Statistic	-21.35
DF	223
P- values	0.0000
	*****p< 0.0001**

H_0: A = B H_1: A ≠ B (α = p< 0.05)

The T-test was used to compare the means of the pre-test and the post-test scores a resulted in p-value < 0.0001. This showed that there was a statistically significant difference between the means of the pre-test and the post-test; therefore the null hypothesis was rejected. The change in the means of the test scores for the LO 2 questions was not by chance but due to the effectiveness of the interventions which were the animal organ dissections carried out by learners.

The distribution of the pre-test and post-test scores was illustrated by the box and whisker plots in Figure 4.14.

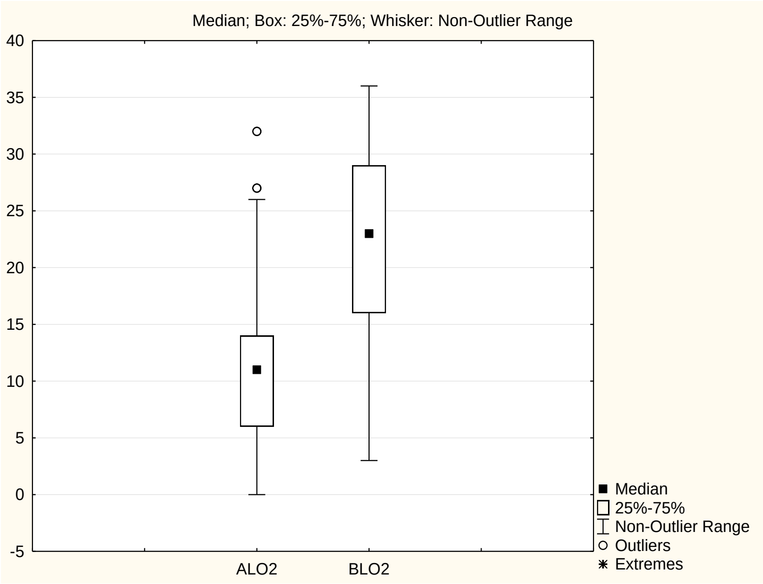


Figure 4.14: Box and whisker plots showing data distribution of the pre-test and post-test scores for Learning Outcome 2 questions

The ALO2 represents the distribution of LO 2 scores for the pre-test and the BLO2 represents the distribution of LO 2 scores for the post-test. Figure 4.14 shows that the median for the pre-test was 11 and the median for the post-test was 23. The pre-test had about two outliers but the post-test had no outliers. Looking at the two outliers of the pre-test which were above 25, it may be argued that these were generally above average performers. The magnitude of gain was much higher for the low-scorers owing to the intervention which was animal organ dissections, thus clustering the post-test scores resulting in no outliers on the post-test.

Data presentation for the Learning Outcome 3 questions

The sixth variable considered for analysis was Learning Outcome 3 (LO 3) whose data was presented on Table 4.16. It reflects the medians, means and standard deviations of the pre-test and post-test. The LO 3 questions contributed to 26 marks. The table reflects that the mean for the pre-test was 5.29 and the mean for the post-test was 13.55; the median was 4 for the pre-test and 13 for the post-test. The difference between the means of the LO 3 scores was 8.26. Matched T-test was used to establish if the difference between the means of the LO 3 scores was statistically significant.

Table 4.23: Comparison of the means of the pre-test and post-test for LO 3 questions

	Matched T-test
Test Statistic	-20.28
DF	223
P- values	0.0000
	*****p< 0.0001**

H_0: A = B H_1: A ≠ B ($\alpha = p < 0.05$)

The T-test used to compare the means of the pre-test and the post-test scores resulted in p-value < 0.0001 showing that there was a statistically significant difference between the means of the pre-test and the post-test; therefore the null hypothesis was rejected. The change in the means of the test scores for the LO 3 questions was not by chance but due to the effectiveness of the interventions which were the animal organ dissections carried out by learners.

The distribution of the pre-test and post-test scores was illustrated by the box and whisker plots in Figure 4.15. The ALO3 represent the distribution of LO 3 scores for the pre-test and the BLO3 represent the distribution of LO 3 scores for the post-test.

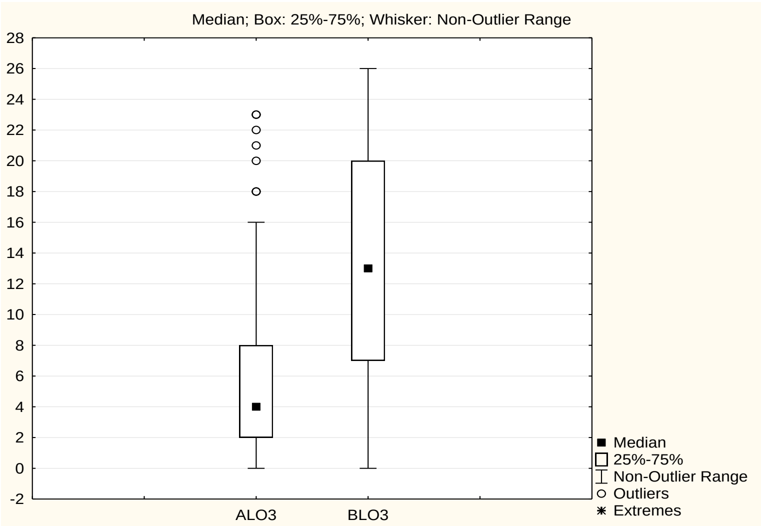


Figure 4.15: Box and whisker plots showing data distribution of the pre-test and post-test scores for Learning Outcome 3 questions

Figure 4.15 shows that the median for the pre-test was 4 and the median for the post-test was 13. The pre-test had about five outliers but the post-test had no outliers. Looking at the five outliers of the pre-test which were above 18, it may be assumed that these were generally above average performers. The magnitude of gain was much higher for the low-scorers owing to the intervention which was animal organ dissections, thus clustering the post-test scores resulting in no outliers on the post-test.

4.2.3.2 ANOVA procedure comparing the pre-test and post-test learning gains between the schools

Having established that there were statistically significant differences between the pre-test and post-test scores further analysis was done to investigate the effect of school, culture, gender and moral position on dissection on the learning gains. The ANOVA procedure analyses by comparing the pre-test to post-test learning gains on all six scores with respect to School, gender and moral position. The models for four of the six scores, excluding Rote learning and Learning Outcome 3 were significant at the 5% significance level with model degrees of freedom = 4 and Error degrees of freedom=211. The statistics for each of the six scores for school, gender and moral position are summarised in Table 4.24 below.

Table 4.24: ANOVA statistics for learning gains with respect to School, Gender and moral position

Score	School DF=3		Gender DF=1		Moral Position DF=1	
	F statistic	p-value	F statistic	p-value	F statistic	p-value
Total	5.34	**0.0014**	0.71	0.3994	0.64	0.4251
Rote learning	1.49	0.2186	0.06	0.8078	0.17	0.6822
Problem solving	6.17	**0.0005**	1.22	0.2707	0.57	0.4525
LO1	4.79	**0.0030**	1.03	0.3124	0.04	0.8500
LO2	7.51	**0.0001**	1.29	0.2571	0.81	0.3697
LO3	2.34	**0.074**	0.19	0.6658	0.01	0.9199

p-values <0.05 are highlighted in **bold** typeface *****< 0.05**

The Analysis of Variance (ANOVA) was used to establish if the learning gains between the four schools were statistically significant. Taking into consideration the learning gains between the schools for the total mark, the p-value was 0.0014 which is less than the level of significance. For the rote learning questions the p-value is 0.2186 which is greater than 0.05. The problem-solving questions resulted in a p-value of 0.0005 which is less than 0.05. LO 1 questions had a p-value of 0.0003 which is also less than 0.05 while LO 2 resulted in a p-value of 0.0001. LO 3 had a p-value of 0.0744 which is more than 0.05.

It was interesting to note that there were statistically significant differences between the learning gains of the four schools for the total mark, problem-solving questions, LOs 1 and 2 questions. It is imperative to note that the mentioned variables are considered to be variables which can be enhanced by engaging in practical activities like animal organ dissections. It can therefore be argued that the significant differences amongst the schools can be attributed to the level of engagement learners from different school environments had with animal organ dissections. Following the same line of argument, it was noted that there were no significant differences in rote learning means and LO 3 means amongst the four schools. This may be because rote learning variables can be theoretically addressed with a minimal level of engagement with animal organ dissections on the part of learners, irrespective of the school environments. The differences between the means of the four schools for Learning Outcome 3 were also not significant. This may be because the learners from the four different school environments may have managed to apply the knowledge acquired to society at almost the same level irrespective of the different learning environments. Measuring the effectiveness of the intervention by gender and by learners being morally for or against animal organ dissections was also considered but the ANOVA procedure reflected that there was no statistically significant difference between the scores of the males and the females on the developed tests and between the learning gains of the learners morally *for* or *against* animal organ dissections hence the differences between the means were done between school and not between gender or morality. The schools in the study were all co-educational schools. The males and females compared were coming from the same classes and the assumption is that they were all subjected to the same conditions of teaching and learning. This means that the other variables that could have affected the performance of the learners were constant to both genders. The result therefore suggests that the test was not gender biased. The other factor which was the learners' moral position regarding animal organ dissection might not have a significant impact because in as much as some learners were morally against animal organ dissections, they still participated in the practical activity benefitting just like any other learner.

4.2.3.3 The box and whisker plots comparing learning gains of schools per variable

The learning gains per school for each variable were calculated and presented in Table 4.25 and used to draw the box and whisker plots which compared the learning gains amongst the four schools for each of the six variables.

Table 4.25: The learning gains of the four schools for the six variables

School	Total Diff		Rote Diff		Problem Diff		LO1 Diff		LO2 Diff		LO3 Diff	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
A	22.32	12.68	6.68	4.52	15.64	10.52	6.02	3.95	10.81	8.45	8.20	6.54
B	24.60	10.94	5.72	4.41	18.89	10.12	4.09	2.98	14.00	7.11	8.83	6.17
C	16.93	10.82	5.11	4.00	11.83	9.01	4.39	3.09	7.35	6.74	6.63	6.01
D	26.14	8.18	6.50	4.38	19.64	7.20	4.57	2.90	13.14	5.67	10.07	3.59

Figure 4.16 reflects for the total mark that the learning gain for School A was 22.32 with one outlier. The learning gain was 24.60 for School B, 16.93 for School C and 26.14 for School D.

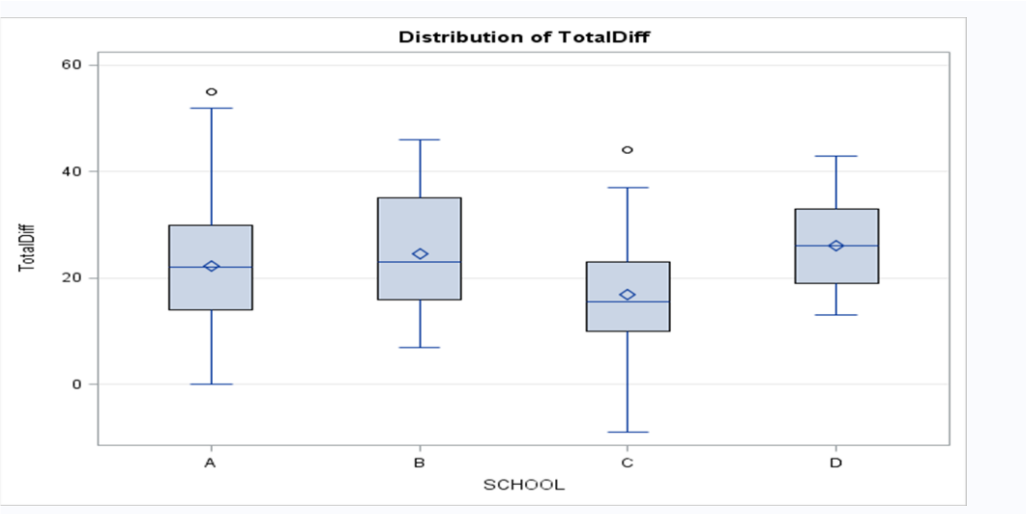


Figure 4.16: Box and whisker plots to illustrate spread/distribution of scores for each School

It did not come as a surprise that School B had the most even distribution of scores in comparison with the other schools. This may be because, it is a former Model C school (former whites only school under apartheid) which has adequate laboratory facilities and the learners were accorded the opportunities to work independently without too much involvement of the teachers.

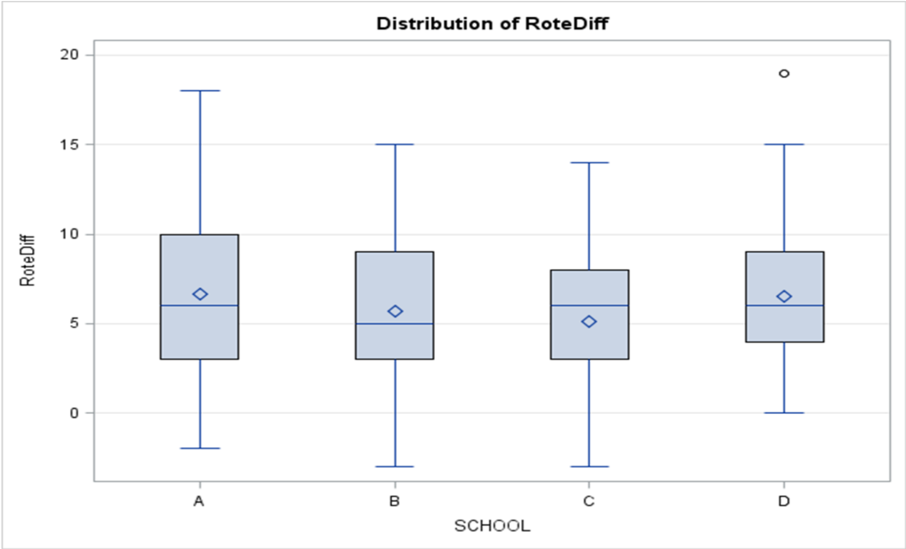


Figure 4.17: Box and whisker plots learning gain differences between schools for the rote learning questions

Figure 4.17 reflects that the learning gain of the rote learning questions for School A was 6.68. For School B, it was 5.72 while it was 5.11 for School C and lastly 6.5 for School D with one outlier.

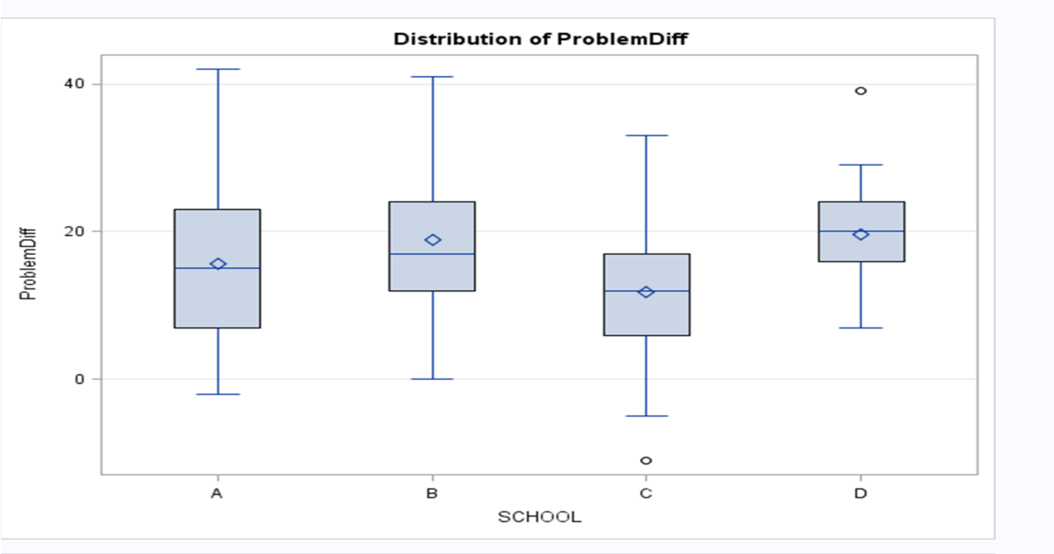


Figure 4.18: Box and whisker plots learning gain differences between schools for the problem-solving questions

Figure 4.18 shows the box and whisker plots learning gain differences between the means for the problem-solving questions. School A had a learning gain of 15.64, about 18.89 for School B, 11.83 for School C with one outlier and 19.64 for School D with one outlier.

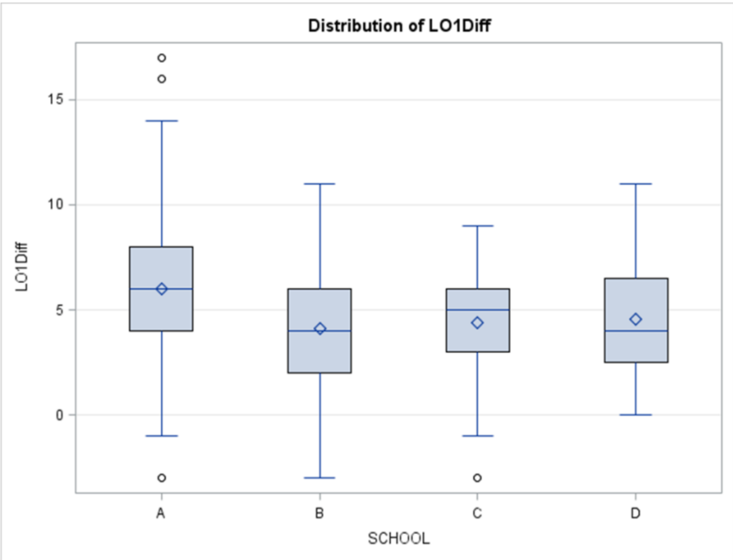


Figure 4.19: Box and whisker plots comparing learning gain differences between schools for the Learning Outcome 1 questions

Figure 4.19 shows the box and whisker plots for the learning gain differences between the means for the LO 1 questions. School A had a learning gain of 6.02 with two outliers, 4.09 for School B, 4.39 for School C with one outlier and 4.57 for School D.

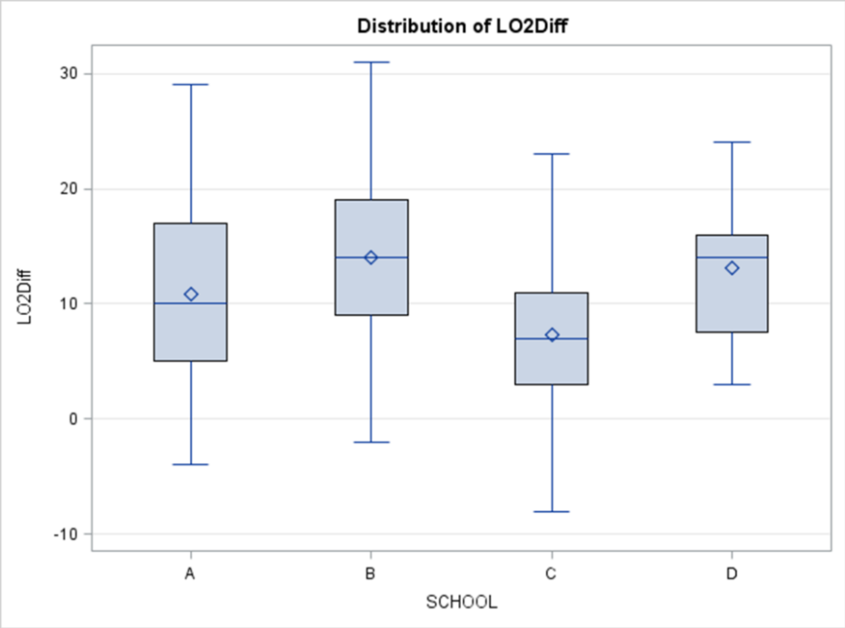


Figure 4.20: Box and whisker plots comparing learning gain differences between schools for the Learning Outcome 2 questions

Figure 4.20 shows the box and whisker plots for the differences between the learning gains for the LO 2 questions. School A had a learning gain of 10.8, about 14 for School B, 7.35 for School C and 13.14 for School D.

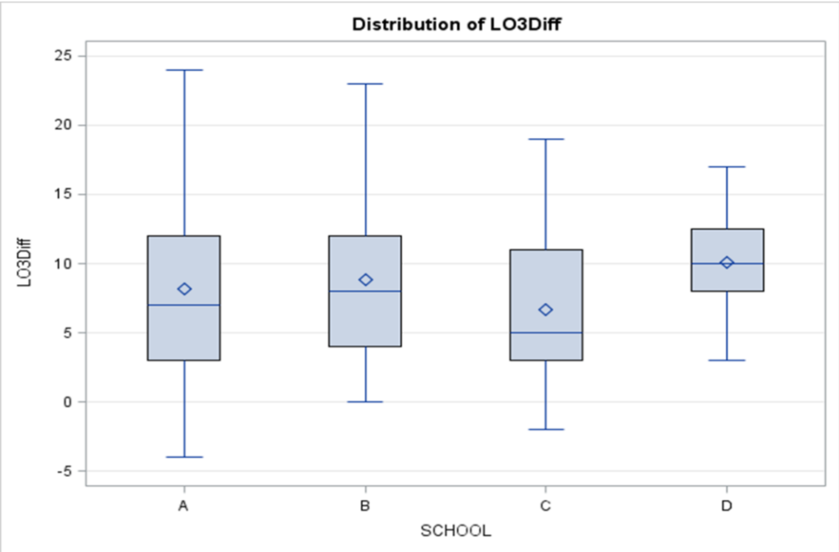


Figure 4.21: Box and whisker plots comparing learning gain differences between schools for the Learning Outcome 3 questions

Figure 4.21 shows the box and whisker plots for the differences between the learning gains for the LO 3 questions. School A had a difference between the means of 8.20, School B had 8.83, School C had 6.63 and School D had 10.07. The implications of the data presented in the box and whisker plots will be discussed together with the Scheffe's test findings in 4.2.3.4.

4.2.3.4 The Scheffe's test comparing learning gains between paired schools

The learning gains differences were then used to carry out a Scheffe post-hoc test specifically which was used to determine if there were statistically significant differences between the learning gains of schools in pairs. The differences between the pre-test and post-test (learning gain) for each school were used to compare with the learning gain of another school and the significant differences in learning gain were established. Each pair of schools had a comparison for each of the six variables, however, Table 4.26 only presents school pairs with statistically significant differences between learning gains for the different variables to avoid results overload.

Scheffe's test was computed as follows $\sqrt{}$ (k-1) $F_{critical}$ $\sqrt{}$MSE ($1/n_1 + 1/n_2$) and the results for the comparison between the difference of the means per paired schools.

Table 4.26: Comparison between school groups' learning gains in pairs

Variables	School comparison	Difference between the learning gains	Significance ($p< 0.05$)
Total	B-C	7.669	***
	C-D	9.208	***
Problem-solving	B-C	7.061	***
	C-D	7.817	***
LO 1	A-B	1.9263	***
LO 2	B-C	6.652	***
	C-D	5.795	***

Schools B and C had a learning gain difference of 7.669 which is significant at 0.05 level of significance. The same schools also had statistically significant differences between the learning gains for problem-solving questions of 7.061 and 6.652 for LO 2 questions 0.05 level of significance. In all three variables, School B had higher mean differences in comparison with School C. It is worthwhile to note that while schools B and C have adequate laboratory facilities and apparatus, they still exhibited significant statistical differences between the learning gains for three variables which were for the total mark, problem-solving and LO 2.

This could be attributed to the teaching approaches employed by the teacher as observed by the researcher. It was evident to the researcher during lessons observations that learners from School B were given an opportunity to dissect and explore the animal organ independently with minimal guidance from their teachers. On the contrary learners from School C had very little independent participation as the teacher overly assisted the groups on the slightest hitch. As a result learners may not have fully engaged with animal organ dissections to acquire the necessary skills to enhance their performance in the post-test.

Schools C and D had a difference of 9.208 which is significant at 0.05 level of significance for the total mark. The same schools had a difference of 7.817 for problem-solving questions and 5.795 for LO 2 questions, both of which are significant at a significance level of 0.05. In all three variables, there were statistically significant differences between the learning gains of the two schools with School D having a higher learning gain. It is worth noting that School D, despite having limited laboratory facilities and apparatus, showed a bigger learning gain difference than School C which has adequate laboratory facilities and apparatus. It can be argued that the greater improvement in scores for School D may be attributed to the intervention which was animal organ dissections carried out by the learners. The learning gain for School C, once again is lower than School D, despite having an upper hand on laboratory facilities, owing most likely to lack of full engagement with animal organ dissections as highlighted earlier on.

The comparisons of the group learning gains for the LO 1 questions resulted in schools A and B having difference of 1.9263 which is less than the level of significance $p<0.05$. This means that there was a statistically significant difference between the learning gain difference of School A and B. It is not surprising that these two schools have a significant difference in their learning gains for LO 1. Irrespective of School B having adequate laboratory facilities and apparatus unlike School A which has limited laboratory facilities and apparatus, School A had a higher difference between the pre-test and post-test mean. It may be asserted that the level of engagement with the animal organ dissections for School A could have been enhanced by the positive attitude of the learners as they carried out the animal organ dissections and when answering the post-test questions. Some of the School B learners adopted the same negative attitude that their teacher was exhibiting which lowered their level of engagement with the animal organ dissections. As a result there was significant difference between the learning gains of Schools A and B.

As was observed with the Analysis of Variance (ANOVA) in Section 4.2.3.2, there were no significant differences in rote learning means and LO 3 means amongst the four schools. This may have been because rote learning variables can be theoretically addressed with a minimal level of engagement with animal organ dissections on the part of learners from different school environments. As for Learning Outcome 3, it may be because the learners (from the four different school environments) may have managed to apply the knowledge acquired to society at almost the same level irrespective of the different learning environments.

4.3 SUMMARY OF THE PRESENTATION AND DISCUSSION OF THE QUANTITATIVE DATA

In this Chapter 4, the presentation and discussions of the quantitative data has brought to the fore the following:

- Firstly, the Cronbach's Alpha reliability test results for the questionnaire, the pre-test and the post-test were presented showing that all three instruments were reliable.
- Secondly, the descriptive data from the Sections A, B and C of the questionnaire which was completed by the 224 learners from the four selected schools was presented and discussed in terms of the frequencies, graphs, percentages and cumulative frequencies. Some of the highlights established from the questionnaire data include the finding that only 42.86% of the learners had actually carried out hands-on animal organ dissections while 57.14% of the learners had never carried it out in previous grades. This brings out the stark fact that a large proportion of learners progress to higher grades without fulfilling some of the requirements of the National Curriculum Statement. A cumulative percentage of over 90.00% of the learners are of the opinion that animal organ dissections are useful in learning and understanding of the structure and function of the organ. This is a positive aspect as it means that learners may be more receptive to the animal organ dissections.
- A Chi-square test was run to explore the association between school environment and culture. The test results showed that there is a statistically significant association between the school environment and culture at a confidence interval of 95% with the p-value ***$p<0.0001$. The high significance of association justified the use of the diverse school environment as a significant variable rather than both variables
- Thirdly, inferential statistics compared the performance of the learners in the pre-test that is before the intervention which was animal organ dissections and in the post-test.

The inferential statistics were applied to establish the statistical significance of the differences between the means of the pre-test and the post-test scores using the Matched T-test. The Post-test minus Pre-test matched T-test comparisons were all highly significant with p-values <0.0001. All six tests had DF=223.

- The statistics for learning gains with respect to schools, Gender and moral position of learners was determined using the ANOVA procedure. It was established that there were statistically significant learning gains between the means of the pre-test and post-test among the schools for four of the six variables which are: the total mark, problem-solving, LO 1 and LO 2.
- To establish the differences between the learning gains of the schools in pairs, the Scheffe's test was used. It was established that the teaching approach and the availability of adequate laboratory facilities and apparatus play crucial roles in the level of engagement with animal organ dissections by leaners.

In Chapter 5, the presentation and discussion of the qualitative data from the interviews with the teachers and lessons observations will be done. The presentation of both quantitative and qualitative data is in the hope of deepening the understanding on possible reasons for the findings of the study and synthesis of both chapters will be reported in Chapter 6.

CHAPTER 5

FINDINGS DRAWN FROM THE QUALITATIVE DATA

5.1 OVERVIEW OF THE CHAPTER

The previous chapter presented and discussed the findings drawn from the quantitative approach while this chapter presents and describes the findings drawn from the qualitative approach. Interviews with the Life Sciences teachers and lessons observations were the instruments used to collect data qualitatively. After the collection of qualitative data, the researcher familiarised herself with it as a way of establishing patterns which would help her to develop a coding system. This coding system was used to summarise the data collected from the teachers that were interviewed and from the lessons that were observed. A logical analysis method was applied to extract the information and to create themes and categories. The activities of the Life Sciences teachers and their learners during the lessons were recorded and summarised into eight themes which were divided into numbered code categories and tabulated according to the teachers' activities, class activities and specific comments based on activities of interest during the lessons. The eight themes in which the lessons were broken down were:

(1) Classroom organisation before the dissections lesson commenced;
(2) The writing of the pre-test
(3) The lesson introduction by the teacher;
(4) The teaching method or approach;
(5) The teacher-learner interaction;
(6) The subject content;
(7) Other important points, for example post-observation points, and
(8) Specific comments of interest.

Although there are different software programmes such as ATLAS/ti which can assist in the development of a coding scheme, in this study it was decided to code and analyse manually because the number of respondents and the data generated by the interviews and the lessons observations were manually manageable (See Appendix II and IV). The ATLAS/ti software is especially useful when an unstructured or open instrument is used to generate data, but during this study structured and semi-structured teachers' interviews and an observation schedule for the lessons observations were used. This meant that the coding was based on structure already present in the instruments before the data analysis started. As explained in Chapter 3, written permission was sought and granted by the Gauteng Department of Education, the principals of the selected schools, the Grade 11 Life Sciences teachers, the parents of the learners and the learners to conduct the research at the four schools.

5.2 DATA FROM LESSON OBSERVATIONS AND THE RECORDED VIDEOS

The lessons observations of the animal organ dissections, group discussions, the writing of the pre-test and the post-test by learners were recorded on an observation checklist and video-recorded as well. The video recording was used by the researcher to back up and capture information such as behaviour patterns of learners or any other events of interest which the researcher might have missed or had not captured on her observation checklist.

The lessons observations were carried out for all six teachers during which animal organ dissections, group discussions and the writing of the post-test were done. For anonymity and confidentiality purposes, pseudonyms were assigned to each teacher as follows:

School A – Thato (Teacher 1; T1) (49 learners) School B – Yvonne (Teacher 3; T3) (27)
Mark (Teacher 2; T2) (48) Bertha (Teacher 4; T4) (26)
School C – Mary (Teacher 5; T5) (2 x 23= 46) School D – Tia (Teacher 6; T6) (28)

The number of learners per class is indicated in the second bracket. The results obtained from this qualitative data was presented in a narrative format, with reference to specific class activities where they contributed to strengthen arguments. Tabulated and categorised data from the class activities was attached as Appendix II. All the teachers were guided by the same dissection lesson plan which included time allocation for each activity and they provided learners with dissection worksheets (Appendix V & VI).

The purpose of these lessons observations was to answer research sub-questions two, three, four, five and six:

2. *How do teachers use animal dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners?*
3. *How does learners' engagement with animal organ dissections aid in developing problem-solving skills?*

4. *What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*
5. *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?*
6. *To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?*

In observing the teachers and their learners carrying out dissections of animal organs, the researcher's intention was to be able to answer some of the research questions which focused on the following: (a) How teachers used animal organ dissections in problem-solving as a teaching strategy; (b) Problems learners experienced as they were carrying out animal organ dissections; (c) The extent to which the three Learning Outcomes of the National Curriculum Statement in Grade 11 Life Sciences were being achieved using animal organ dissections and; (d) How learners engaged with dissections and used it in developing problem-solving strategies.

5.2.1 Classroom organisation activities before the dissection lessons commenced

On the observation checklist (see Appendix I), the first theme was to observe the activities by the teachers and the learners during the time of classroom organisation from when the learners walked into the laboratory or classroom until they were settled and ready to start their lesson. The researcher observed different patterns of learner behaviour from different classes and their teachers which are summarised in Table 5.1.

Table 5.1: Classroom organisation activities before the dissections lesson commenced

Activities codes	Teacher code name	Specific comments
1.1 Learners settled down <5min to settle down 5-10min to settle down	 T3, T5 T1, T2, T4, T6	School A: More time to settle learners. because of large numbers and lesson after school. School B: Bertha's classes had a casual Attitude, both learners and the teacher dragging their feet. School D: Lesson after normal school hours.
1.2 Learners attentive as they receive pre-tests	T1, T2, T3, T4, T5, T6	Pre-test written for 25minutes and collected
1.3 Learners attentive	T1, T2, T3, T5	Waiting for the next instruction
1.4 Learners inattentive	T4, T6	As the researcher was placing the organ, some started fiddling with the organ.
1.5 Learners late	T4, T6	School B: Some learners dragged their feet to get to the lesson in Bertha's class. School D: Some learners were approximately 10 minutes late from lunch.
1.6 Learners distracted by latecomers	T4, T6	Latecomers distracted others as they joined their groups.
1.7 Learners sit in groups	T1, T2 T3, T4 T5, T6	Thato and Mark's groups 5-7 learners. Yvonne and Bertha's groups 3-4 learners. Yvonne assigned the learners into groups separating naughty ones. Mary's learners were in pairs and Tia's learners were in 3s. Female students complaining about the smell of the kidneys.
1.8 Learners waiting for the teacher's introduction	T1, T2, T3, T4 ,T5, T6	Mark and Bertha's learners impatiently waited, eager to start dissecting.
1.9 Teacher stands in front of the class	T1, T2, T3, T4, T5, T6	Teacher introduced the researcher and explained why she was at their lesson.
1.10 Dissections instruments set up on working tables by the teacher	T1, T3, T5	The practical was set up before the lesson.
1.11 Dissections instruments set up on working tables by the researcher	T2, T4, T6	School A and D: Researcher brought the kidneys to be dissected and teachers helped her to set up. Researcher set up for Bertha to save time because she had not set up before the lesson.

As the learners were coming to their Life Sciences lesson during the normal school hours for Schools B and C, they seemed more in a hurry than when the Schools A and D learners were coming from lunch for the dissections lesson after the normal contact time. As a result of this, Yvonne (T3 from School B) had her class settled in less than five minutes and this also applied to Mary's classes (T5 from School C). Unlike those groups, Bertha's classes (T4 from School B) took more than five minutes to settle down and the researcher could already see a casual attitude in the learners, and the teacher was not doing anything to hurry them up. Learners from Schools A and D took between 5 and 10 minutes to settle down. Learners from

School A took longer than School D because of the large numbers of learners in both Mark's (T2 from School A) and Thato's (T1 from School A) classes. Tia's (T6 from School D) learners were late because they had to go for lunch and then come back after lunch for the lesson. Some trickled in distracting the other learners that had come on time and settled in groups.

Once settled, the learners were attentive as they received the pre-test, which they wrote for 25 minutes. When the pre-tests answer scripts were collected, Thato, Mark, Yvonne and Mary's learners were attentive and ready for the next instructions. In Bertha and Tia's classes, learners were inattentive and some learners were fiddling with the organ as the researcher was placing the organs on their workstations. Some of the learners were grumbling about why they had to do dissections and especially in the afternoon. Since they were choosing their own groups, they spent much time moving from one group to another. Yvonne assigned the learners into groups to ensure that the naughty learners were in separate groups. Mary did the same but before putting them into groups she let them sit on the classroom side so that they would pay attention to all her instructions without being distracted by the organs and the instruments which were already set for the practical on the workstations. When she had finished with all her instructions, the learners then moved to the laboratory side in the pairs assigned by the teacher.

All six teachers introduced the researcher and explained the reason for her observing their lesson. The learners expected the lesson observations since it was explained in the consent letter they had signed. During the introductions, Mark's learners were eagerly and excitedly waiting to start the dissections even before the lesson was introduced.

By the time the researcher arrived, Yvonne and Mary had already set-up the dissections instruments on the working tables or desks. The researcher did the set-up for the dissections instruments and the kidneys she had brought for the disadvantaged schools (lack laboratory facilities and apparatus) with the help of Thato, Mark (School A) and Tia (School D). Even though Bertha had the instruments and the organs, the researcher only set them on the working tables when she arrived, with the learners already in the laboratory.

5.2.2 Lesson introduction by the teachers

As with any other lesson, the researcher observed how the different teachers introduced their lessons with a time allocation of ten minutes and how the learners responded to their teachers' introductions. Her observations are recorded in Table 5.2.

Table 5.2: Introduction of the dissections lesson by the teacher

Activities codes	Teacher code name	Specific Comments
2.1 Teacher reviews previous work by asking questions	T3, T5	Thato, Mark and Tia: Previous work was not discussed due to time pressure. Bertha did not review previous work.
2.2 Learners participate by answering questions based on the previous work	T3, T5	Learners participation enabled the lesson to progress on time.
2.3 Teacher provides an overview of the lesson (expected outcome)	T1, T2, T3, T5, T6	Teachers summarised the objectives and expectations of the lesson. Bertha did not give the overview of the lesson.

Yvonne and Mary introduced their lessons by asking learners questions on the previous lessons which were on the urinary system and their learners participated actively which enabled the lesson to progress to the next stage within five minutes. Thato, Mark and Tia did not revisit the work done in previous lessons. They later justified to the researcher that the reason for not recapping the previous lesson was because they wanted to give their learners more time to carry out the dissections of organs and to write the post-test before 4p.m as some of them used buses which picked them up at that time. Bertha did not review the previous work, and for that day's lesson, she asked the researcher to explain to the learners what the expected outcome of the lesson was. Thato, Mark, Yvonne, Mary and Tia summarised the objectives and expectations of the lesson.

5.2.3 Teaching methods applied during the animal organ dissections lessons

The success of every lesson depends on how the teacher delivers the lesson. Taking that into consideration, the researcher observed and recorded the different teaching methods that the teachers applied in the dissections lessons. Her observations are recorded in Table 5.3.

Table 5.3: Teaching methods applied by the teachers

Activities codes	Teacher code name	Specific comments
3.1 Teacher reviews learners' knowledge of animal organs	T1, T3, T5	Thato, Yvonne and Mary encourage learners to discuss their knowledge in their small groups and ask questions to remind them of their theoretical knowledge.
3.2 Learners contribute the theoretical knowledge acquired on animal organs	T1, T2, T3, T4, T5, T6	Learners debated their theoretical knowledge in their groups. In Tia's class, the less casual learners contributed to the discussions constructively.
3.3 Provides worksheet with dissections instructions	T1, T2, T3, T4, T5, T6	Learners were instructed to read the worksheet carefully.
3.4 Learners receive the worksheet and read it carefully before starting the dissections	T1, T2, T3, T4, T5, T6	Thato, Yvonne, Mary and Tia read the worksheet together with the learners and explained.
3.5 Provides learners with the organ to be dissected	T3, T4, T5	School A and D: Researcher provided the kidney due to financial constraints, some learners brought their own kidneys. Mary's learners requested gloves to avoid touching blood.
3.6 Learners receive the organ and place it on the dissecting table and wait for further instructions	T1, T2, T3, T5	Bertha did not offer any further instructions, some learners had started handling and pricking the organ. Generally some learners were disgusted by the organ.
3.7 Demonstrates the step by step dissection procedure	T1, T3, T5	Mark and Tia explained theoretically with the aid of a diagram how the dissection was to be done. Bertha did not explain or demonstrate the dissection.
3.8 Teacher well-skilled in dissection	T3, T5 T1	Yvonne and Mary showed a lot of expertise in dissection. Thato struggled with the dissection as she was using improvised cutting instruments.
3.9 Learners pay attention to the dissection demonstration by the teacher	T1, T3, T5	Mark, Bertha and Tia's learners were impatient and restless, wanted to start without explanations.
3.10 Employs learner-centred approaches (learners dissect the organs in small groups)	T1, T2, T3, T4, T5, T6	Thato, Yvonne and Mary: Teacher facilitated learner-centred approach. Mary assisted the learners more than necessary. Mark and Bertha: completely learner-centred approach. Tia sometimes moved around guiding the learners, but it was mostly learner-centred. Learners helped each other in handling the organs and cutting in all the classes.
3.11 Teacher discipline management (ensure groups not distracting each other)	T1, T3, T5	Mark and Bertha were not very involved. Mark and Bertha were seated at their desks marking and just shouting for learners to keep quiet and discuss quietly. Bertha's learners moved between groups, some fiddled with dissection instructments. and some were on their cell phones. Some of Tia's learners took photos of the kidney and of themselves, using their cellphones.

3.12 Learners carry out dissections in groups	T1, T2, T3, T4, T5, T6	Mary: Dissections were carried out in pairs since they had adequate dissection tools and ensured maximum participation, in discussions as well.
3.13 Learners handle scalpel, dissection scissors, dissection pins with caution	T1, T2, T3, T4, T5, T6	School A and D: Scalpel handling was problematic because it was improvised instruments like razor-blades and knives, no dissection boards and pins. Some School B learners fiddled with their dissection instruments.
3.14 Learners use tools as indicated	T3, T4, T5	School B and C: Adequate instruments, some learners handled the dissection tools as per instructions but some still struggled. In all four schools: there were some neatly done dissections but removal of capsules was problematic.
3.15 Learners show respect to the specimen by not fooling around with it	T1, T2, T3, T5	Bertha and Tia: Some learners started mutilating the organs after dissecting them.
3.16 Teacher invites the small groups to discuss what was observed	T1, T2, T3, T4, T5, T6	Teacher encouraged learners to discuss what was observed on the dissected organ. Thato, Yvonne and Mary ensured that constructive debates were taking place by moving around the groups. Tia and Bertha assisted the learners in their discussion while seated at their desks.
3.17 Learners initiate discussions and participate actively	T1, T2, T3, T4, T5, T6	Learners showed great enthusiasm irrespective of the apparatus limitations in Schools A and D. Discussions were orderly.
3.18 Teacher provides learners with ill-structured problem-solving questions to answer individually	T1, T2, T3, T4, T5, T6	Questions formulated by the researcher were given to each learner.
3.19 Learners answer the questions individually	T1, T2, T3, T4, T5, T6	Some learners in Bertha's class rushed through their work leaving many unanswered questions.

Before the dissection worksheet was given to the learners and they were instructed to spend about 30 minutes on the dissection activity and discussions with the guidance of the teacher. Thato, Yvonne and Mary encouraged learners to discuss in their small groups the theory they had studied on animal organs and asked them questions to help them remember the knowledge on the kidney as it would help them during the dissections. Without much encouragement from the teachers, Mark, Bertha and Tia's classes started debating about the organs even before they started dissecting the kidneys. All six teachers provided the learners with worksheets which had the dissection instructions and asked them to read them carefully (see Appendix VI). Thato, Yvonne, Mary and Tia read and explained the instructions to the learners to ensure that they understood the instructions. As the learners received the kidneys, some learners could not stand the sight of blood and the smell, and were covering their noses in disgust. Mary's learners told her they would only touch the kidneys if she provided them with gloves, which she did.

Once the organ was received, the researcher could see some degree of unrest as the learners just wanted to dissect the kidneys but Thato, Yvonne and Mary instructed them to observe first as they demonstrated the dissection procedure to each of their classes. The learners were very attentive to these demonstrations. Yvonne and Mary showed a lot of expertise in dissection but Thato also showed that if given efficient dissecting instruments, she would also do a good dissection. Mark and Tia did not do a hands-on demonstration of the dissection but they used diagrams to explain theoretically how dissections were done and their learners were just eager to start the dissections before they finished explaining. Bertha did not explain or demonstrate the dissection; she just instructed them to follow the worksheet instructions.

All six teachers employed the learner-centred approach but Thato, Yvonne and Tia employed a guided learner-centred approach, guiding the learners to dissect and observe the important parts. They were to relate them to their functions so as to fulfil the objectives of the lesson and manage to answer the post-test on time as well. Mary was moving around assisting her learners with the dissections and group discussions most of the time. Mark and Bertha were seated at their desks most of the time while their learners dissected the kidneys. The learners identified and discussed without much guidance from the teachers unless they went to the teacher's desk to ask for assistance which was not always possible, especially with big groups as in Mark's class. Generally the learners helped each other in handling the organs as they struggled to cut because of its slippery texture. In Schools A and D, the razor-blades were too small to cut deep into the kidney resulting in some rough dissections.

The researcher observed that the discipline of the classes in which the teachers were moving round the groups was much better than where the teachers were less involved. In Tia's class, while she was seated at her desk, some learners just moved between groups distracting the other learners, and some fiddled with the scalpels and their cellphones. Bertha's learners also played on their cellphones as she was busy marking and shouting to keep them quiet. The most disciplined classes were Thato, Yvonne and Mary's classes and the three were involved and moving between groups throughout the entire lesson.

All six teachers instructed the learners to carry out the dissections in their groups. The number of learners in each group varied between schools, depending on the class sizes and the availability of dissection instruments. The smallest groups were in Mary's classes where the dissections were carried out in pairs since they had adequate dissection tools. Working in pairs ensured maximum participation of the learners in carrying out the dissections of the organs and in discussions as well. She decided to make them work in pairs so that they could assist each other to dissect the organ and then discuss what they were observing. In Yvonne and Bertha's classes, groups consisted of 4 learners, while it was 3 learners per group in Tia's class. The biggest groups were in Thato and Mark's classes where the dissections were carried out in a group of seven learners and not all learners participated. The main problems the learners had, as observed by the researcher, were:

- The handling of the dissection instruments owing to the instruments being either blunt or the improvised instruments like the razor-blades being too small in the case of Schools A and D.
- In the case of Schools B and C which had adequate instruments, the learners also showed the problem of handling the dissection instruments. The scalpels were slippery because of blood and the organ texture also made it difficult for them to cut it owing to its slippery nature.
- Very few groups managed to remove the capsules neatly with the rest of the learners struggling to remove them at all. Mary and Yvonne assisted their learners to remove them.
- Some learners in Bertha's class were observed fiddling with the dissection instruments playfully and mutilating the organ after they had identified the organ parts. This had the effect of distracting those learners who were still carrying out the dissections.
- Tia allowed her learners to take some photos of the dissected kidney using their cellphones for the benefit of their classmates who had refused to look at the actual dissections taking place. Some of the learners were observed taking photos of themselves to which Tia responded by confiscating the cellphones.

All the teachers encouraged learners to discuss what they had observed on the dissected organ. Constructive discussions and arguments with the guidance of the teachers in most cases, some teachers asked questions which guided the learners' thoughts towards solving given problems, by engaging more with dissections. Thato, Yvonne and Mary ensured that constructive debates were taking place by moving around the groups, posing questions and interacting in the discussions when it was necessary. Mark encouraged them to discuss the posed questions and go to him if they could not agree on certain concepts. Tia assisted the learners in their discussions while seated at her desk and Bertha was still marking but also encouraged them to discuss in their groups; the discussions were carried out by learners without her guidance. The learner discussions were very enthusiastic. The learners from School A were the most enthusiastic irrespective of having used limited dissection instruments and laboratory facilities.

All six teachers provided the learners with the post-test which was formulated by the researcher. The post-test was to be compared with the pre-test that the learners wrote before the intervention, which was the animal organ dissection. The teachers made sure that the test was done as individual work, but some learners especially from Bertha's class, rushed through the work leaving some questions unanswered. Equal time (25 minutes) was allocated to answer the pre-test and the post-test. It is acknowledged that the discrepancy in the group sizes between schools may have influenced the post-test performances but one way of looking at it is that, the big groups had an advantage of more contributions from group members but there was a disadvantage of minimised hands-on participation. On the other hand the smaller groups were ensured of maximum hands-on participation with a disadvantage of fewer contributions from group members. Both situations had advantages and disadvantages and because of discrepancies in resource availability, groups had to work as they usually do in their practicals according to the school context.

5.2.4 Teacher-learner interaction

The interaction between the teachers and their learners is of vital importance for an effective teaching and learning process. One of the aspects that the researcher focused on was how the teachers interacted with their learners during the dissections lesson. Her observations are recorded in Table 5.4.

Table 5.4: Interaction between the teachers and the learners

Activities codes	Teacher code name	Specific comments
4.1 Teacher moves around assisting learners with the dissection when necessary and ensuring discipline	T1, T3, T5	The three teachers were very involved every step of the way assisting their learners. e.g Yvonne gave de-merits to two learners fiddling with their cellphones on social sites. Mark, Bertha and Tia were seated at their desks; if learners needed help they would go to the teachers' desk. Tia occasionally moved around.
4.2 Ensures and encourages all learners in the group participate actively	T1, T2, T3, T5	All learners were participating either dissecting or sticking labels on toothpicks and onto the organ parts. Bertha and Tia: some learners were using their cellphones to take pictures of the organs or friends.
4.3 Provides dissections alternatives to learners uncomfortable with real organs dissections	T4, T6	Bertha and Tia encouraged learners who were uncomfortable with dissecting to either watch others dissect, take photos of the dissected organ or to Google on their cellphones the dissections procedure. None of the teachers had artificial organs as alternatives to real organs. Mark and Thato told learners it was for marks so they had to participate or forfeit the marks. Yvonne encouraged the learners uncomfortable with dissecting to watch others dissect.
4.4 Learners ask the teacher for assistance when necessary	T1, T2, T3, T5	Thato, Mark, Yvonne and Mary were hands-on assisting the learners especially as they struggled to separate the capsule from the kidney. Bertha and Mark hardly assisted as they were seated at their desks and few learners approached them for help.
4.5 Learners actively participate in the dissection	T1, T2, T3, T4, T5, T6	Most learners were fascinated by the dissections.

Thato, Yvonne and Mary were highly involved throughout, assisting and ensuring discipline in their learners. Mark occasionally stood up and assisted the learners when they were struggling with the use of dissection instruments or when they could not agree on the labelling of the organ parts. The four teachers ensured that all the learners were participating. Each learner was supposed to either dissect the kidney or stick labels on toothpicks and then onto the organ parts as identified and agreed by the group. As for Bertha's classes, some group members were actively participating while a few others were fiddling with their cellphones or taking pictures of the organs or their friends.

In the classes of five of the six teachers, all except Mary's class, there were some learners who indicated that they were uncomfortable with the dissections for different reasons like feeling nauseous, being vegetarian, blood phobic, the smell and being squeamish. Bertha and Tia encouraged learners who were uncomfortable with dissections to either watch others dissect, take photos of the dissected organ or to Google on their cellphones the dissections procedure. Mark and Thato told learners it was for marks so they had to participate or forfeit the marks. Yvonne encouraged the learners uncomfortable with dissecting to watch others dissect and then participate in identifying the parts of the organ and the group discussions. None of the teachers had artificial organs as alternatives to real organs. They indicated that they were not aware of artificial organs which could be dissected and some felt it would be costly for their schools to use such organs.

The learners' participation was enthusiastic and they showed a lot of interest and fascination in the dissections but when it was time to write the post-test, some of Bertha's and Tia's learners were grumbling and did not understand why they had to write a tough test like that one but they wrote it anyway. All learners were persuaded by their teachers to write and finish their post-test in the allocated time and most of them finished on time.

5.2.5 Content covered and linked in the animal organ dissections lessons

The researcher acknowledged that the dissections of the kidney were linked to some theoretical content which the learners were supposed to acquire and consolidate in the dissections lesson. Taking this into consideration she also focused on how the teachers guided the learners to link the observed with the concepts they had covered during the theory lessons on the urinary system. Please refer to Table 5.5.

Table 5.5: Content covered and discussed in the dissections lessons

Activities codes	Teacher code name	Specific comments
5.1 Teacher links what was observed with anatomy and morphology concepts	T1, T2 T3, T5 T4, T6	Thato and Mark asked learners to link what was observed with morphology concepts. Yvonne and Mary cited specific examples of the observed kidney parts, relating their structures to functions. Bertha and Tia just encouraged learners to do group discussions; not much input from the teachers.
5.2 Teacher relates what was observed with real life health situations	T1, T3, T5	Yvonne moved around groups showing them parts of the kidney which could have kidney stones, implications of blockages in the tubules. Mary reminded them of the role of the nephron and how the dialysis machine resembles the role of the nephron. Thato discussed with the learners implications of the blockage of the ureter considering its position and function.
5.3 Learners participate actively	T1, T2 T3, T4 T5, T6	Groups were too large, so some learners were idle. Since groups were smaller, most learners participated. Mary: all leaners participated and in Tia's class some just sat because they refused to dissect.
5.4 Learners manage to link What was observed with how to solve real life health situations	T1, T2 T3, T4 T5, T6	Learners discussed health implications of blockages. In their discussions, learners reflected on the different parts of the organ and the health implications. Leaners discussed roles of dialysis and kidney failure.

Thato and Mark, the teachers from School A, encouraged their learners to relate the structures of the kidney they were observing with the functions of each structure they had discussed in the previous lessons. Yvonne and Mary cited different examples of the observed kidney structures with their functions reminding the learners of the theory they had covered in class. Bertha and Tia just encouraged learners to do group discussions, without much input from themselves as the teachers. As a way of linking what was observed with real life health situations, Yvonne moved around the groups showing the learners the parts of the kidney which could have kidney stones and the implications of blockages in the tubules. Mary reminded them of the role of the nephron and how the dialysis machine resembles the role of the nephron. Thato discussed with the learners the implications of the blockage of the ureter considering its position and function. Following their teacher's instructions and guidance, the learners participated in the discussions actively but in some cases, as in Thato and Mark's classes, groups were too large, so some learners were idle or just observing. Thato's learners focused on the health implications of blockages and some of the learners shared their real life experiences. In Yvonne and Bertha's classes, the groups were smaller; most learners participated in the discussions where they reflected on the different parts of the organ and the health implications. In Mary's class, all leaners participated since they were working in pairs. In Tia's class, some learners worked actively but some just sat giving reasons like being vegetarian and their religion; they only observed the dissected organs afterwards and then drew the diagrams. Their focus was on health implications, kidney failure and dialysis. Tia guided the learners through the discussions.

5.2.6 Other important points taken note of during the lesson observations

There were some other points which the researcher considered important to take note of: the use of language by both the teachers and the learners, if relevant content was covered during the lesson, if there were any learning moments on the part of the learners and if the curriculum expectations, especially in terms of the three learning outcomes, were met. Please refer to Table 5.6.

Table 5.6: Other important points observed during the lesson observations

Activities codes	Teacher code name	Specific comments
6.1 English language used in discussions	T1, T2, T3, T4, T5, T6 T1, T2	General instructions were given in English but discussions in small groups were done in mixed languages (vernacular, Afrikaans or English). Some instructions and discussions, especially regarding discipline, were done in vernacular.
6.2 Relevant content covered by the practical	T1, T2, T3, T4, T5, T6	The worksheets, post-test, instructions, guided the learners towards the relevant content to be covered.
6.3 Learners had many learning moments through the practical and discussions	T1, T2, T3, T4, T5, T6	For most learners in Schools A and D, it was their first time to dissect, feel the texture and observe a real organ, its parts. Constructive discussions were held in groups; even shy learners were encouraged to speak up in smaller groups.
6.4 Meets the curriculum expectations	T1, T2, T3, T4, T5, T6	On the part of the learners.
6.5 Learning Outcomes 1, 2 and 3 achieved by this lesson	T1, T2, T3, T4, T5, T6	All Learning Outcomes were achieved: LO1: Hands-on dissections LO2:Knowledge acquired and question sanswered LO3: Discussions relating the organ parts observed to societal problems relating to them.

All six teachers generally gave their instructions in English but the researcher noticed that the discussions in the small groups were in mixed languages, depending on the predominant language in the school. She noted that Thato and Mark gave some of their instructions in vernacular and especially when it came to issues regarding discipline; unfortunately the researcher did not understand the language. In all six classes the relevant content was covered by giving the learners worksheets, post-test and instructions which guided them during the dissections towards the relevant content to be covered.

There were quite a few learning moments for most learners at different schools; for most learners in Schools A and D, it was their first time to dissect, feel the texture and observe a real organ and its parts. Constructive discussions were held in groups; even shy learners were encouraged to speak up in smaller groups regarding the organ, its structures, functions and relevant real life situations. The curriculum expectations were met on the part of the learners by fulfilling all three learning outcomes. For instance, Learning Outcome 1 was achieved by the hands-on dissections, Learning Outcome 2 by the knowledge acquired and answering the given questions, and Learning Outcome 3 was achieved through the discussions relating the organ parts observed to societal problems relating to them.

5.2.7 Specific comments pertaining to different schools

It was noted with great interest how different the facilities were between the four schools and how the teachers from the disadvantaged schools enabled their learners to carry out the dissections irrespective of the limited laboratory facilities and apparatus. Refer to Table 5.7.

Table 5.7: School specific comments

Activities codes	Teacher code name	Specific comments
7.1 Improvised dissection tools	T1, T2, T6	White paper used in place of dissection board. Razor- blades used instead of scalpels. Desks used due to lack of laboratory facilities.
7.2 Group sizes	T1, T2 T3, T4 T5 T6	Group sizes ranged between 5 and 7 learners in a small venue, made it a bit difficult to control noise levels. Group sizes of 3-4 learners in a big laboratory. Learners in pairs in a big laboratory. Groups of 3 learners in a classroom.

Thato, Mark and Tia improvised almost all the dissection tools; the learners were provided with white or filter paper in place of dissection boards which the schools did not have. Razor-blades were used instead of scalpels because they either did not have them or they were too old or blunt to cut through the slippery kidney. Desks were used in place of laboratory tables and that was a bit difficult especially for large groups of up to seven learners. Group sizes varied depending on the schools. School A's group sizes ranged from 5-7 and working on the desks and in a small venue made it difficult to control the noise levels and learner participation. School B's group sizes ranged from 3-4 learners which was manageable in a big laboratory. School C's learners were in pairs in a big laboratory and school D learners worked in groups of three on desks.

5.3 DATA FROM INTERVIEWS WITH THE LIFE SCIENCES TEACHERS

Six teachers were interviewed because they were the Grade 11 Life Sciences teachers at the selected schools. For anonymity and confidentiality purposes, pseudonyms (see 5.2) were assigned to each teacher. The results obtained from this qualitative data was presented in a narrative format, with reference to specific verbatim quotes where they contributed to strengthen arguments. The data from the interviews with the Life Sciences teachers was summarised into coded categories which were labelled with numbered codes and the numbers of responses were recorded as frequencies. The tabulated and categorised data from the teachers' responses is attached as Appendix IV. The purpose of the interview was to answer research sub-questions one, two, four and six:

1. *What is the teachers' understanding and how well-acquainted are they with problem-solving strategies?*
2. *How do teachers use animal dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners?*
4. *What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*
6. *To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?*

5.3.1 Biographical data of the interviewed Life Sciences teachers

Of the six teachers interviewed, five were females and one male. Section A of the interview was closed-ended; the teachers had to fill in their biographical information on the spaces provided on the interview schedule. The biographical information required included their gender, age, religion, culture group, highest qualification, years of experience as Life Sciences teachers and the level of education when they first carried out dissections. It was deemed vital to gather the biographical information of the teachers for statistical purposes in the case of age and gender. Teachers were also asked their religion and culture group as these variables could possibly have some influence on the teachers' way of viewing dissections and their associated attitude. Data was also obtained on the teachers' highest qualification in order to determine whether they were qualified to teach Life Sciences. Question 6 was designed to obtain data regarding Life Sciences teachers' experience in the teaching of the subject; they were requested to state their teaching experience in years. This information was used to determine the experience of the teachers teaching the subject. Lastly, teachers were asked for their level of education when they carried out dissections for the first time. This information was used to determine how well-versed the teachers were with dissections as it would possibly have implications in the dissections lessons with their learners.

Table 5.8: Biographical information of the interviewed teachers

Biographical information	Categories	Codes	Teachers	Frequency
1. Gender	Female Male	F M	T1, T3, T4, T5, T6 T2	5 1
2. Age in years	20-29 30-39 40-50	20-29 30-39 40-50	T4 T6 T1, T2, T3, T5	1 1 4
3. Religion	Christian	Ch	T1, T2, T3, T4, T5, T6	6
4. Culture group	Afrikaans English North-Sotho	Afr Eng N-S	T4, T5 T3, T6 T1, T2	2 2 2
5. Highest academic qualification	Master's degree Honour's degree Postgraduate certificate Postgraduate diploma	MSc HD PGCert PGDip	T3, T1, T5, T6 T4 T2	1 3 1 1
6. Years of teaching Life Sciences	5-10 11-15 16-20	5-10 11-15 16-20	T4, T6 T3, T5 T1, T2	2 2 2
7. Level of education when first dissection was carried out	University College High School Never carried out dissection	Univ Coll HSch Never	T1, T3, T5, T6 T2 0 T4	4 1 0 1

Table 5.8 reflects the biographical data of the six teachers. The majority of the teachers (n=4) fall in the age category of 40-50. One teacher, Tia, is within the 30-39 age category and the other teacher, Bertha, is within the 20-29 age category. When it comes to religion, all six teachers were Christians but from different cultures; teachers Thato and Mark are North-Sotho, while teachers Yvonne and Tia are English and teachers Bertha and Mary are Afrikaans. School A, which has predominantly North-Sotho learners has two teachers of the same culture which is North-Sotho, while School B which has predominantly English and Afrikaans learners has an English teacher and an Afrikaans teacher. School C which has predominantly North-Sotho and Afrikaans learners has an Afrikaans teacher and School D which has predominantly North-Sotho learners has an English teacher.

From the data collected on the teachers' highest qualifications, all six teachers are qualified to teach Grade 11 Life Sciences Yvonne has a master's degree; she has teaching experience ranging between 11-15 years. She first carried out animal dissections at university level. Thato holds an honour's degree; she has teaching experience ranging between 16-20 years. She first carried out animal dissections at university level. Mary also holds an honour's degree; she has teaching experience ranging between 11-15 years. She first carried out animal dissections at university level. Tia holds an honour's degree; she has teaching experience ranging between 5-10 years. She first carried out dissections at university level. Bertha holds a Postgraduate Certificate in Education; she has teaching experience ranging between 5-10 years. She never carried out animal dissection during her schooling, only first carried out animal dissections together with her learners at school as a teacher. It was quite unsettling for the researcher to realise that a Life Sciences learner could attain a Postgraduate Certificate without having dissected at all during her schooling. It begs the question how much confidence such a teacher without any experience in any dissections will have to demonstrate the animal organ dissections to the learners before they carry out the animal organ dissections themselves. Lastly, Mark holds a Postgraduate Diploma in Education; he has teaching experience ranging between 16-20 years. He first carried out animal dissections at College.

5.3.2 Data from the semi-structured section of the interviews with the teachers

This section is comprised of responses given by the Grade 11 Life Sciences teachers from the semi-structured section of the interviews and the discussions based on these responses by the researcher. The implications of these findings will be further explored in Chapter 6 and relevant recommendations will be made in Chapter 7 which will deal with human resource development and the establishment of support structures that would support the schools and the Life Sciences teachers to maximise the use of animal organ dissections as a teaching strategy in problem-solving skills.

The Life Sciences teachers were asked 25 questions and in some cases, where there was need, some follow-up questions were asked. The responses are presented per question in categories; codes were given to the responses; the frequency was recorded, indicating teachers who concurred with each response. Pseudonyms in correspondence with the teacher code in the table will be used in the description. The pseudonyms key is under Section 5.2. The main focus of these questions was to establish how well acquainted the teachers were with problem-solving strategies and how they would use animal organ dissections to improve their teaching strategies.

5.3.2.1 The animal organ dissections in Life Sciences curriculum in Grade 11

The teachers were asked what the dissections in Life Sciences curriculum in Grade 11 were and the reasons for performing the dissections of the organs they mentioned.

Table 5.9: Responses regarding the animal organ dissections in Grade 11

Categories	Codes	Teachers	Frequency
Kidney	O1	T1, T2, T3, T4, T5, T6	6
Heart	O2	T1, T2, T3, T4, T5, T6	6
Easy to get	Rs1	T1, T2, T5	3
Cheap	Rs2	T1, T5	2
Part of the curriculum (pace setter)	Rs3	T1, T2, T3, T6	4

O = Organs dissected; Rs = Reason

All six teachers concurred that the kidney and the heart dissections were carried out according to the Grade 11 Life Sciences curriculum. When asked why they mentioned only two organs, three reasons were given which included that they were easy to get according to Thato (T1), Mark (T2) and Mary (T5). Thato and Mary also said because they were cheap to buy and Thato, Mark, Yvonne (T3) and Tia (T6) said they dissected the mentioned organs, especially the kidney, because it was a curriculum or pace setter requirement so they had to dissect those organs.

5.3.2.2 Other opportunities for dissections in the Grade 11 Life Sciences curriculum

In order to establish if the teachers were taking every opportunity to dissect or if it was just to fulfil the curriculum requirement, the researcher asked if there were other opportunities for dissections in the curriculum. Table 5.10 shows the responses by the teachers of what they could dissect besides the organs they had mentioned earlier.

Table 5.10: Other dissections opportunities in the curriculum

Categories	Codes	Teachers	Frequency
Digestive system	Op1	T1, T2	2
Animal Diversity e.g. starfish, earthworm, frogs, insects, piglet	Op2	T3, T5, T6	3
Skeleton	Op3	T4, T6	2
Plant organs	Op4	T4, T6	2
Lungs and tissues	Op5	T4	1

Op = Opportunities for dissections

Regarding other dissections opportunities the teachers could take, Thato and Mark acknowledged that it was possible to carry out dissections of the digestive system, though it was much more delicate than the kidney dissections which they carried out in their school. Yvonne, Mary and Tia concurred that in the topic of animal diversity one could carry out dissections of the starfish, earthworm, frogs, insects or piglets to show the learners the relationships of organs and the roles they play. Yvonne acknowledged that the organisms mentioned were not easy to get which is why she only dissected the kidney with her learners. Mary said that sometimes if she gets earthworms or insects, she asks them to dissect them but not as often as she would want due to time constraints. Tia was quoted saying:

> “Whenever I get a chance I dissect the entire piglet as a demonstration but the problem is several of them do not enjoy it and would rather sit in the corner, stand outside or they feel nauseated and run away”.

Bertha and Tia said that it was also possible to dissect skeletons, plant organs, lungs and tissues. Bertha was quoted saying:

> “I think if you can do the lungs for example, that would be very interesting to see how it works with the circulatory system and maybe different tissues of the animals, because we do tissues and so on, if you maybe can look at the muscles and skin and I think that will also help”.

The responses of the some of the teachers show that they are aware of the several topics in which learners could carry out animal organ dissections but they were not doing it. Apparently the drive to carry out animal organ dissections is just to comply with the curriculum requirement. In most cases their responses were according to which topics learners *could* carry out animal organ dissections, and not topics in which they were letting the learners carry it out. Mary is the only teacher who was going an extra mile by even dissecting the whole animal as a demonstration so that learners can integrate the links between the systems of the whole organ.

5.3.2.3 Problems or difficulties faced by learners during animal organ dissections

The researcher deemed it necessary to determine from the teachers the difficulties or problems faced by their learners during animal organ dissections; the teachers' responses would complement the learners' responses on the same question which they responded to in the learners' questionnaire. For this theme, two questions were asked of the teachers and their responses are shown in Table 5.11:

Table 5.11: Problems or difficulties faced by learners during animal organ dissections

Categories	Codes	Teachers	Frequency
Difficulties in instrument manipulation	Df1	T1, T2, T4, T6	4
Scared to open the organ	Df2	T2, T6	2
Religious beliefs problems	Df3	T2, T3, T4	3
Insufficient dissection equipment	Df4	T1, T2, T6	3
Learners curious, interested	Df5	T1, T2	2
Difficult to observe all the organ parts	Df6	T3, T4	2
Easy when given clear instructions	Df7	T4	1
Do not follow instructions	P1	T1	1
Cutting wrongly/themselves	P2	T1, T4, T5	3
Need for step by step guidance	P3	T1	1
Some not willing due to religion	P4	T1, T2, T6	3
Scared/squeamish to touch the organ	P5	T3, T2, T5	3
Nauseous, blood and smell phobia	P6	T3, T4, T6	3
Difficult to fit the structure in the textbook with the real organ	P7	T5	1

Df= Easy or difficult; P=Problems

The responses to the first question, which was to find out from the teachers how easy or difficult the dissections of different organs were on the part of their learners, are shown in the first band of the table. Four teachers, namely Thato, Mark, Bertha and Tia, concurred that one main difficulty their learners had was the manipulation of dissection instruments, that is, instrument handling problem. Bertha said her learners sometimes struggle to use the scalpels or they use their hands instead of the dissecting instruments and they make a mess of the organ. Tia's learners struggle with where to cut and how to cut, in some cases instead of making the long continuous cut, they instead make short little stabs at the organs, then they fail to see what they are supposed to observe. Tia and Mark's learners also struggled with fear to cut the organ. Yvonne and Bertha's learners had reservations with dissecting due to religious reasons because they have a few learners who are of the Muslim, Hindu and Jewish religion and Mark has vegetarian Christians who struggle to touch flesh. Thato, Mark and Tia who are the teachers from the disadvantaged schools echoed the same sentiments regarding the insufficiency and inefficiency of the dissection instruments due to lack of funds in their schools. Mark was quoted saying:

> "You know if you don't have the necessary and enough equipment, you know like children find it difficult to actually to make use of the inefficient scalpels. This makes manipulation and the dissection itself difficult. And to a certain extent you will find that learners are somehow afraid of actually opening up an organ. You see. Some of this is due religious beliefs like in my class, I have learners that are Seventh Day Adventist members and they can't touch meat because they are vegetarians but as an educator you need to actually explain the importance of the practical before, so that this whole practical can go on and we improvise the dissection instruments as well".

Yvonne and Bertha were of the opinion that their learners found the animal organ dissections easy when they were give adequate instructions. Yvonne said she made sure she demonstrated the dissections before they started so that they would not struggle. Their learners only found it difficult to observe some parts of the organs.

The responses to the second question, which asked the teachers what problems their learners experienced in doing animal organ dissections, are shown in the second band of the table. Thato said the problem with her learners was that they did not follow instructions even when she gave them step by step guidance. As a result they ended up cutting wrongly or cutting themselves. Bertha and Mary also echoed the same sentiments of learners cutting wrongly and in some instances cutting themselves. Mary also said her learners struggled to relate the diagram in the textbook with the real organ due to size, colour and texture differences. Yvonne, Mark and Mary's learners were scared to touch the fresh organ, being squeamish of the slippery texture of the kidney. Yvonne, Mark and Tia concurred that some of their learners felt nauseous due to the smell of the fresh organ and their blood phobia. Yvonne was quoted saying:

> "I think the problem they experience is they all want gloves, the reason being that they are scared to touch the organ. The other problems I think they experience are that some of them are afraid of the sight of blood or afraid of actually dissecting an organ, they are a bit squeamish yes. But what's nice with the group work is that it is invariable, in a group you will always find one or two learners that are quite prepared to get stuck in and the other learners are quite prepared to participate but not maybe actually physically touch it themselves".

5.3.2.4 Stages of the topic at which dissections are carried out by the learners

A practical can be carried out at different stages of the topic, hence it was essential to find out from the teachers at which stages they considered it crucial to carry out the animal organ dissections with their learners. Table 5.12 reflects in the first band the stages of the topic at which the animal organ dissections are carried out by learners and the second band shows the reasons for their choices.

Table 5.12: Stages of the topic at which dissections are carried out by the learners

Categories	Codes	Teachers	Frequency
Consolidation	Stg1	T1, T2, T3, T4, T5, T6	6
Introduction	Stg2	None	0
Investigative	Stg3	T2, T5, T6	3
Generates interest in the topic	Reas1	T2, T6	2
Understand the topic more	Reas2	T2	1
Link the theory given with the real organ	Reas3	T1, T3, T4, T6	4
Give them background of the organ first before dissecting	Reas4	T3, T4, T5	3

Stg = Stages of the topic; Reas = Reasons

All six teachers prefer to have the dissection practical as a way of consolidating the topic, their main reason being that if the learners are taught the theory first, they will link that theory with the real organ and relate the structures they observe with the functions they will have learnt in the lessons. Yvonne, Bertha and Mary concur that it is better to give the learners a theoretical background first before they randomly start dissecting without background knowledge of the organ. Mark, Mary and Tia are of the opinion that they can use the dissections either for investigative purposes or as a consolidation because it can arouse interest in the learners about the topic they will be doing, so instead of giving them all the information, they introduce the topic and then let the learners investigate the kidney through dissecting it. When more interest and curiosity has been generated they culminate the topic, and they argue that the learners understand more. Mark argued and was quoted saying:

> "In my case it was in the middle of the topic of course. You know, to arouse interest. You know if you talk of something and complete the whole session without a practical, I felt the learners would not enjoy the topic itself. I found it working very well for me because at the middle of the topic itself, as I am saying after the dissection the learners are very much more interested in the topic itself".

For the sake of consistency for this study, all the dissections were carried out as a way of consolidating the topic.

5.3.2.5 Fulfilment of the three National Curriculum Statement's Learning Outcomes

According to the Department of Education, all learning areas must fulfil the Learning Outcomes 1, 2 and 3. Learning Outcome 1 (LO1) is when learners investigate phenomena in Life Sciences mostly through a practical investigation, Learning Outcome 2 (LO2) is when learners construct Life Sciences knowledge and Learning Outcome 3 (LO3) is when learners are able to apply the acquired Life Sciences knowledge in society. The teachers were asked how they ensured that the intended learning outcomes were fulfiled and secondly, to what extent the three National Curriculum Statement learning outcomes were fulfiled through animal organ dissections. The researcher also asked the teachers if there were other outcomes they expected from the dissections lesson besides the three learning outcomes. Table 5.13 shows the three bands with the responses for each of the three questions asked.

Table 5.13: Measures and extent of fulfilment of the three learning outcomes

Categories	Codes	Teachers	Frequency
Hands-on practical	LO1	T1, T2, T4, T5, T6	5
Task is given to complete	LO2	T1, T2, T3, T4, T5, T6	6
Task related to real life (organ transplant)	LO3	T3, T4, T5, T6	4
Hands-on dissection (dissecting skill)	Ex1	T1, T2, T3, T4, T5, T6	6
Construct knowledge by: observe, identify parts, relate structure to function, interpretation of diagram, discuss	Ex2	T1, T2, T3, T4, T5, T6	6
Solve practical situations given, linked to society	Ex3	T3, T4, T5, T6	4
Handling of apparatus	Ot1	T1	1
Cleaning up afterwards	Ot2	T1, T3	2
Good task marks	Ot3	T1, T3	2

LO = Learning Outcome; Ex = Extent of fulfilment; Ot = Other outcomes

When the teachers were asked how they ensured that all the learning outcomes were fulfilled during the dissections lesson, five of the six teachers explained that the hands-on dissections by the learners fulfilled LO 1. Yvonne had apparently forgotten what the learning outcomes were in their order. She asked the researcher to remind her again what each learning outcome consisted of. After the reminder she then concurred with the other five teachers that the learners constructed their own knowledge through dissections which is the LO 2 and they ensured that by testing their knowledge, giving them a worksheet to complete individually. As for LO 3, Yvonne, Bertha, Mary and Tia said that they included questions in the worksheet that related the dissected kidney to real life situations. Thato argued that:

> "When we dissect we have a particular task. We don't just dissect for the sake of dissecting. They dissect, they must complete a task and then it counts towards their year mark. It is a formal task, ja".

Bertha also argued that:

> "Well they definitely need to able to draw a diagram afterwards and know all the labels. Maybe they will have to answer questions about the organ, maybe some of the functions and when you walk around they must be able to show you the structure, name it, and identify it. Ja and maybe have some real life questions on how it works in real life. I think that is the only way you know".

Bertha's response was based on what may be included in the worksheet like real life situations questions but she did not say that was what she was doing exactly. It can be argued that in some cases the teachers might be aware of what they could do to ensure that all the learning outcomes are fulfilled but it does not mean they do it. This might mean that the learners are not adequately acquiring all the skills they could get from one activity.

In terms of the extent to which all the three learning outcomes were fulfilled, all six teachers confidently said LO 1 was fulfilled by the learners carrying out the hands-on dissections. In terms of LO 2, they also agreed that the learners constructed their knowledge by: observing, identifying parts, relating structure to function, interpretation of diagram and group discussions. For LO 3, Yvonne, Bertha, Mary and Tia said they would give the learners practical situations to solve, linked to society. Mary strongly argued that:

> "Basically learning outcome one they are physically dissecting, cutting it open and they acquire that skill to do that otherwise you can't see the different parts. The second one is knowledge; they applied their knowledge to what they had learnt in the book to the real life or to the situation in front of them. And then learning area or learning outcome three they basically applied the knowledge to real life situations, which they did by discussing diseases to do with the kidney. So they have to say, okay but this is where you find the nephron and if the nephron was damaged, what disease they would have or what part of the kidney were damaged if you had blood or glucose in the urine? And they correlated with the kidney that they had in front of them. What parts were damaged by what diseases?"

All six teachers showed that they were knowledgeable about how the learners can fulfil the LOs 1 and 2. As for the LO 3, only four teachers confidently mentioned how they made sure that it was fulfilled during the animal organ dissections. Bertha showed that she knew what she was supposed to do so as to have the learners fulfil the LO 3 as well, but she just did not give them the opportunity to do so. It can be argued that some learners can be disadvantaged if the teacher does not give them enough challenging situations, their full potential is not achieved. Mark only responded to how he ensured that the first two learning outcomes were fulfilled and could not explain to what extent LO 3 was fulfilled by his learners during animal organ dissections.

Thato and Yvonne also argued that besides the three learning outcomes, there were other outcomes learners achieved during dissections which included handling of apparatus, cleaning up afterwards and obtaining good task marks.

5.3.2.6 Sources of the animal organs dissected

As a way of finding out the state of the organs when the learners dissected them, the teachers were asked the source of the organs the learners dissected. The first band of Table 5.14 shows the responses of the teachers regarding the sources of the animal organs dissected and the second band shows the responses of the teachers regarding the breeding of their own source of organs.

Table 5.14: Sources of the animal organs dissected

Categories	Codes	Teachers	Frequency
Butchery	S1	T1, T2, T6	3
Abattoir	S2	T3, T5, T6	3
Not sure because school orders them	S3	T4	1
Just Buy	OS1	T1, T2, T3, T4	4
No Lab to breed the animals	OS2	T1, T6	2

S=Source; OS= Own source

Thato, Mark and Tia obtained the animal organs from the butcheries. They acknowledged that the organs they bought in most cases would have had some of the essential parts like the capsules and the ureter removed and cleaned but they were not aware of any farms or abattoirs nearby where they could go and buy the kidneys before they are cleaned. Another reason to go to abattoirs was affordability. Due to the schools' financial constraints they buy the organs using their own money, hence they prefer the cheapest way to get them. Thato said they also ask the learners to bring organs they also buy from the butcheries just to spread the expense between them and the learners. Yvonne, Mary and Tia said they sometimes get the organs which have not yet been stripped of the essential parts at abattoirs and Tia also gets them from a friend who owns a farm but it depends on whether they are slaughtering at that time of dissections. Bertha was not sure exactly where the organs came from because the school ordered for them:

> "Right when I need organs, then the laboratory assistants always order them. I know sometimes they just get it from any random shop. But ja, the school's laboratory normally just order it for us. So I am not quite sure where the sources are. But when you buy them at Spar a lot of the parts can be removed already or the organs can be damaged and you can't really see it. Or like for example if you buy the kidneys it is already cut open and the capsule is removed and which does not make sense".

Even though Yvonne and Bertha are at the same school, Yvonne knew what their source of organs was but Bertha did not. This may be because Yvonne was the Life Sciences Head of Department and was actively involved in the ordering of laboratory apparatus including the kidneys used for the animal organ dissections.

When asked if they could not breed their own animals as organ sources: Mark, Yvonne, Bertha and Mary said they preferred to buy which was easier than breeding animals. Thato and Tia argued that the school did not have proper laboratory facilities and there was no way they would afford to breed animals when they did not even have proper laboratories.

5.3.2.7 Time constraints in animal organ dissections

One of the reasons why some teachers fail to let learners dissect is due to time limits. Taking that into consideration, the researcher asked the teachers if they had any reservation on dissections in terms time of consumption or constraints.

Table 5.15: Responses on time constraints in animal organ dissections

Categories	Codes	Teachers	Frequency
No practicals are done after school	R1	T1, T2	2
Lab too small, hence need for more time	R2	T1	1
Time constraints due to lack of proper facilities and instruments	R3	T2, T6	2
Learners take their time as they will be enjoying it	R4	T2, T5	2
No time constraints because of long double periods	R5	T3, T4	2

R = Responses on time constraints

Thato and Mark indicated that if they did the dissections during the normal 45 minutes periods, they would not finish or it would be done hurriedly therefore, in their school, they organised for the Grade 11 learners to attend the dissections lesson after the normal contact time. They acknowledged that the practical on its own was time consuming and the learners also enjoyed it so they took a lot of time exploring the kidney and debating. Thato, Mark and Tia argued that due to inadequate laboratory facilities, apparatus and their large classes, they needed more time, hence their dissections lessons were done in the afternoons. Mary said that the learners took their time because they were enjoying it. She had no reservations despite the time constraints because it was part of the learning process and the more dissections one did the better and she felt one actually never does enough. In School B which is Yvonne and Bertha's school, they did not have a problem with time constraints because the Grade 11 learners had double periods and that was enough time to complete the lesson including cleaning up.

None of the teachers used time constraint as an excuse for not carrying out animal organ dissections. One can understand why Thato, Mark and Tia did not carry out more animal organ dissections than just to comply with the curriculum requirements because, if the animal organ dissections are carried out after normal school hours, it would not be easy to ask learners to attend such lessons except when it is really unavoidable.

5.3.2.8 How the animal organ dissections take place without the necessary infrastructure

Another reason why some teachers fail to let learners dissect is due to lacking or limited dissections infrastructure and apparatus. Taking that into consideration, the researcher asked the teachers how dissections took place in their schools if they did not have the necessary infrastructure.

Table 5.16: Responses on how dissections were done without the necessary instruments

Categories	Codes	Teachers	Frequency
Use knives in place of scalpels	Hw1	T1, T2	2
Use card box in place of dissection board	Hw2	T1, T2, T6	3
School adopted by University of Pretoria, can book their laboratory	Hw3	T2	1
Organise with neighbouring schools with better facilities	Hw4	T2	1
School has the necessary infrastructure	Hw5	T3, T4, T5	3
If it did not have, would show on the internet, have never done online dissection so pictures only	Hw6	T4	1
They are good	Res1	T1, T2, T6	3
Internal parts clear	Res2	T1	1

Hw = How dissections are done; Res = Response

Thato and Mark from School A, which had no laboratory and dissection apparatus, said that they improvised the instrument by using sharp knives to dissect in place of scalpels and Tia from School D concurred with Thato and Mark on the use of card box in place of dissection boards. Sometimes they organised with neighboring schools with better laboratory facilities to go and carry out the dissections lessons at that school. School A was also assisted by the University of Pretoria and sometimes they booked the Life Sciences laboratory at the university to use for the dissection lessons. The challenge with that was the learners would have to pay for the hired bus to take them to the university and most of the learners were from disadvantaged backgrounds and they could not afford even to pay for the bus. Thato confirmed by saying:

> "We use knives because we don't have the scalpels. We don't have the dissection board, we improvise. We use the card box, anything just to cut on it and we improvise".

Tia echoed the same issue by saying:

> "We don't have the necessary infrastructure here, the lab is not fully equipped, so I do the dissections on normal plastic, I suppose you can call them breadboards, the cutting boards and then I have got few scalpels, dissection needles and that sort of stuff, and then we do it on one of the desks or a couple of the desks when it's a few groups".

The researcher asked the three teachers what the dissections results were like with improvised instruments and they all agreed that they were good and the internal parts were clear. Yvonne, Bertha and Mary said their schools had the necessary infrastructure but Bertha argued that if her school did not have, she would show the learners dissections on the internet, but since she has never done online dissections she would show them pictures only.

5.3.2.9 Advantages of hands-on group work during animal organ dissections

In all the lessons that the researcher observed, learners worked in groups. She wanted to find out from the teachers if there were any advantages in having their learners work in groups that ranged from pairs to up to six people in a group depending on the school's laboratory facilities and apparatus. The teachers' responses were complemented by the learners' responses regarding their opinion on group work as shall be discussed in the next chapter.

Table 5.17: Advantages of hands-on group work during animal organ dissections

Categories	Codes	Teachers	Frequency
Link theory with reality	Ad1	T1, T2	2
They are hands-on and they encourage each other	Ad2	T1, T2, T4, T6	4
Debate enhances understanding	Ad3	T1, T2, T4, T6	4
Learners focus more	Ad4	T2, T4	2
Learners from different cultures work together	Ad5	T3, T4, T6	3
Helps struggling learners	G1	T1, T3, T5	3
Strong learners boost the morale of the group(empathy)	G2	T1, T3, T5, T6	4
Helpful discussions	G4	T1, T6	2
Discussions were only allowed per group	Ds1	T1, T3, T5, T6	4
Individual work was done after discussions.	Ds2	T1	1

Ad = Advantage; G = Group work importance; Ds = Discussions

The first band of Table 5.17 reflects the responses given by the teachers when they were asked on the importance of group work. Thato and Mark concurred that group work helped the learners to link the theory with reality as they debated their real life experiences during the dissections in groups. Bertha and Tia agreed with them that debates learners had during dissections enhanced their understanding of how the kidney worked relative to the different structures observed. The same teachers, Thato, Mark, Bertha and Tia, are also of the opinion that learners encourage each other to participate when they work in groups and tend to focus more on the practical and their discussions. Tia argued that:

> "The advantages are that well, number one being hands on they get to identify the parts of the organs themselves and the fact that they are in a group means that they are more willing to say things or answer questions because they are not so embarrassed and they help each other out when they are looking at the organ".

Yvonne, Bertha and Tia were of the opinion that group work allows learners from different cultures to work together. Yvonne was quoted saying:

> "I think it is very valuable because it teaches learners from different cultures to work together, talk to each other and to experience each other's fears. Perhaps learners from a different culture have their own fears or reservations and so it gives them a bit of empathy to the fellow learners".

Yvonne's opinion was supported by the study that was done by Giles (2004) which established that learners who worked on problem-solving activities in groups were more willing to help, promoted each other's learning, shared ideas and information, asked each other to elaborate on their points, listened to each other, provided constructive criticism when appropriate and worked together evaluating the group's progress. (For example, 'What have we accomplished? What do we still need to do? How are we going to manage that?'). This level of cooperative learning or group work was also noted by the researcher during the lesson observations. Ediger (2009) also emphasises that learners working in groups give each other a feeling of worth, support and help each other to develop confidence to actively participate in the dissections of the animal organs, as in the case of this study and in the group discussions regarding what was observed on the dissected organ. These arguments are supported by earlier writers, even during the 1980s when The American Association for the Advancement of Science (1989) argues:

> " … students gain experiences sharing responsibility for learning with each other. In the process of coming to common understandings, students in a group frequently inform each other about procedures, meanings, concepts, relationships, argue over findings and assess how the task is progressing. In the context of team responsibility, feedback and communication become more realistic and of a character very different from the usual individualistic textbook-homework-recitation approach" (p. 202).

It may be argued that the capacity of the learners to engage in persistent and systematic inquiry during the group animal organ dissections activities may be pivotal to the learning that occurs and the development of problem-solving skills.

Mary was the only teacher who acknowledged that group work also had its own disadvantage because it minimised the individual participation of learners, hence at her school the learners only worked in pairs so as to maximise their participation. Such a decision to have learners work in pairs can only be done at a school where the laboratory facilities and apparatus are available.

As a follow-up question, the teachers were then asked if they considered group work as an important aspect of their teaching and learning strategy. Thato, Yvonne and Mary agreed that group work helped the struggling learners because they could be assisted by the stronger learners. The same three teachers, in agreement with Tia, said that strong learners boost the morale of the group (empathy) and helpful and constructive discussions then take place within the groups. The researcher also asked if discussions were allowed throughout the lesson and Thato, Yvonne, Mary and Tia said discussions were only allowed per group and then individual work was done after discussions.

5.3.2.10 Teachers' preferences in animal organ dissections

Teachers were asked whether they preferred just to demonstrate the dissections of animal organs or to let the learners carry out the dissections of animal organs themselves in groups or as individuals. They were also asked to state the reasons for their preferences, as shown in the two bands of Table 5.18.

Table 5.18: Teachers' preferences in animal organ dissections

Categories	Codes	Teachers	Frequency
Group work	Pref1	T1, T2, T3, T4, T6	5
One by one	Pref2	T5, T6	2
In pairs	Pref3	T5	1
Group work: we use less kidneys: cheaper	Pref1	T1, T2	2
Encourages group discussion, enhancing understanding	Pref2	T1, T2, T3, T4, T6	5
Fewer groups easier to monitor and guide	Pref3	T2, T3	2
Some learners encourage others to be hands- on	Pref4	T3	1
One by one: each learner gets to dissect	Pref5	T1, T5, T6	3
In pairs: maximum participation and they help each other in handling the organ	Pref6	T5	1

Pref = Preference and reasons

Thato, Mark, Yvonne, Bertha and Tia prefer to have learners carry out dissections in groups although Tia said if the school could afford it she would let them dissect one by one to ensure that each learner dissected hands-on. Thato and Mark supported group work for their school because they would use fewer kidneys and that would result in a lesser financial burden on them. Mark was quoted saying:

> "Normally I put them in groups. I identify and place them in groups like if they are 40. I say I divide them in groups of seven you know so that there is maximum participation and then I am able to monitor them to see if they are doing it correctly the way it should be done".

The researcher then asked if having seven learners in a group was not too big and he responded…

> "Of course not all of them can do the cutting but a few from the group will encourage one another and maybe help to stretch the organ, while one is holding the scalpel to cut that particular kidney but I will always encourage maximum participation and they use less kidneys which is cheaper for us as teachers".

In as much as Mark acknowledges that seven learners in a group meant that not all learners would participate, his opinion was that it was better than the learners not experiencing the animal organ dissections at all, which showed some degree of determination on the part of the teacher.

These two teachers, together with Yvonne, Bertha and Tia, agreed that group work encouraged discussions which enhanced understanding. Mark and Yvonne were also of the opinion that group work resulted in fewer groups to monitor and guide and some learners encouraged others to be hands-on. Mary and Tia preferred that the learners dissected as individuals to ensure that they dissected hands-on but they both acknowledged that it was not possible, especially at Tia's school. Mary said her learners dissect in pairs to ensure maximum participation and to help each other in handling the organ.

5.3.2.11 How teachers handle situations where some learners are not willing to participate in actual dissection

Dissection as a controversial issue has been reported, both nationally and internationally, to have even led to court cases when a learner was not willing to participate. Taking that into consideration, the researcher considered it essential to find out from the teachers how they handled situations where learners were not willing to participate in the actual dissections for some reason, which could be religious, cultural, moral, and ethical or being vegetarian.

Table 5.19: Handling of learners not willing to dissect

Categories	Codes	Teachers	Frequency
They have to participate for marks	H1	T1, T4	2
Risk of forfeiting marks	H2	T1, T2, T4	3
No choice curriculum requirement	H3	T1, T4	2
Encourage them to watch others dissect and discuss	H4	T2, T3, T4, T6	4
Can do another hands-on practical which is not dissection	H5	T3	1
Use the internet to watch dissection	H6	T4	1
No such problems yet	Hn1	T1, T5	2
Most learners are Christians	Hn2	T1	1
Have encouraged them to just watch others	Hn3	T2, T3, T5, T6	4
Can use their phones to go on internet or can show them how it is done online or take a picture	Hn4	T4, T5, T6	3

H = Handling of learners; Hn = Solution

If some of the learners were not willing to participate, Thato and Bertha said that they would remind them that the dissection was part of the curriculum from the Department of Education and they had to do it for marks. These two teachers, in agreement with Mark, also said they would warn these learners that they ran the risk of forfeiting marks which contribute to the year mark. Thato confirmed this by saying:

> "Before the dissection they know that it is the formal task, it is for their own year mark. And if you do not do it you are going to forfeit the marks. So they know that it is not just a favour, it is needed by the curriculum. So if you don't dissect it means that you are going to forfeit the marks. So far we haven't had that religious problem as an excuse. Maybe it is because Christianity is the religion that is dominating, I don't know. But I never had a problem of learners saying according to my religion I won't do this".

It is interesting to note that, when Thato experienced dissection for the first time, she was scared but she did it because she had no choice because it was for marks and now, after almost 20 years of teaching Life Sciences, she still persuades her learners to carry out the animal organ dissections or else they run a risk of forfeiting the marks that count for their year mark. These three teachers' approach is in disagreement with Rowan et al. (1995) who are of the opinion that if a role of the educator is to stimulate critical thinking and not to indoctrinate, it would be a sound educational decision for teachers to give learners a choice whether or not to take part in a laboratory that they may find distasteful or with which they are uncomfortable. If these teachers take heed of this opinion, they would find dissections alternatives for the learners who are uncomfortable with fresh organ dissections. This argument concurs with that of Downie and Meadows (1995) who introduced the opt-out of dissection scheme which allowed learners to use alternatives to work through the practical schedule with models, charts or interactive videos and the examination results even on questions related to the dissection were not significantly different from other students who had carried out the actual dissection.

Thato and Mary said they have not experienced learners who use religion as an excuse not to dissect, maybe mostly because most of their learners are Christians and since the species used was lamb, most Christian doctrines do not have a problem with handling it.

Mark, Yvonne, Bertha and Tia acknowledged that they could not force them to dissect if they felt strongly against it but they encouraged them to watch others dissect and participate in the discussions. In some cases where the learner was not even willing to watch others dissect, Bertha, Mary and Tia encouraged them to use their phones to go on the internet or have a photo of the dissected kidney taken by a friend and use the picture to identify the parts of the dissected kidney. In cases where the learners have access to the internet, as with Bertha's learners, she would show them how dissection is done online. Tia had this to say:

> "I have got a few who, that are vegetarians or something like that so they don't want to do it and in that case I will not force them to do it. I don't think it is fair to do that because it is against what they believe in and they don't want to do it. The alternative that I found with a lot of them is quite strange; a friend will take a photo on their phone and then the person that didn't want to see the dissection will actually look at the picture on the phone because it feels better I suppose that they are not doing it themselves, so they do that".

5.3.2.12 Significance of virtual or online animal organ dissections

All six teachers acknowledged that some of their learners, for one reason or the other, were not willing to participate in the dissections. The researcher wanted to find out if they had considered using virtual or online dissections in place of the fresh organs especially for the learners who were not willing to dissect the real organ. The teachers were also asked what the financial implications of the use of virtual organs would be in comparison with the use of real organs. Table 5.20 shows the responses of the teachers.

Table 5.20: Significance and financial implications of the use of virtual or online animal organ dissections

Categories	Codes	Teachers	Frequency
Never used virtual or online dissections	Sign1	T1, T3, T4, T5	4
No online, smart computers or projectors	Sign2	T1, T2	2
Learners enjoy seeing and touching the real organ not on paper or computer	Sign3	T2, T5, T6	3
It must be very good because you can zoom in and out	Sign4	T4, T6	2
School cannot afford virtual organs, it is a waste	Im1	T1, T6	2
Teacher or Principal improvise, buy organs	Im2	T1, T2	2
Most learners needy	Im3	T1	1
School has no such facilities	Im4	T1, T2, T3, T6	4
Not aware of artificial organs which can be dissected	Art1	T1, T3, T4, T6	4
Just have models already cut	Art2	T2, T6	2
School cannot afford virtual ones	Art3	T2	1
Texture not the same as the real organ	Art4	T2, T3	2
It is a good idea, will look into it	Art5	T3	1
Financially we could get them, we just have not explored that angle	Art5	T4	1

Sign = Significance; Im = Implications; Art = Artificial organs

The first question was to establish the significance of virtual or online dissections to the teachers. Four of the six teachers, Thato, Yvonne, Bertha and Mary admitted that they had never done virtual or online dissections. Thato and Mark also concurred that there were no online computers, smart boards or projectors at their school. Mark, Mary and Tia were not supportive of virtual dissections because learners enjoy seeing and touching the real organ not on paper or computer. Mary was quoted saying:

"It is an ideal way for learners to see the *real deal*".

Schrock (1990) is in complete agreement with Mary because he prefers traditional dissections rather than alternatives because it is only the former that provides the learner with 'real material' and 'real experience'. He points out that no model is complete to replicate an actual organ or organism. Their opinion was also supported by teachers at Glasgow University who feel that alternatives and models could be used sparingly partly because it is not the same as the real material even though they agreed that interactive videos could work almost the same as the real material dissection (Downie & Alexander, 1989).

Bertha and Tia supposed that it could be very good because you could zoom in and out. In terms of financial implications of actual dissections versus virtual dissections, Bertha and Yvonne admitted that in their school, finances were not an issue. However, virtual animal organ dissection was just one aspect of doing dissections they had not considered exploring. They would start looking into the possibility of using the virtual or online dissections in the case of learners who would be uncomfortable with the actual dissections. Thato, Mark and Tia said their schools had no such facilities and the school would not afford to set it up. Their principals would rather improvise by buying the real organ and their learners are mostly needy so any extra expense would not be possible. The researcher also asked if the teachers had considered the use of artificial organs instead of real ones; all six teachers indicated that they had not considered the dissections of artificial organs. Thato, Yvonne, Bertha and Tia admitted that they were not aware of artificial organs that could be dissected; they have models of already cut kidneys, which show the internal parts of the organ. They considered that once the expensive artificial organ was dissected it would go to waste, and their schools could not afford that. Yvonne and Mark argued that in as much as it was a good idea, the texture would not be the same as the real organ. The responses by the teachers show that the Life Sciences teacher may not have had enough exposure or information regarding alternatives to real tissue animal organ dissections.

5.3.2.13 Management of discipline during animal organ dissections

Carrying out a practical can lead to non-accomplishment of the lesson objectives if the disciplinary aspect is not well-handled by the teacher. Dissections, as an important aspect of the Grade 11 curriculum needs the discipline to be well-managed to accomplish its objectives and without any incidences since it involves the use of sharp objects as well. Hertzfeldt (1994) and Long (1997) argue that poorly supervised learners can degenerate and misbehave to a point where little or no meaningful learning takes place. In that light, the researcher wanted to find out from the teachers how they managed discipline during the dissections.

Table 5.21: Management of discipline during animal organ dissections

Categories	Codes	Teachers	Frequency
Motivate them	Dsc1	T1, T4	2
Deduct marks if naughty	Dsc2	T1, T3	2
Become problematic when task is done, give them more work	Dsc3	T2, T6	2
Each group stays at its own table	Dsc4	T3, T5, T6	3
No intergroup communication	Dsc5	T3, T5	2
Make sure they dissect not mutilate	Dsc6	T3, T4	2
Always moving around the tables guiding them	Dsc7	T1, T3, T4, T5	4

Dsc = Discipline

Thato and Bertha considered that motivating the learner and reminding them of the importance of the practical before they started the practical, would ensure some discipline during the dissections. Yvonne and Thato then concurred that if some learners instigated indiscipline, some marks would be deducted. Yvonne had this to say:

> "I manage discipline by making sure that each group is sitting at its own table. I do not encourage walking around or communication with one group from the next. You know obviously within reason, but I don't allow them to walk around. I will make sure that they are seated; I make sure that I am present during the dissection. I don't just leave them doing what they want to. Sometimes they can get a little bit carried away. Before the dissections starts I always tell them this is a dissection, this is not a mutilation. So I think you just have to be around and then sure that they actively doing what they are supposed to be doing and deduct marks from the naughty ones".

Thato agreed by saying the following:

> "When they dissect you have to move around to see what is going on. Because others are naughty, others they can even injure one another. I just move around. And then before they start I tell them also that don't do this, otherwise I am going to subtract marks, otherwise. So as soon as they hear you are going to subtract the marks then they become contained".

Whether a teacher is from a former Model C school or from the townships, sometimes the forms of disciplining the naughty or disruptive learners could be the same. This is evident for Yvonne and Thato who deducted marks from naughty learners.

Mark and Tia said it always helps them to give the learners questions to answer including challenging ones to keep them busy throughout the lesson. Tia was quoted saying:

> "That's always a difficult thing because they get really excited but generally by putting them in groups and giving them certain things that they have to do in the dissection, so it's not that they sit and do whatever they want in the dissection. They actually have steps they have to follow, there are questions that they have to answer as they are dissecting, that tends to keep them busier".

Tia's ways of ensuring discipline agrees with Michael (1993) who observes that hands-on activities like animal organ dissections are only effective for learning if the learners' heads are being kept as busy as their hands.

Yvonne, Mary and Tia made sure the learners stayed in their groups and discussions were within the group which meant that intergroup communications were prohibited, and they made sure that no mutilation took place. Thato, Yvonne, Bertha and Mary said moving around the tables guiding them was also a way of ensuring that discipline was maintained. Bertha confirmed by saying:

> "Well during discipline you must obviously be involved all the time otherwise they will go hay wire and make fun of it. So while they do the dissection I will always be walking around and go from group to group and see that they are doing alright or that they are doing or following the instructions and I will ask them questions and ask them if they understand it and if they are fine. So I will just be constantly talking to them and walking around in the groups and try and manage it like that".

The researcher noted with interest that Bertha was contradicting herself because during the animal organ dissections, she was seated most of the time but in the interview she then said she would be talking to them and walking around. This once again shows that Bertha may be the kind of teacher who is good at the theory of teaching methodology and she simply just does not practise it, maybe due to a negative attitude towards animal organ dissections or the teaching of Life Sciences.

5.3.2.14 The teachers' views regarding the learners' attitudes towards animal organ dissections in general and its use in problem-solving

Attitude is an aspect that can affect the outcome of the lesson drastically. It was therefore considered essential to find out from the teachers what the learners' attitudes were towards animal organ dissections in general and its use in problem-solving. The researcher also wanted to find out if the keenness of the learners during the dissections of organs was the same as when they were then answering problem-solving questions.

The teachers' opinions on the learners' attitudes were complemented by the learners' responses on the same aspect from the questionnaire and what the researcher deduced during the lessons observations. The integration of the data shall be discussed in Chapter 6.

Table 5.22: The teachers' views regarding the learners' attitudes towards animal organ dissections and its use in problem-solving

Categories	Codes	Teachers	Frequency
Initially they did not understand the purpose of dissecting	Att1	T1, T2, T4	3
When presented with challenging questions, they were encouraged to explore more the dissected kidney and discuss as a group	Att2	T1, T3, T4	3
They became more curious, challenges them to think further and research more	Att3	T1, T2	2
Positive, Learners were eager to discuss and answered most questions	Att4	T2, T4, T6	3
They are more interested in cutting and drawing	Kn1	T2, T4, T5	3
A bit negative because its more work and effort	Kn2	T2, T4, T5	3
Some were keen all the way	Kn3	T1, T6	2

Att = Attitude; Kn = Problem-solving

Thato, Mark and Bertha said that initially their learners did not understand why they had to dissect. For them dissection was just cut and draw which seemed more interesting. Yvonne further added that when they were presented with challenging questions, they were encouraged to explore the dissected kidney further and discuss as a group. Mark, Bertha and Mary's learners were more interested in cutting and drawing the kidney, they were not so happy about having to answer more challenging questions because it meant more work and there was less enthusiasm about having to answer challenging questions. Some of their learners realised that answering these questions broadened their knowledge in a different kind of way and especially the problem-solving ability. Most of the learners in the three teachers' classrooms were encouraged; there was a change of attitude and they discussed and answered most questions. Bertha explained how her learners' attitudes made a turnaround:

> "Well I know that they are very interested when they do practicals. They are very excited when you announce that the practical will be done. So I think their attitudes are very positive and I just think, they also think that their knowledge will be broadening in a different kind of way. So it is definitely positive and it works, it let them think of it further, it is not just a question and an answer. It is something that they can discuss and talk about, share their experiences and so they definitely think further and maybe if you give them a little bit of research to do with it, then it also helps to solve their problems. Ja they definitely want to cut and draw. I think for all of us actually it is the more boring part or the effort part. So I think during the dissection it is if they have a positive attitude, but yes if they must do work afterwards, they are always a bit negative. You know it is extra work after the dissection".

Mark supported what Bertha had said by saying:

> "You know after the dissection they were initially not keen to answer the questions but after encouraging them to try, I really found that it worked the way I wanted it to because you know even those learners who tended to be negative before you know were eager to answer most of the questions after the dissection. It means it helped them a lot and performed even better than in the previous test which made them so excited".

Thato and Tia said the learners were positive and enthusiastic throughout the lesson because they became more curious to explore the organ and the problem-solving questions challenged them to think further and research more. They realised that it helped them to understand the topic better by exploring the kidney, trying to answer the problem-solving questions. The majority of the learners who have had experience with animal organ dissections were used to the idea of just cutting the organ and labelling. When they were presented with the post-test with problem-solving questions for the second time, there was much grumbling but when they started to write they realised how essential it was to engage more with the dissected organ to relate the dissected organ to what was being asked.

5.3.2.15 Teachers' attitudes towards animal organ dissections

The teacher's attitudes towards animal organ dissections can also have an impact on the outcome of the lesson and on the attitudes of their learners, hence the need to establish the attitudes of the teachers towards animal organ dissections on problem-solving. The teachers were asked three questions which helped the researcher to establish their attitudes towards dissections. The first question asked the teachers to recall and describe their feelings when they first carried out dissections. This question was meant to establish the attitude of the teachers when they first carried out dissections in comparison with the attitude they have now which is more important. Secondly, they were asked to describe their feelings whenever they have to carry out dissections with their learners. Thirdly, they were asked if there were any instances where as teachers they did not want to dissect the animal organs during the lesson and would just let the learners dissect without their involvement.

Table 5.23: Attitudes of the teachers towards animal organ dissections

Categories	Codes	Teachers	Frequency
Scared, blood phobia	Rc1	T1, T4	2
Felt like I had no choice, it was for marks	Rc2	T1	1
Very interesting, fun, worth it	Rc3	T2, T3, T4, T5, T6	5
Yes, very new, explored and learnt together with the learners	Rcc1	T4	1
Not bad	F1	T1, T3, T4	3
Understand their fear	F2	T1, T4	2
The preparation is too involving	F3	T5	1
Gratified by their excitement and experience	F4	T1, T2, T3, T4, T5, T6	6
No, I always demonstrate	Inst1	T1, T2, T5	3
Always enjoy dissection	Inst2	T2, T3, T5, T6	4
I force myself for the sake of learners' marks	Inst3	T4	1

Rc = Recall the feelings; Rcc = Recall; F = Feeling; Inst = Instances

Thato admitted that when she first carried out dissections she was really scared and could not get herself to dissect the frog she was supposed to dissect. She knew, however, she had no choice because of the examination; she did the dissections until she got over the fear. Thato acknowledges that she feels much better now as her learners are dissecting especially because it is just organs and not the whole animal but she understands the fear of the learners because she experienced it once. Bertha only did her first dissections when she was a teacher and she explored and learnt together with the learners but she is still fighting the blood phobia. Bertha confirmed by saying:

> "It was scary and very exciting to actually think that I was working with something that was inside me and to see how it really looks and the size of it. But I am someone that is not very keen on touching organs with blood, so there was a little bit of a knot in my tummy, I didn't like it so much but just the excitement of it made it worth it".

Bertha also said as her learners are dissecting it is no longer that bad but she is still not keen on touching organs with blood, she therefore forces herself for the sake of the learners' marks. Bertha's response did not come as a surprise because the researcher had noticed her detachment from the animal organ dissections as the learners were carrying it out. The researcher had thought that the detachment was due to lack of confidence in the animal organ dissections procedure since she did not have a firm previous experience in it but she also realised that besides the lack of experience, there was also a blood phobia issue.

Dissecting for the first time for Mark, Yvonne, Mary and Tia, was very interesting, fun and it was worth it. As the learners carry out the dissections, Tia feels it is too demanding to organise the organs and prepare for the lesson and the lesson itself including the time constraints but despite her reservations she still enjoys dissections and even demonstrates if it is the whole animal. All six teachers acknowledged that they were always gratified by their learners' excitement and experience. Mark was quoted saying:

> "You know I remember way back when I was still at college you know we did dissections on many organs like we started with that we wanted to see the anatomical canal of a rat you remember? It was very much interesting for me. It was very much interesting. I found it very much interesting, it was fun. I never had any problem with that. I still find it interesting when my learners dissect, it is in me already. I always want to see responses from learners because I have done it many times and I enjoy it. I only look at how learners react and if they react positively and seem to have learnt something, that makes my day".

5.3.2.16 Teachers' understanding and acquaintance with problem-solving strategies

The establishment of the teachers' understanding and how well acquainted they were with problem-solving strategies was one of the important aspects of this study because their level of understanding and acquaintance with problem-solving determined how they would use animal organ dissections in problem-solving as a teaching strategy. To establish this, the researcher asked the teachers three questions and their responses to them assisted her in establishing their level of understanding and acquaintance with problem-solving strategies. The first question intended to find out from the teachers what their understanding of problem-solving strategies was. They were also asked to explain the specific problem-solving strategies that they implemented in their Life Sciences lessons. The second question intended to establish the topics in which they would develop this skill in learners and lastly how they used animal organ dissections to improve the problem-solving skills of Grade 11 learners.

Table 5.24: Teachers' understanding and acquaintance with problem-solving strategies

Categories	Codes	Teachers	Frequency
Apply knowledge acquired in class or during dissection to solve real life problems	Und1	T1, T3, T4, T5, T6	5
Give learners tasks that can help them think of alternative ways to solve problems	Und2	T3, T4, T5, T6	4
No understanding of problem-solving strategies	Und3	T2	1
Always link the theory of each organ with the practical problems associated with it	Strat1	T1, T4, T5, T6	4
If learners come across the problems in real life situations, they will be skilled and can solve them	Strat2	T1, T4	2
No strategies since there is lack of understanding of the problem-solving strategies	Strat3	T2	1

Und = Understanding; Strat = Strategies

When the teachers were asked what their understanding of problem-solving was, a few versions of this concept appeared and the researcher deduced the central theme of their understanding. Five teachers, except Mark, seemed to agree that problem-solving was the application of knowledge acquired in class or during dissections to solve real life problems. Thato was quoted saying:

> "I think problem solving is, the information that they gain or whatever information they get in class, they must be able to use it to solve problems relating to that but outside, the practical examples. You know the Life Sciences now, every organ that we do we also do the diseases associated to it. And then with that knowledge learners become aware of what is going on and I think if they come across the problem in the real life situation, they will be skilled, they will know what is going on and how to solve or prevent it.

Yvette, Bertha, Mary and Tia concurred in that it could be tasks given to learners that can help them think of alternative ways to solve problems besides rote learning. Bertha confirmed this by saying:

> "Okay, depends on what organ you do, you can tell them implications of maybe, if you have a health problem or what health problems are caused in the organs by certain conditions. For example if something is blocked in the organ, how do its products get from one part to another or if something is damaged how does the organ work or still work. Ja I just think if you give them real life situations and they must be able to figure out a way on how the organ still works or what kind of disadvantages can take place when you are experience such a thing as a blockage in the organ. Ja ag I just think if they can just apply their knowledge that they know while they see the real thing, I just think they can maybe solve their problems better and maybe think in another way".

Mary also had a few ideas on problem-solving as a teaching strategy:

> "Ja, problem solving is one of the, I think the most difficult skills to develop in learners, because it is not something you can really teach them. You know it is something that they cannot acquire from text books; they can't go home and study it. So it is something that you must guide them into. So the best I usually do is I give them a problem and say so now in your group, come up with ideas on what can we do to solve the problem and many times in that group you are amazed with all the different ideas that they came up with".

Mark seemed to have a different idea of problem-solving strategy, different from the other five teachers which showed no understanding of the concept and he was quoted:

> "You know how children are, kids are kids and if they have problems you know you have to attend to them head on. Like for instance in a class room situation whereby you are busy on a dissection and you find that there are learners that try to be you know problematic you have to identify them and explain to them why they are doing the practical and the importance of it. Learners should know at the end of this they should have benefitted a lot and once you have put all those to them they can really show you know some cooperation of some sort".

The researcher guided him by clarifying that the problem-solving strategy she meant was the skill which the learners could acquire as per the curriculum requirement and this was his response:

> "They really develop skills you know understanding you know and listening as well you know what I mean? Showing cooperation they develop to be cooperative at times because they would want to understand the importance of the dissection and listening is one of those, you know they develop a skill to listen, to carry out instructions as such. I find it very much helpful".

This response also showed that the teacher had lack of understanding of problem-solving and its strategies. The researcher could not help but wonder how Mark would assist learners to acquire problem-solving skills if he seemed not to be well-acquainted with problem-solving to an extent of failing to provide even one problem-solving strategy. No strategies were given by Mark due to a lack of understanding of the concept of problem-solving strategies. The worry was that if the teacher is not well-acquainted with problem-solving, there was no way he would then be able to use animal organ dissections in problem-solving as a teaching strategy.

All six teachers could not outline specific problem-solving strategies they could use with their learners; the other five only managed to cite examples of how they could promote problem-solving in their lessons. In as much as the other five teachers could not state specific problem-solving strategies, at least the examples they gave on how they could use animal organ dissections to promote problem-solving showed that they were well-acquainted with it. Unfortunately in most cases the teachers explained what they could possibly do, not what they were already practising.

5.3.2.17 Topics in which problem-solving skills are developed

Teachers were then asked to give specific topics in Life Sciences in which they developed the problem-solving skill and explain their reasons for indicating those topics.

Table 5.25: Topics in which problem-solving skills are developed

Categories	Codes	Teachers	Frequency
Skeleton Topic: Diseases associated with bones e.g. Osteoporosis, Gout, Arthritis	Top1	T1	1
Excretion Topic: Kidney, Lungs functions, relating to structure and function and how to take care of their bodies	Top2	T1, T4, T5	3
Circulatory system	Top3	T2, T4, T6	3
Viruses, bacteria and related diseases, cure, prevention	Top4	T3	1
Nutrition: They design how to determine which enzyme is in saliva and its role	Top5	T5	1

Top = Topic

All six teachers mentioned some topics in which they could develop the problem-solving skills. Thato suggested that the skeleton topic would be a good topic; they could dissect the different animal bones and then give learners questions based on the dissected bones and the diseases associated with them like osteoporosis, gout and arthritis, and ask the learners to investigate how to prevent such problems. Thato, Bertha and Mary concurred in that by using the excretion topic, learners could be given tasks which required them to dissect kidneys and lungs, investigating their structures and functions, diseases associated with them and how to take care of their bodies. Bertha was quoted saying:

> "I will definitely use the heart when we do the circulatory system because ja you get a lot of, for example I could ask about the heart attack and what is a stroke and let them dissect the heart and see the parts that blood can't reach if certain arteries are blocked, and implications if blood and oxygen can't reach the heart in a certain way I just think they will have to deduce and understand it better that it the heart just stops working. Or for example the lungs, if they can see the lungs in real life and see how it actually looks like and how it works when you blow into the lungs and it contracts and expands. I just think they will understand it better if there is maybe a puncture in the lungs that they will see but the air will exit in another way and now the lungs can't expand something like that. Ag ja, and I don't know, I know they only do the organs like the sense organs in matric, but I think if you can do interesting sense organs like the ear and actually see really how it looks on the inside maybe that will be very interesting, I don't know".

Yvonne strongly felt that, any topic could be used to develop problem-solving and she gave examples of viruses, bacteria and related diseases, their cure and prevention:

> "I think any of the topics that involve the human body, we can develop the skill. Even the topics that involve, you know the viruses, the bacteria, because all of that relates to illnesses and diseases that animals and humans can get. So there are quite a number of topics in the Grade 11 syllabus that you could use to develop this skill".

In support of Yvonne's opinion that any topic could be used to develop problem-solving skills, Mary gave different examples such as a task on nutrition where learners could design how to determine which enzyme is in saliva and its role; a practical to prove the need for light for photosynthesis, and one to work out after dissections how the kidney gets rid of the waste.

> "We basically do it in all. We are supposed to develop this skill in all topics, so for example if we do photosynthesis. So you are going to ask them how do you determine if sunlight is needed for photosynthesis or how do you know a plant need carbon dioxide, so they must design an experiment.

> So if you do nutrition you can then see, how can you determine which enzyme is present in your saliva you know, so then they must design it. In terms of dissection, I could give them a question where they must figure out how the kidney rid of the waste products; now let them, that is the problem. They must dissect the kidney and figure it out, so then I can guide them in that line, vitally speaking".

Mark, Bertha and Tia said problem-solving skills could be developed using the circulatory system topic. This shows that many topics could be used to develop this skill but the teachers did not confirm that they were already developing this skill in other topics. As Mary rightly pointed out, they were supposed to develop this skill in all topics but they did not for different reasons according to different school environments.

5.3.2.18 How teachers use animal organ dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners

The researcher deemed it essential for this study to find out how the teachers used animal organ dissections to develop problem-solving skills in their learners.

Table 5.26: The use of animal organ dissections to improve teaching strategies and problem-solving skills of learners

Categories	Codes	Teachers	Frequency
When I make them dissect, they master the concepts much more than just theory and diagrams	Hw1	T1, T6	2
When they dissect, I ask them to name and relate structure to function	Hw2	T1, T2	2
Ask them to draw and I ask them questions relating to real life situations related to excretion	Hw3	T1, T3, T4	3
Guide learners towards development of the skill as they dissect, rather than leave them to just cut unguided	Hw4	T3, T4	2
Give them an organ and ask them to dissect and identify all features and answer the related problem-solving task	Hw5	T5, T6	2

Hw = How

Thato and Mary acknowledged that when they make their learners dissect, they master the concepts more than if they just teach the topic using theory and diagrams; as they dissect, they are given questions on a worksheet relating to different parts of the organ and their functions. Mark said he asked his learners to name the parts of the dissected kidney and then relate the different structures to function. Thato, Yvonne and Bertha asked their learners to draw the dissected organ and give them questions relating real life situations to excretion, in terms of functions, diseases and even socially. It was interesting to note that the worksheets that the teachers gave to the learners basically asked learners to dissect, draw, label and a few no so challenging questions were asked. They could also guide their learners towards development of the problem-solving skill as they dissect, rather than leave them to just cut unguided with no skill developed. Yvonne was quoted saying:

> "I think if you use dissections to improve problem-solving skills you have to consolidate with worksheets, you have to consolidate with real life examples. It is not something like they can just have the dissection and be expected to learn from that. You actually have to help them consolidate what they have seen and I think during the dissection you also have to lead them then, if you want them to develop problem-solving skills, you have to lead them to think in that direction during the dissection. It is not something where you can just let the learners do a dissection with no guidance and you have to guide them more in what you are going to be, what problem you would want them to solve afterwards".

Mary and Tia said they could give their learners the organs and ask them to dissect and identify all features and answer the problem-solving questions they will have given them. Tia suggested:

> "Well I suppose if you use like the example of diabetes and the kidney when they dissect the kidney and you ask them to identify the nephron and then if they can link that to the diabetes where I could ask them that if there is a problem with the proximal convoluted tubule which is supposed to absorb all the glucose, where does that glucose go, then they can follow it down through the nephron to the urethra and they can see why there's glucose in the urine and then obviously that would lead to the diagnosis of diabetes".

Mary supported Tia's idea by citing a different example of how she used animal organ dissections to improve the problem-solving skills:

> "Ja, let me try to think now, I am busy now with different animal families. So you can perhaps give them as a challenge and say I have now an example of a plant family now you must dissect it and tell me all the different features. Does it have an endoskeleton or exoskeleton, blood system or not. They investigate all the different features. So you don't tell them beforehand look for this and this stuff. You give them the sample saying you must now discover what is in there. So that can perhaps be more challenging, they already know the diagram and they know okay this is supposed to be there and there. You give them something that they have never seen before. So perhaps that is a good idea to do it from that angle as well and they acquire investigative skill for the problem in front of them that they then solve".

It was interesting to note that the pre-test and the post-test the researcher developed for the learners, as well as the interview, got the teachers to think of approaching the animal organ dissections from a different perspective which could enable them to use it to develop problem-solving skills.

5.3.2.19 Teachers' attitudes towards animal organ dissections in general and its use in problem-solving

Besides establishing the attitudes of the teachers towards dissections, the aspect of vital importance was to establish their attitudes towards the use of animal organ dissections on problem-solving. The researcher asked them two questions on their attitudes towards dissections, whose responses were linked to those in the previous section. The first question was to determine if the teachers thought the dissections of organs were important or significant in problem-solving and secondly, if they thought animal organ dissections have any contribution to the development of problem-solving skills of Grade 11 Life Sciences learners.

Table 5.27: Teachers' attitudes towards animal organ dissections and its use in problem-solving.

Categories	Codes	Teachers	Frequency
Yes it is, clear understanding of kidney and how to solve problems associated with its structure and function	Sign1	T1, T3, T5, T6	4
Yes, seeing the real organ and its parts can make learners think from a different angle and solve presented problems in a better way and improves their complex skills	Sign2	T4, T6	2
Yes it is, learners develop listening, observation and cooperative skills	Sign2	T2	1
It does especially to those aspiring to pursue the medical or Life Sciences career	Contr1	T1, T6	2
They can apply the same knowledge to other organs or how to investigate them, the same way they did with the kidney	Contr2	T1, T2, T3, T4, T5, T6	6
It does because they did much better in the post-test than before they dissected	Contr3	T2,T5	2

Sign = Significant; Contr = Contribution

According to Thato, Yvonne, Mary and Tia, animal organ dissections were significant in problem-solving because when learners dissect the organ, they gain a clear understanding of the kidney structure and then are able to understand the problems associated with its structure and function and how to solve them. Bertha and Tia are of the opinion that seeing the real organ and its parts can give learners a different perspective and solve presented problems in a better way than if they were just using theoretical knowledge to answer the same questions. They argue that there will be an improvement in their complex skills thereby improving their problem-solving skills. Bertha was quoted saying:

> "Well as I believe that if they can see the real life thing they will think of it further on how something like an organ works. And they will think in a different angle, if they see how it actually looks and what implications it can have when you have a problem like a puncture in the lung, or a blockage in the urethra, that they will be able to solve their problems better and think about solutions maybe".

According to Mark's understanding of problem-solving, dissection is significant because the learners develop listening, observation and cooperative skills, and he had this to say:

> "Yes, I think I have seen this in the pre-test that I gave and the posters that I gave afterwards, you know before the dissection they could not answer some of the questions but afterwards they showed a greater understanding that there might be some implications in certain organs like diseases you know and that was something I really wanted them to understand. You know what I mean and that on its

> own brings about the knowledge that the organs such as a kidney are very much delicate organs and it tends to have you know diseases, which would affect their body system in general".

The teachers were asked if they thought animal organ dissections had any contribution to the development of problem-solving skills of Grade 11 Life Sciences learners. Thato and Tia were of the opinion that it made a great contribution especially to those learners who were aspiring to pursue a medical or Life Sciences career. All six teachers concurred in that learners could apply the same knowledge to other organs or how to investigate them, the same way they did with the kidney thereby expanding their problem-solving skills. According to Mark and Mary, animal organ dissections made a significant contribution to the development of problem-solving skills because their learners did much better in the post-test than before they dissected. Overall, the responses by the teachers showed a positive attitude towards animal organ dissections in developing problem-solving skills. The positive attitude of the teachers in most cases has serious implications on the attitude of the learners. The attitude of the teachers may have been the reason why generally the learners engaged with the dissections and managed to improve their performance in the post-test.

5.4 SUMMARY OF THE QUALITATIVE DATA

Chapter 5 has presented and discussed the qualitative data. This included:

- Firstly, the narrative data was presented which was obtained from lessons observations of the six Life Sciences teachers and their Grade 11 learners in which they carried out animal organ dissections and wrote the pre-test and the post-test. Some of the highlights established from the lesson observations data include the level of engagement of learners with animal organ dissections which did not necessarily depend on the availability of adequate laboratory facilities and apparatus but on the level of motivation the learners had towards the activities. Learners from the disadvantaged schools also managed to have very nice and clear dissections in most cases even though they were using improvised dissection instruments; they just had to be more focused and careful as they carried it out. The researcher also observed that even if teachers were at the same school, their teaching approaches were different even if they wanted to fulfil the same objective. The way Thato approached the animal organ dissections lesson was different from the way in which Mark approached it.

This also applied to Yvonne and Bertha who approached the same lesson so differently. Each approach had its own advantages and disadvantages.

From the researcher's point of view, all three learning outcomes were fulfilled during the animal organ dissections, but the LO 3 was fulfilled through the test the researcher developed. The test guided the learners to engage more with dissections to solve the presented problems based on the dissected organ.

It was noted that the idea of touching the fresh animal organ was not so appealing to most learners especially the girls. Some spent most of the lesson with their noses covered and only uncovered them during discussions and as they were writing the post-test. Group-work helped other learners that were initially scared to touch blood to be involved until they were excited as well. Generally the attitude of the learners towards animal organ dissections was positive until the time came for them to write the post-test. With a bit of persuasion from the teachers, all learners wrote the test. The class which was the least disciplined belonged to Bertha who was the least involved in the animal organ dissections carried out by learners. This showed that if the teacher has a negative attitude towards animal organ dissections, so will the learners.

- Secondly, narrative data was presented from the responses given by the six Life Sciences teachers during semi-structured interviews. The researcher noted with great interest and relief that all the teachers were well qualified to teach Life Sciences in Grade 11. It was also noted that one of the six teachers had never experienced dissections during her schooling and it was evident during the lesson observations that she was not confident to carry out an animal organ dissections demonstration. Her attitude was worsened by blood phobia which also evidenced itself during the lesson observations and she confirmed it during the interview.

The attitudes of the other five teachers towards animal organ dissections were considered positive. They reflected in their learners' behaviour. A few exceptions in each class were dealt with accordingly in cases of indiscipline or not willing to dissect. The teachers also confirmed that most learners had a positive attitude towards animal organ dissections but the attitude shifted towards the negative when they had to apply the observed information from the dissected animal organ to solve problems on the post-test because it was less interesting.

There was reason for concern because not all teachers are well acquainted with problem-solving strategies and as a result could not explain how they could use animal organ dissections in problem-solving as a teaching strategy. Some teachers were aware of how they can use animal organ dissections in problem-solving as a teaching strategy but they were not going beyond letting the learners dissect, draw and label the diagrams. Some argue that it is time-consuming as they have to complete the syllabus according to the National Curriculum Statement on time.

Chapter 6 will integrate the collective results emanating from both the quantitative and qualitative studies in detail. The research questions will be revisited to determine to what extent they have been answered. The final chapter will make recommendations for future interventions and research in this field.

CHAPTER 6

DISCUSSIONS AND ANALYSIS OF THE FINDINGS OF THE STUDY

6.1 OVERVIEW OF THE CHAPTER

The data that was collected using the quantitative and qualitative data collection techniques were presented and discussed separately in Chapters 4 and 5. In order to fully triangulate the findings of the previous two chapters, both the quantitative and qualitative data required further discussion and analysis. The data was processed, analysed separately and compared where applicable in this chapter. According to Cohen et al. (2000, p. 147), data analysis "involves organising, accounting for, and explaining the data; in short, making sense of the data … noting patterns, themes, categories and regularities". They further suggest that early analysis reduces the problem of data overload as huge amounts of data rapidly accumulate in qualitative-quantitative research. Analysis and interpretation of data enables the researcher to deduce meanings and implications of the findings of the study. This chapter focuses on the discussion, analysis and interpretation of the data that was collected for this study

Data analysis involves a systematic search for meanings from the collected data so that what is learned can be communicated to others (Hatch, 2002). Different types of data often require different analysis strategies. To analyse the data presented and described in Chapters 4 and 5, the data was firstly organised according to the conceptual framework. Secondly, groups, patterns or themes were formed according to the conceptual framework as well. Thirdly, the data was put in context by establishing relationships and linkages between the domains and also between the sets of data from the questionnaires, pre-test, post-test, lessons observations and interviews with the Life Sciences teachers. This can be done by "identifying confirming cases, by seeking *underlying associations* and connections between data subsets" (Cohen et al., 2000, p. 149). Fourthly, from the analysis, a conclusion was reached, a few assumptions were put forward and the implications of these findings were looked into. In the fifth place, all the discrepancies were found in the data and put into context.

The results obtained from both the quantitative and qualitative approaches were extracted and were used to address the six research sub-questions which were used to help answer the main research question. More than one data source was used to address each sub-question in order to triangulate and for convergence of data as this would give an in-depth understanding of the study. The main research question intended to establish the contribution of animal organ dissections to the development of teachers' teaching strategies and Grade 11 Life Sciences learners' problem-solving skills in diverse environments.

6.2 DISCUSSIONS, ANALYSIS AND INTERPRETATION OF THE DATA FROM THE LEARNERS

The following four research sub-questions were used to address the main research question using the data obtained from the pre-test, post-test, learners' questionnaire, lessons observations and the teachers' interviews.

3. *How does learners' engagement with animal organ dissections aid in developing problem-solving skills?*
4. *What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*
5. *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?*
6. *To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?*

6.2.1 Learners' engagement and usage of animal organ dissections in the development of problem-solving skills

The third research sub-question: *How does learners' engagement with animal organ dissections aid in developing problem-solving skills?* was addressed by the triangulation of data from the pre-test, post-test, lesson observations and the questionnaire. The triangulated data show that the learners generally understood what animal organ dissection was, even though only 42.86% indicated that they had carried out animal organ dissections in the previous grades. The concern then would be how these learners would engage with animal organ dissections to develop problem-solving skills when more than half of them had no hands-on experience with animal organ dissections (See Section 4.2.2.2, Figure 4.8). This concern was addressed by giving the learners a pre-test which had rote learning, problem-solving, LOs 1, 2 and 3 questions, before carrying out the animal organ dissections. The Matched T-test results showed a statistically significant learning gain ($p<0.0001$) between the means of the pre-test and the post-test for each of the six variables (Section 4.2.3.1). It may therefore be asserted that the learners' engagement with dissections possibly resulted in the improvement of their scores in the test overall. This assertion was supported by the distribution of data shown by the box and whisker plots in which the same scores of the pre-test and the post-test were used. The median was 23 for the pre-test and 46 for the post-test showing that the pre-test median was doubled in the case of the total mark; the pre-test median was 11 and a post-test median of 17 for the rote-learning questions, the median for problem-solving questions was 13 for the pre-test and 29 for the post-test showing that the median increased significantly after the dissections of organs.

These results may be used to argue that even though 57.14% were engaging with hands-on animal organ dissections for the first time, they still managed to improve their performance in the test which had predominantly problem-solving questions. The researcher could therefore conclude that the learners' level of engagement with animal organ dissections could have improved their scores in the test overall. Even though one can argue that learners could still have done well in rote learning questions, having done the theory only, it should be noted that the learners wrote the pre-test after covering the theory of the urinary system. The pre-test mean was however significantly lower than the post-test, an indication that those learners improved significantly after carrying out animal organ dissections. This shows that their engagement with animal organ dissections influenced this improvement. While learning theory may have had an impact on the learners, this was less significant in comparison to the impact the animal organ dissections had on the learners' capabilities to answer even the rote learning questions. This strengthens the earlier argument that in this case learners engaged with animal organ dissections and managed to develop problem-solving skills as they explored the organs and discussed in small groups. As a result, post-test means generally improved.

6.2.1.1 Analysis across the four schools

Since there were four schools from different environments it was deemed essential to determine the effectiveness of the animal organ dissections by calculating the learning gains of each school per variable and compare them with the learning gains of other schools. The effect of school environment, gender and moral position on the use of animal organ dissections on the Learning gains was established using the ANOVA (Analysis of variance).

The p-values for the total, problem-solving, LO 1 and LO 2 variables showed statistically significant difference of learning gains between the four schools which may be attributed to the diversity of the school environments as explained in Chapter 3 (See Section 4.2.3.2, Table 4.24). The differences between the schools included the availability or lack of laboratory facilities and apparatus in the four schools. Another difference which the researcher noticed during the lesson observations was the different teaching approaches used by the six teachers which resulted in different levels of engagement with animal organ dissections by the learners from the different schools. Possible explanations for the lack of statistically significant differences in learning gains for LO 3 and rote learning variables between the four schools include; rote learning questions can be theoretically addressed with a minimal level of engagement with animal organ dissections on the part of learners from different school environments; as for LO 3, it may be because the learners from the four different school environments may have managed to apply the knowledge acquired to society at almost the same level irrespective of the different learning environments.

6.2.1.2 Comparison of the pre-test and post-test means of the schools in pairs

The *Scheffe's test* was used to establish if there were significant differences between group means of schools in pairs. For the total mark, the pair of School B and C had a learning gain difference of 7.669. The problem-solving learning gains for the same pair had a difference of 7.061. As for LO 2 learning gains had a difference of 6.652. This showed that there was a statistically significant difference between the means of the two schools. School B, as a former Model C public school has all the facilities the learners require for animal organ dissections while School C is an independent school which also has the facilities the learners needed for dissections. The significant difference between the means of these two schools, as noted by the researcher during the lesson observations, could be attributed to the way in which the learners engaged with the animal organ dissections during the lesson which resulted in the learners of School B showing a greater improvement between its pre-test and post-test. The School B learners mostly worked independently without much assistance from the teachers which could have encouraged them to explore and get the answers for the challenging questions given to them. On the other hand, School C had their teacher hands-on throughout the lesson which might have led the learners to depend too much on her. When it came to answering of questions which were more challenging, they then found themselves not quite prepared to work independently and this resulted in a lower magnitude of improvement than School B. The researcher is of the opinion that the same explanation could be given as to why there were significant differences between the means of the pair comprising Schools D and C. School D learners mostly worked independently and School C teacher was mostly hands-on. The scores of the learners show that the learners that worked mostly independently scored higher than the *spoon-fed* learners, hence the differences between the two schools showed that School D proved to be stronger than School C. Schools A and B had a significant learning gain difference of 1.9263 for LO 1. It is acknowledged that the issue of animal organ dissection novelty for most of the learners may have influenced level of engagement with the animal organ dissection by School A learners and the positive attitude of the learners as they carried out the animal organ dissections and when answering the post-test questions was another contributing factor. The same attributes cannot be said for School B learners, some of who adopted the same negative attitude that their teacher was exhibiting which may have lowered their level of engagement with the animal organ dissections. As a result there was significant difference between the learning gains of Schools A and B (Section 4.2.3.4).

During the lessons observations, the researcher also focused on how the learners engaged with animal organ dissections to improve problem-solving skills. She noted with great interest that most learners did not just cut the organ and draw but they dissected, attached labels on the toothpicks and placed them on the identified parts. As the learners did that, many group discussions and debates ensued that were quite constructive to improve their problem-solving abilities. She noted with great interest that the Schools B and D, which had the least help from the teachers, resulted in differences between the means for the problem-solving questions of 18.89 and 19.64 respectively which were much higher than that of Schools A and C which had 15.64 and 11.83 respectively (See Section 4.2.3.3, Table 4.25). The researcher is of the opinion that the holistic learner-centred approach with minimal assistance from the teachers encouraged these learners to explore more on their dissected organs and managed to improve their problem-solving skills more than the other two schools who were over-assisted by their teachers.

In the *questionnaire* completed by the learners, they also acknowledged that animal organ dissections were helpful in improving their problem-solving skills. This is reflected in Table 4.4 where above 90% of the learners acknowledged that animal organ dissections helped them to understand the structure and functions of the kidney, to improve their investigative skills and to develop skills to solve real life problems. The researcher asserts that if the learners had this opinion on animal organ dissections, it meant that they would engage with it more and in so doing acquire the necessary skills which they believed would be gained from animal organ dissections. Besides the above-mentioned opinions, 92.86% of learners were of the opinion that animal organ dissections would give them first-hand information about the anatomy of the organ they were studying, 90.18% acknowledged that it would help them to know more about their own bodies and 73.66% preferred to be tested after animal organ dissections to establish how much skill they had acquired. Some (81.70%) of the learners even argued that animal organ dissections helped them as Life Scientists preparing them for real life situations and disease; some acknowledged that animal organ dissections helped to link the theory they had with reality. All of these learners' responses show that the majority of learners did not just dissect for the sake of cutting and drawing but to acquire skills like problem-solving, investigative and to understand more of the animal organ morphology. This could mean that the degree of engagement with animal organ dissections of these learners was intensified by their acknowledging how much animal organ dissections was helping them to acquire all the essential skills that one needs even in real life.

The pre-test, post-test results, the lessons observations data and the questionnaire responses all indicate that learners may engage with animal organ dissections and use it to develop or improve their problem-solving skills. They can explore the organ, debate on what was observed, discuss what was observed in groups challenging each other with real life situations related to their observations, respond to problem-solving tasks given by the teachers and can also become less dependent on the teacher.

6.2.2 The learners' perceptions and attitudes towards animal organ dissections in in general and its use specifically in problem-solving

Part of the fourth research sub-question which pertained to the learners: *What are the learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?* was addressed by the data that came from the questionnaire the learners completed, the interview with the Life Sciences teachers and the lessons observations in which the learners wrote a pre-test before carrying out the animal organ dissections and a post-test after carrying out the animal organ dissections. The question was intended to obtain data to establish what the learners' attitudes and perceptions were towards animal organ dissections and its use in problem-solving.

6.2.2.1 Learners' opinions regarding the importance of animal organ dissections

In the questionnaire there were quite a few items which the researcher considered essential to establish the attitudes and perceptions of the learners. In the closed-ended items of the questionnaire there was a high frequency of learners who acknowledged the *usefulness* or *importance* of dissections of animal organs. Responses in Table 4.4 reflect that 96.43% of the learners were of the opinion that animal organ dissections were useful in the learning of the organ structure and functions, 97.77% of the learners acknowledged that it helped them to understand animal organ morphology, 97.76% were of the opinion that it helped them improve their investigative skills, and 81.70% to solve real life problems. The majority (92.86%) of the learners were interested in dissecting because they were interested in finding out first-hand about organs. The responses of 31.25% (n=70) of learners on the open-ended responses acknowledged that animal organ dissections gave them a first-hand or hands-on experience which was vital to prepare them as Life Scientists.

> "It makes me feel like a surgeon already. It's a very good experience". [Respondent: 223]

> "The organ helped me to see the parts of the organ which I will always remember them forever even during exam time because I have seen them than only studying about them looking at the textbook. It also helped understand the function of it and why we should take care of them, while they still function well in our bodies". [Respondent: 002]

With this acknowledgement one can already say it shows that some of the learners have a degree of positive attitude towards animal organ dissections.

The researcher further explored if this positive attitude would still be evident in situations where these learners were to be involved in hands-on animal organ dissections. It was noted with great interest that the patterns of the responses started to change as she noticed that 84.82% of the learners preferred to carry out the animal organ dissections while 15.18% were not comfortable with the idea of dissecting the organs. This showed an almost 10% deterioration in the interest on animal organ dissections, which can be interpreted as the sceptism of some learners regarding hands-on animal organ dissections rather than just watching it being done by others. The deterioration in the attitudes of the learners shows that in as much as the learners acknowledge the usefulness and importance of the animal organ dissections, it does not necessarily mean that they are keen to touch and dissect the fresh animal organs.

6.2.2.2 Emotional difficulties experienced by learners during animal organ dissections

The attitudes of the learners were also affected by the *emotional difficulties* they experienced during the dissections. Almost a quarter (24.11%) of the learners which were mostly females acknowledged that they were emotionally affected by dissecting fresh animal organs, hence their preference to dissect artificial organs, while 75.89% of the learners were not affected emotionally as shown in Table 4.4. The perception that the organ was bloody and real made the learners feel as if the dissection was being done on one of their organs, hence the emotional or sentimental effects.

> "When I was dissecting the kidney it felt like I was cutting my own insides, I wish there were other alternatives than fresh organs with blood". [Respondent: 318]

> "I love animals and I felt like crying, shaking because we were exploring the inner parts of another animal, felt bad". [Respondent: 215]

6.2.2.3 Religion and cultural restrictions to animal organ dissections

Other aspects which could greatly influence the attitudes of the learners were their *religion* and *culture.* It was noted with great interest that 13.84% of the learners acknowledged that their religion restricted them from dissecting while 86.16% were not influenced by religion. This 86.16% is not so different from the 85.27% of the learners who said they were Christians and the researcher is of the opinion that it is most likely that the 13.84% consists mostly of non-Christians as insinuated by one of the teachers (Thato: School A) during the interview who said:

> "So far we haven't had that religious problem as an excuse. Maybe it is because Christianity is the religion that is dominating, I don't know. But I never had a problem of learners saying according to my religion I won't do this".

Only 8.04% of the learners said that their culture restricted them from dissecting but the majority confirmed that their culture had no influence on their attitude towards dissections of animal organs. The researcher asserts that culture and religion do not really have much of an effect on the attitudes and perception of learners towards dissections in this study and this may have been influenced by the small proportion of learners adhering to the dissection restrictions.

6.2.2.4 Moral issues regarding animal organ dissections

Besides the attitudes and perception of learners influenced by religion, culture or emotions, another aspect that had a great influence on the learners' attitudes was *moral issues.* The majority of the learners (83.04%) showed that they were morally *for* animal organ dissections and some of them strongly argued their perception as they were quoted:

> "It is not like I am murdering the animals for some sick sadistic purpose. It's purely for exceptional, justified reasons so nothing is wrong with it". [Respondent: 125]

> "The organ helped me to see the parts of the organ which I will always remember them forever even during exam time because I have seen them than only studying about them looking at the textbook. It also helped understand the function of it and why we should take care of them, while they still function well in our bodies". [Respondent: 002]

> "Animal organ dissections are moral because it will make us get more knowledge about the structure in a specific animal. As the future scientists of tomorrow we have to investigate by means of cutting the organs to identify those different structures, to write books and expand and share our knowledge". [Respondent: 020]

> "I love animals, but I think using dead animals is a more useful way to find out more about our bodies. As students study sometimes is too hard, it is much easier to remember just dissecting, observing and identifying parts". [Respondent: 223]

Table 4.11 reflects responses given by the learners when they were further probed on how they felt as they were carrying out animal organ dissections. Some responses were linked to moral issues, for example (n=25) 11.16% of the learners said they felt respect towards the animal which had to die for their benefit. These responses and many others showed that even though society has many facets advocating against dissections, these learners feel that as long it is done for a good cause, dissections are morally justified. This opinion was shared by the prospective Life Sciences teachers studied by De Villiers and Sommerville (2005) which revealed that 70% of the students had a positive attitude towards animal dissections because it was for their educational benefits. Donaldson and Downie (2007) also reported a study wherein university-level students were questioned on their attitudes to animal uses in higher education and they recognised the educational value of animal uses, while disapproving of killing animals for this purpose.

The National Association of Biology Teachers (NABT) also supports the dissections of animals as long as they are conducted responsibly to convey substantive knowledge of Life Sciences (Moore, 2001). NABT believes that Life Sciences teachers are in the best position to ensure that animal dissections are used to foster a respect for life and for the animals from which the organs came. Twenty-five learners mirrored the views of NABT, but there were about 16.96% of the learners who were morally *against* dissections and they also argued strongly, as quoted:

> "The only reason why I think we should be cutting up animals is for the sole purpose of our protein. I feel the amount of animals that had to die so that we can just look at their kidney and throw it away". [Respondent: 104]

> "I am against it because some people use it for traditional medicines, which they believe it can make them rich and powerful". [Respondent: 303]

Some learners (23.91% of the responses) considered it cruel to kill so many animals just for their organs. It was explained to the learners that the kidneys were bought from the abattoirs where the animals were killed for meat, but for some, due to a combination of religious and cultural beliefs, they were still against animal organ dissections. These learners' perceptions were supported by the New England Anti-vivisection Society (2004); it echoed that many people feel it is morally wrong to kill an animal for the purpose of dissections of the animal or its organs. The society also says that some religions do not support the use of animals for dissections for unnecessary purposes and they feel that it results in disrespect of animals. De Villiers (2011) established that 54 % of the Biology prospective teachers found it acceptable to dissect already dead animals, whilst 41% only supported the dissection of animal organs as long as they were not killed specifically for dissection purposes which were basically conditional acceptance of animal dissections. Five learners (10.87% of the responses) who were vegetarians could not touch the fresh organ. Table 4.7 reflects other aspects which showed the opinions of the learners who were morally against dissections; they felt guilty, cruel and disrespectful towards the dead animal.

> "It felt like I was being cruel, treating another animal like that, as if I was disrespecting the dead animal, but I still think the experience was overwhelming". [Respondent: 239]

The researcher observed that even though these learners were morally against dissections, some of them still participated in the dissections even in Bertha, Mary and Tia's classes where they were allowed to use alternatives to dissections; this showed that they acknowledged the importance of carrying out the animal organ dissections.

6.2.2.5 The issue of *disgust* as per the researcher's observations and according to the learners

The issue of *disgust* evidenced itself a lot during the lessons observations, in the teachers' interviews, with the learners confirming it in the questionnaire. Almost a quarter (23.22%) of the learners acknowledged that they found animal organ dissections disgusting while 76.78% disagreed with that statement. Table 4.11 reflects the issue of disgust as well with 44 learners saying the organ was smelly, gross and nauseating. The researcher noted that during the dissections lessons some learners could not even get themselves to touch the fresh organ while some were even covering their noses. School C learners said they would only touch the organs if they were provided with latex gloves. School C learners were provided with gloves since the school could afford to buy them. Although the teachers and the researcher were aware of the general standard to use gloves when dissecting, affordability on the part of Schools A and D was prohibitive. However, the health and safety issues were considered, hence the use of fresh kidney instead of preserved ones. Tia, who is Teacher 6 from School D said, some of her learners could not even stand the sight of the organ and some ran out of the class or stood apart from the groups. This attitude has a great impact on the learners as they could not participate in the actual dissections of animal organs thereby having an impact on their performance in answering questions pertaining to dissections. Ultimately some learners acknowledged that after overcoming the issue of disgust, it was worth carrying out the dissections as two learners were quoted saying:

> "Dissection does help because I somehow had a blood phobia, but I enjoyed this dissection and overcame my fears". [Respondent: 101]

> "The smells usually get to me, but the adrenalin I receive from enjoying dissection is addictive thereafter dissection excites me as it shows that biology is not just theoretical but factual/practical". [Respondent: 109]

Hart et al. (2008) also noted that for some learners it is both unpleasant and very intriguing and if the intrigue is stronger than the unpleasantness, then the disgust plays a role in making the experience much more memorable, which is what respondents 101 and 109 expressed. The study by Downie and Alexander (1989) suggests that students who strongly object to dissections or any form of animal use, but remain keen to study biology may be offered alternative practical covering similar work, rather than force students to dissect even when they are uncomfortable.

6.2.2.6 Attitudes and perceptions towards animal organ dissections in general and its use in problem-solving

Since the focus was on the attitudes and perception of learners towards animal organ dissections and its use in *problem-solving*, the questionnaire also included items which probed the role of dissections in problem-solving. About 81.70% of the learners acknowledged that one of the roles of animal organ dissections was to help them develop skills to solve real life problems, in other words, problem-solving skills, while a very high percentage (97.76%) also acknowledged that it would help them to improve investigative skills. The teachers confirmed in the interviews that the attitudes of the learners during the hands-on dissections part was very positive but when it came to answering the problem-solving questions, some of them were grumbling because it meant more effort to respond to challenging questions individually. During the lesson observations, the researcher also noted that the learners were more jovial as they were carrying out the dissections. The idea of writing the test did not please all of them; some rushed through the work and the teachers had to be firm with them to do their work properly. This is also confirmed by their responses in Table 4.4 where 26.34% said they did not like the idea of being tested to assess their knowledge after dissections of animal organs as it would mean more work for them. Another factor which might have influenced the dislike of being tested was the carrying out of animal organ dissections after normal school hours in the case of Schools A and D. The learners' response is also noted in literature by Aaronsohn (2003) that learners can tend to be resistant to new instructional methods because they are more comfortable in their routine or old method of instruction. It is evident that the 26.34% of the learners who did not like being given challenging problem-solving questions after carrying out the animal organ dissections were merely comfortable with the traditional dissections lessons where they just cut, draw and label the observed parts of the organs without engaging with the organ in order to use the knowledge acquired to answer the given challenging questions.

Generally more than 80% of the learners echoed that they found the animal organ dissections exciting, enjoyable, fascinating, amazing, arousing their curiosity and motivating to see the organ parts on the real tissue.

6.2.3 Problems learners experience with animal organ dissections in general and its use in problem-solving

The fifth research sub-question: *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?* was addressed by the data that came from the questionnaire the learners completed, the interview with the Life Sciences teachers and the lessons observations in which the learners wrote a pre-test before carrying out animal organ dissections and a post-test after carrying out the animal organ dissections. The question was intended to obtain data to establish what problems learners experienced in doing animal organ dissections and in its use in problem-solving.

6.2.3.1 Difficulties in the manipulation of dissection instruments

According to the responses of the learners from the questionnaire, more than a third (38.84%) of the learners found it *difficult to manipulate the dissection instruments* (See Table 4.4*)*. Some (32.57%) expressed their fear of cutting themselves because the scalpels were too sharp. This may be interpreted as the lack of experience in the animal dissections skill since 57.14% of the learners were dissecting for the first time.

> "Nervous, scared that I would cut wrongly and damage the organ because the scalpels were slippery and I was not confident how to use it". [Respondent: 148]

6.2.3.2 Inadequacy and ineffectiveness of the dissection instruments

Besides the difficulties experienced by learners in manipulating the dissection instruments, the *inadequacy and ineffectiveness of the dissection instruments* also played a role in making the dissection procedure difficult. The learners from Schools A and D feared cutting themselves with razor-blades which were improvised in place of scalpels; this situation was more problematic because it was now a combination of lack of dissecting skills and the use of inefficient dissecting instruments. The researcher noted during the lesson observations that the learners that struggled the most with the manipulation of instruments were from Schools A and D who were using improvised dissection instruments like razor-blades and knives. Teachers Thato, Mark and Tia, who are from these disadvantaged schools (Schools A and D), echoed the same sentiments regarding the insufficiency and inefficiency of the dissection instruments sighting the lack of funds in their schools (See Section 5.3.2.3). Mark was quoted saying:

> "You know if you don't have the necessary and enough equipment, you know like children find it difficult to actually to make use of the inefficient scalpels. This makes manipulation and the dissection itself difficult. And to a certain extent you will find that learners are somehow afraid of actually opening up an organ. You see some of this is due religious beliefs like in my class, I have learners that are Seventh Day Adventist members and they can't touch meat because they are vegetarians but as an educator you need to actually explain the importance of the practical before, so that this whole practical can go on and we improvise the dissection instruments as well".

Some learners were also quoted commenting on the problem they faced with dissecting instruments during the dissections of the animal organ:

> "My problem was that the animal organ was very soft, so we wasted so much time on trying to dissect the kidney correctly". [Respondent: 302]

> "Texture was slippery than what I thought from the book diagrams. This made it so difficult to cut using a small razor-blade". [Respondent: 304]

It may be argued that the inadequacy and ineffectiveness of the dissection instruments could be considered a hindrance to good animal organ dissections by the learners. The slipperiness of the organs is another factor which was an impediment to the learners' progress during the animal organ dissections. It is imperative to note that all these problems did not discourage the learners from carrying out the dissections of the organs. Some groups dissected more than one organ until they had a good dissection. Bertha (a teacher from School B) said her learners sometimes struggle to use the scalpels or they use their hands instead of the dissecting instruments and they make a mess of the organ. The irony of Bertha's response is that even though she knew that her learners struggled with the use of scalpels, she did not bother to demonstrate to them how to handle the scalpels when dissecting. The researcher just wondered how this teacher expected the learners to know how to handle the instruments without any demonstration.

6.2.3.3 Inadequate reading and following of instructions

The other problem which the researcher observed was that some learners just started dissecting the organ *without reading the instructions on the worksheet* that was given to them. As a result, they dissected the organ wrongly and could not observe the parts of the organs they were supposed to observe. Even though Schools B and C had adequate dissection instruments, some learners also struggled with the manipulation of instruments but this was mainly a result of their failure to follow instructions and just rushing to cut without reading the instructions. In the case of School C, the teacher ended up assisting the learners to dissect the organ which the researcher considered as an approach which encouraged dependency syndrome on the part of the learners. Thato (a teacher from School A) confirmed this by highlighting that the problem with her learners was that they did not follow instructions even when she gave them step by step guidance. As a result they ended up cutting wrongly or cutting themselves. Bertha and Mary (teachers from Schools B and C respectively) echoed the same sentiments of learners cutting wrongly and in some instances cutting themselves.

6.2.3.4 Failure to relate the textbook diagram with the real organ

Another problem, according to Mary (teacher from School C), was that her learners struggled to *relate the diagram in the textbook with the real organ* due to size, colour and texture differences. Some only realised for the first time how slippery the kidney was, an experience that one cannot have by just looking at the organ in the textbook. Some of the learners also said that the diagram in the textbooks looked different from what they actually saw on the actual kidney and this created some confusion. The result was that learners ended up failing to identify some parts. In most cases the researcher realised that some of the parts which were microscopic were presented as macroscopic on the diagrams and the learners expected to observe them by using the naked eye. The problem was solved by the use of hand lenses. One learner expressed how amazed she was at the difference between what she had thought the kidney would look like with what she saw when she dissected the real organ:

> "When I was carrying out the dissection I was amazed because I thought that the kidney is a big thing that will be about 2.5kg because of how important it is to us humans and animals. The role that the kidney plays it is very big to our life. Also scared and I felt like my body was shaking when I had now dissected and exploring the inner parts". [Respondent: 001]

Hart et al. (2008) acknowledges the above statement by arguing that some learners find animal organ dissections unpleasant, scary but also intriguing and if the intrigue is stronger than the unpleasantness, than they will be amazed and explore the organs even more, as confirmed by respondent 001.

6.2.3.5 Fear of touching the fresh organ

Yvonne, Mark and Mary's learners were *scared to touch the fresh organ* due to being squeamish about the slippery texture of the kidney. Yvonne, Mark and Tia concurred that some of their learners felt nauseous due to the smell of the fresh organ and their blood phobia. Yvonne was quoted saying:

> "I think the problem they experience is they all want gloves, the reason being that they are scared to touch the organ. The other problems I think they experience are that some of them are afraid of the sight of blood or afraid of actually dissecting an organ, they are a bit squeamish yes. But what's nice with the group work is that it is invariable, in a group you will always find one or two learners that are quite prepared to get stuck in and the other learners are quite prepared to participate but not maybe actually physically touch it themselves".

The teachers' comments were confirmed by 66 learners (29.46%) who said that their problem during animal organ dissections was *the constant urge to vomit, nausea, being squeamish, smell and blood phobia* (See Table 4.8).

The researcher also observed that the mentioned problems were real and for some learners it was so bad that they could not stand the sight of blood, let alone touch the organ. Some learners were covering their noses as the other group members were dissecting as they could not stand the smell of the organs. This was confirmed by Hart et al. (2008), who said that some learners cannot stand the smell of the organs, the squishy-looking and bloody organs to an extent that some would rather forfeit the marks than touch the fresh organs. The researcher is of the opinion that some of these learners could overcome some of problems like blood phobia and the squeamishness by being exposed to animal organ dissections more frequently. When the learners get used to the touching of organs they may then engage with dissections to develop problem-solving skills.

6.2.4 The extent to which Learning Outcomes 1, 2 and 3 (NCS) were being achieved by animal organ dissections in Grade 11

The sixth sub-question: *To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?* was addressed by the data from the pre-test, post-test, lessons observations and the interviews with the teachers. The pre-test and the post-test written by learners consisted of questions which could be answered by learners who had achieved the three learning outcomes. In order to find out the extent to which the learning outcomes were achieved, a Matched T-test was used to establish if there was a significant learning gain between the pre-test and the post-test scores for each learning outcome.

6.2.4.1 Learning Outcome 1 (LO 1)

Learning Outcome 1 involves: Scientific inquiry and problem-solving skills where the learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem-solving, critical thinking and other skills.

For LO 1, the p-value < 0.0001 indicated a statistically significant difference between the means. This showed that there was a great achievement of this learning outcome. It may be inferred that the significant changes in the test scores for this learning outcome was due to the effectiveness of the animal organ dissections as the intervention to achieve this learning outcome. The Analysis of Variance (ANOVA) which was used to establish if the difference between the means of the four schools was statistically significant also confirmed that the intervention may have resulted in significant differences between the schools for LO 1. The differences between the means of the four schools were largely owing to the level of engagement which the learners from different schools had with animal organ dissections. The learners that engaged and focused more on the animal organ dissections irrespective of the adequacy of instruments, excelled in this learning outcome's questions. Taking into consideration the differences between the means of the schools for the LO 1 questions, the p-value of 0.0003, which is also less than 0.05, showed that the intervention had improved the extent to which this LO 1 was achieved. During the lesson observations, the researcher also noticed that the learners carried out the hands-on dissections with a high level of engagement and as a result managed to score significantly higher marks in the post-test. It is very important to note that the LO 1 is considered to be a variable which can be enhanced by engaging in practical activities like animal organ dissections as confirmed by the teachers in their interviews. All six teachers were aware of how animal organ dissections can achieve this learning outcome. They confirmed by commenting that it was fulfilled by the learners carrying out the hands-on animal organ dissections focusing on using the acquired and observed information to solve given problems.

6.2.4.2 Learning Outcome 2 (LO 2)

Learning Outcome 2 involves: Construction and application of Life Science's knowledge. The learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences.

As for Learning Outcome 2, the p-value < 0.0001 showed a statistically significant difference between the means. This showed that there was a great achievement of this learning outcome. It may be assumed that the significant changes in the test scores for this learning outcome may have been due to the effectiveness of the animal organ dissections as the intervention to achieve this learning outcome. During the lesson observations, the researcher noticed that most of the learners observed the dissected organ, identified the parts and had group discussions relating the structure to function which achieved the LO 2. This was evidenced by the significant differences between the means for this learning outcome. The six teachers also concurred with the researcher's observations that the LO 2 was achieved by the learners constructing their knowledge by observing, identifying parts, relating structure to function, interpretation of diagram and group discussions.

6.2.4.3 Learning Outcome 3 (LO 3)

Learning Outcome 3 involves: Relating knowledge acquired to technology, culture and society.

The LO 3 was also achieved by the animal organ dissections as evidenced by the p-value < 0.0001 which is less than 0.05 (p< 0.05) for the Matched T-test. This showed that the change in the means of the test scores for the LO 3 questions was not by chance but possibly due to the effectiveness of the interventions which were the animal organ dissections carried out by learners. The researcher acknowledges that in this lesson, the LO 3 was achieved. During the interviews, however, not all the teachers showed confidence on how they used animal organ dissections to achieve this learning outcome. Four teachers namely Yvonne, Bertha, Mary and Tia, said they would give the learners practical, society-based situations to solve. Only one teacher (Mary) was quoted citing specific examples of how she would use animal organ dissections to achieve LO 3.

> "Basically Learning Outcome 1 they are physically dissecting, cutting it open and they acquire that skill to do that otherwise you can't see the different parts. The second one is knowledge; they applied their knowledge to what they had learnt in the book to the real life or to the situation in front of them. And then learning area or Learning Outcome 3 they basically applied the knowledge to real life situations, which they did by discussing diseases to do with the kidney. So they have to say, okay but this is where you find the nephron and if the nephron was damaged, what disease they would have or what part of the kidney were damaged if you had blood or glucose in the urine? And they correlated with the kidney that they had in front of them. What parts were damaged by what diseases"?

All six teachers showed that they were knowledgeable about how the learners can fulfil LOs 1 and 2. As for the LO 3, only four teachers confidently mentioned how they made sure that it was fulfilled during the animal organ dissections. Bertha showed that she knew what she was supposed to do to have the learners fulfil the LO 3 as well but she just did not give them the opportunity to do so. She explained what she would do and not what she was already practising. This cast doubt on how much teachers were using animal organ dissections to achieve this learning outcome. It can be argued that some learners can be disadvantaged if the teacher does not give them enough challenging situations to solve; their full potential is not achieved.

6.3 DISCUSSIONS, ANALYSIS AND INTERPRETATION OF THE DATA FROM THE TEACHERS

The following five research sub-questions were used to address the main research question using the data obtained from the teacher interviews and lessons observations.

1. *What is the teachers' understanding and how well-acquainted are they with problem-solving strategies?*
2. *How do teachers use animal organ dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners?*
4. *What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*
5. *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?*
6. *To what extent are Learning Outcomes 1, 2 and 3 being achieved by animal organ dissections in Grade 11?*

6.3.1 Teachers' understanding and their acquaintance with problem-solving strategies

The first research sub-question: *What is the teachers' understanding and how well-acquainted are they with problem-solving strategies?* was addressed by the data that came from the semi-structured interviews. The question was intended to establish the teachers' understanding and how well-acquainted they were with problem-solving strategies. The teachers were asked what their understanding of problem-solving was, the types of problem-solving strategies they implemented in their lessons and in which topics in Grade 11 Life Sciences they applied the problem-solving strategies.

The researcher noted with great interest that not all teachers were clear on what problem-solving strategies were. In one instance, Mark (teacher 2 of School A) showed a complete lack of understanding of the problem-solving strategy. As far as he was concerned problem-solving strategy was linked to how he as the teacher would solve behaviour problems amongst the learners, as quoted:

> "You know how children are, kids are kids and if they have problems you know you have to attend to them head on. Like for instance in a class room situation whereby you are busy on a dissection and you find that there are learners that try to be you know problematic you have to identify them and explain to them why they are doing the practical and the importance of it. Learners should know at the end of this they should have benefited a lot and once you have put all those to them they can really show you know some cooperation of some sort".

When the researcher redirected him towards the curriculum problem-solving strategy as per the National Curriculum Statement requirement, there was still no satisfactory response from the teacher as this was his response:

> "They really develop skills you know understanding you know and listening as well you know what I mean? Showing cooperation they develop to be cooperative at times because they would want to understand the importance of the dissection and listening is one of those, you know they develop a skill to listen, to carry out instructions as such. I find it very much helpful".

This response also showed that the teacher had lack of understanding of problem-solving and its strategies. This was an issue of concern on the part of the researcher that if one out of six teachers (which represented 17% of the teacher sample) was not well-acquainted with problem-solving strategies, it may be very difficult to implement the strategies in his lessons so as to improve the problem-solving skills in his learners. This argument may be supported by his learners' performance which was the best relative to other schools for rote learning and LO 1 questions with learning gains of 6.68 and 6.02 respectively, but the problem-solving questions performance was third best (15.64) in comparison with other schools. Another issue of concern would be how the less experienced and less qualified teachers would fare with problem-solving strategies if a teacher of Mark's calibre with so many years of experience and holding a Postgraduate Diploma in Education (PGDE), was still not acquainted with problem-solving strategies. The crucial question is how then are the learners expected to acquire problem-solving skills when the teachers themselves are not well-acquainted with the problem-solving strategies? This becomes an issue of great concern in the Life Sciences education.

The other five teachers seemed to have a common understanding of problem-solving strategies which revolved around application of knowledge acquired in class or during dissections in this case, to solve real life problems. At least most of these teachers were aware of how to implement the problem-solving strategies in their lessons. Even though they could not state or name specific strategies, most teachers explained how they would implement them. To show their level of understanding, Yvonne, Bertha, Mary and Tia further explained that tasks given to learners could help them to think of alternative ways to solve problems besides rote learning. This explanation showed that the four teachers had a clear understanding of how to implement problem-solving strategies. When the teachers were probed more to outline the problem-solving strategies they would implement in their classes, none of the teachers managed to state any of the problem-solving strategies but they elaborated on what they considered to be problem-solving strategies. Mary argued the importance of the teachers' guidance towards the activities that can enable learners to acquire the problem-solving skills. Bertha, Yvonne and Mary concurred on the importance of allowing learners to work independently on problem-solving questions highlighting how it would be amazing to see how many different brilliant ideas the learners would come up with, as confirmed by Mary:

> "Ja, problem-solving is one of the, I think the most difficult skills to develop in learners, because it is not something you can really teach them. You know it is something that they cannot acquire from text books; they can't go home and study it. So it is something that you must guide them into. So the best I usually do is I give them a problem and say so now in your group, come up with ideas on what can we do to solve the problem and many times in that group you are amazed with all the different ideas that they came up with".

6.3.2 The improvement of the teachers' teaching strategies and the problem-solving skills of learners by using animal organ dissections

The second research sub-question: *How do teachers use animal organ dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners?* was addressed by the data that came from the semi-structured interviews, lesson observations, worksheets given to learners and lesson plans. The question was intended to establish how teachers used animal organ dissections to improve their teaching strategies in problem-solving skills of Grade 11 learners. During the interview with the teachers, the researcher noted with interest that two teachers (Thato and Mark) from the same school had asked their learners to label the observed parts and then relate the structure to the function during the animal organ dissections. As far as they were concerned, that was good enough to improve teaching strategy in problem-solving. This response did not come as much of a surprise to the researcher because one of the teachers was Mark, the same teacher that had shown lack of understanding of problem-solving strategies. It may be assumed that teachers like Mark who still need to be educated on problem-solving strategies, still exist in our education system. Such teachers need to be well-acquainted with problem-solving strategies to facilitate delivery and instil problem-solving skills in their learners.

Thato, together with the other four teachers, added that when their learners had dissected, drawn and labelled the diagram, they would ask them questions related to real life situations regarding the excretory system. Mary and Tia confirmed that their learners would be expected to answer the problem-solving task given by the teacher which would be related to what was observed on the dissected organ (Section 5.3.2.18 paragraph 3). Two teachers (Yvonne and Bertha) acknowledged that it was possible to use animal organ dissections to improve teaching strategies in problem-solving but it required a lot of guidance of the learners by the teachers towards the development of the skill as they dissected. The learners would thus focus on the important parts of the organ that would help them answer the problem-solving tasks. Yvonne was quoted saying:

> "I think if you use dissections to improve problem-solving skills you have to consolidate with worksheets, you have to consolidate with real life examples. It is not something like they can just have the dissection and be expected to learn from that. You actually have to help them consolidate what they have seen and I think during the dissection you also have to lead them then, if you want them to develop problem-solving skills, you have to lead them to think in that direction during the dissection. It is not something where you can just let the learners do a dissection with no guidance and you have to guide them more in what you are going to be, what problem you would want them to solve afterwards".

Yvonne's opinion concurs with Hofstein and Lunetta (2004) in that animal dissections do not only promote science content, it also promotes science process skills, creative thinking, problem-solving ability, and the scientific method. The Life Sciences teachers interviewed agreed with these authors as they acknowledged that animal organ dissections brought about more than just acquisition of Life Sciences knowledge but also investigative skills, creative thinking, problem-solving skills and many others.

The researcher noticed that in some instances the animal organ dissections lessons coupled with the problem-solving pre-test and post-test had been an eye-opener to the teachers. It was evident during the interviews, that the teachers had realised that it was possible to use animal organ dissections to develop problem-solving skills in their learners. The teachers were citing many examples in which they could let their learners dissect and then give them problem-solving tasks that would guide them towards the development of problem-solving skills. Some teachers like Mary, Yvonne and Tia even acknowledged that using animal organ dissections to develop teaching strategies in problem-solving is one something that they had not considered. Now that we had done it together, they had so many ideas and topics in which they were going to use animal organ dissections. This means that they were not only going to use the animal organ dissections for problem-solving in the excretory system, which was very encouraging. This is evidenced by Mary and Tia's arguments. Tia suggested:

> "Well I suppose if you use like the example of diabetes and the kidney when they dissect the kidney and you ask them to identify the nephron and then if they can link that to the diabetes where I could ask them that if there is a problem with the proximal convoluted tubule which is supposed to absorb all the glucose, where does that glucose go, then they can follow it down through the nephron to the urethra and they can see why there's glucose in the urine and then obviously that would lead to the diagnosis of diabetes".

Mary supported Tia's idea by citing a different example of how she would use animal organ dissections to improve the problem-solving skills:

> "Ja, let me try to think now, I am busy now with different animal families. So you can perhaps give them as a challenge and say I have now an example of a plant family now you must dissect it and tell me all the different features. Does it have an endoskeleton or exoskeleton, blood system or not. They investigate all the different features. So you don't tell them beforehand look for this and this stuff. You give them the sample saying you must now discover what is in there. So that can perhaps be more challenging, they already know the diagram and they know okay this is supposed to be there and there. You give them something that they have never seen before. So perhaps that is a good idea to do it from that angle as well and they acquire investigative skill for the problem in front of them that they then solve".

It was interesting to note that the pre-test and the post-test the researcher developed for the learners and the interviews got the teachers to think of approaching the animal organ dissections from a different perspective which could enable them to use it to develop problem-solving skills not only in the excretory system topic but in other topics as well, which was gratifying.

During the lesson observations, the researcher noted that the teachers gave the learners the worksheets which required them to dissect, draw and label the diagram. Thato and Mark's worksheet also required the learners to relate the observed structures to their functions. The worksheets given to the learners showed that the teachers had no intention to develop any other skill in the learners except to dissect, draw and label the organ (see Appendix VI). The task which then required the learners to focus on the dissected organ in such a manner that they would solve the given problems was the pre-test and the post-test which was developed by the researcher. It may be assumed that the Life Sciences teachers up to the day of the lesson observations had not considered using animal organ dissections as a teaching strategy in problem-solving. Even though the teachers had not used animal organ dissections in problem-solving before, they showed enthusiasm in encouraging the learners to write the post-test and complete it. Maybe they were also keen to see if animal organ dissections could be used to develop problem-solving skills. Mark acknowledged that the animal organ dissections had helped his learners to develop problem-solving skills as he argued:

> "You know it brings a lot of attention to most of the learners you know. Learners really want to see that which they saw in a text book, in real. They seem to enjoy it very much and I think it works well for them. I saw it in an exercise I gave them afterwards you know it proved to me really the questions that I gave before and after the dissection, you know it proved to me they were very much on the answers, after the dissection than before the dissection itself".

It is then imperative to note that, even though the Grade 11 Life Sciences teachers were not yet using animal organ dissections to improve teaching strategies in problem-solving, the pre-test, the animal organ dissections lessons and the post-test, which was predominantly problem-solving questions, opened a new door of possible teaching and learning method which they had not yet explored even with an average of 15 years teaching experience. They acknowledged that if the problem-solving skill was well-developed in learners, it would help them in higher education levels and even in real life.

6.3.3 Teachers' perceptions and attitudes towards animal organ dissections in general and its use in problem-solving specifically

The fourth research sub-question: *What are the teachers' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?* was addressed by the data that came from the semi-structured interviews with teachers and lesson observations. The question was intended to establish the teachers' and learners' perceptions and attitudes towards animal organ dissections and its use in problem solving. During the interviews, the teachers were asked five questions which enabled the researcher to establish their perceptions and attitudes towards the use of animal organ dissections in problem-solving. The teachers were asked to describe their feelings whenever they had to carry out dissections of animal organs with their learners.

Thato and Bertha showed that they still had reservations about animal organ dissections especially because of their being blood phobic and they understood why their learners feared to touch the organs. They both admitted that they just carried out the animal organ dissections because they had to comply with the Department of Education curriculum requirements. It may be assumed that Bertha's attitude towards animal organ dissections was not only attributed to her being blood phobic. It may also be linked to the fact that her confidence level with any dissections was rather low because she only started carrying out animal organ dissections when she was teaching Life Sciences. This means that she never carried out dissections during her schooling. She confirmed this by saying that she did her first dissection when she was a teacher and she explored and learnt together with the learners but she was still struggling to touch blood and not so keen to carry out animal organ dissections. Bertha's attitude was also observed by the researcher during the lessons observations. Once she introduced the lesson, she did not elaborate much on what was expected of the learners during animal organ dissections and she did not demonstrate to the learners how they were supposed to carry out the animal organ dissections. It did not come as much of a surprise when Bertha's group was the one with learners who were misbehaving. They just assumed their teacher's attitude towards the activity, as confirmed by Brennan (1997, in Balcombe, 2000, p. 17) regarding the influence of the teacher's attitudes on the learners: "The human dimension of the student versus instructor relationship can convey values, attitudes, and signals that transcend the content of textbooks and other written curriculum materials”. Bertha merely advised them to follow the instructions on the worksheet. Soon after the learners started the dissections of the animal organs, she sat at her desk and only assisted the learners if they went to ask her at her desk. The researcher associated this negative attitude towards animal organ dissections with a combination of blood phobia and lack of confidence in carrying out the dissections. As a result, she detached herself from the activity so that she would not expose her inexperience in dissections of animal organs to the learners. Silverstein (2006) supports this observation by saying that there are two teacher attributes which can determine how the teacher delivers the lesson. These attributes include: the academic preparation of the teacher and the teacher’s professional development in laboratory skills. In the case of Bertha, she is not well-prepared to deliver the dissections lessons and has not received any professional development in laboratory skills like animal organ dissections, hence her hesitation to demonstrate it to the learners before they start. Gresham (2008) is of the opinion that if a teacher is uncomfortable with a subject or doubts one’s ability to implement reform-based practice, one may focus less time on it or shows negative feelings to their learners. This is what Bertha did as her learners were carrying out the dissections of organs. Marshall et al. (2009) report that the teacher’s self-efficacy is strongly related to the teacher’s ability to implement the classroom practices, which means if there is lack of confidence on that practice one may opt to avoid it which may disadvantage the learners. Even though Bertha showed a negative attitude towards doing the animal organ dissections herself, she acknowledged that animal organ dissections were significant in problem-solving as she was quoted:

> “Well as I believe that if they can see the real life thing they will think of it further on how something like an organ works. And they will think in a different angle, if they see how it actually looks and what implications it can have when you have a problem like a puncture in the lung, or a blockage in the urethra, that they will be able to solve their problems better and think about solutions maybe”.

This shows that even though teachers may have a negative attitude towards animal organ dissections for different reasons including lack of experience and fear, they still acknowledge that it is important in improving skills like problem-solving. Bertha’s opinion is in agreement with various authors (Cotic & Zuljan, 2009; Lowrie & Logan, 2007; Rose & Arline, 2009) who are of the opinion that problems given to learners must provide them with situations that are personal, meaningful and related to real life situations.

The researcher is of the opinion that negative attitudes by teachers are especially detrimental to learners. If a teacher displays blatant dislike for dissections of animal organs, as in the case of this study, then the learners will not be motivated or enthused about the subject. The learners will use the teacher's lack of enthusiasm as an excuse for their own reluctance to study. Why should the learners care if the teacher does not care? Teachers must be careful with their attitudes towards the lesson. In some cases, it might be helpful for the teacher to admit that they find the dissections practical more difficult or to admit that they are blood phobic. The teachers should then use this as motivation, encouraging the learners to take the challenge posed by animal organ dissections and use it to their own advantage, developing skills like investigative, inquiry and problem-solving. In some cases, if the learners feel they can relate to the teacher in the areas of weakness like squeamishness or blood phobia, they will realise that the teacher is not trying to torture them. They will try to get through it with less reluctance following the teacher’s courage to face his or her fears by touching and dissecting the fresh organ.

The researcher also asked if there were any instances where the teachers did not want to dissect and would just let the learners do it without their involvement. Even though some teachers like Thato acknowledged that they dreaded carrying out animal organ dissections due to her being blood phobic, she was still actively involved in the dissections and carried out a demonstration for the learners on how they were supposed to dissect the organ. It may be noted with great interest that even though the teacher might not be comfortable with the animal organ dissections, in some cases they still show some enthusiasm as they carry out the dissections as a way of encouraging their learners for the sake of the learners’ marks. She even expressed the fact that it was gratifying to see how her learners were excited as they carried out animal organ dissections. The group discussions were done effectively and constructively especially at her school where most of the learners were carrying out animal organ dissections for the first time. Thato also had a positive attitude towards animal organ dissections because it made a significant contribution towards the improvement of problem-solving skills; it enhanced the understanding of the kidney; and how to solve problems associated with its structure and function. Thato and the other five teachers agreed that animal organ dissections enabled the learners to apply the same knowledge in the same way they did with the kidney, if properly guided, towards the development of problem-solving skills. During the lesson observations, the researcher also observed that the teachers encouraged their learners to work and to complete the post-test in class because they acknowledged that the task would guide the learners towards solving the problems given through the dissections of animal organs. Generally the teachers showed a positive attitude towards animal organ dissections in developing problem-solving skills. The positive attitudes of the teachers may have assisted in having most of the learners engaging with animal organ dissections and generally improved their performance in the post-test.

6.3.4 Teachers' opinions on the perceptions and attitudes of learners towards animal organ dissections and its use in problem solving

The perceptions and attitudes of the learners were also established to address the fourth sub-question on the part of the learners: *What are the learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?* The teachers were asked what their learners' attitudes and perceptions were towards animal organ dissections in general and towards its use in problem-solving. They were also asked if the keenness of the learners was the same when they were carrying out animal organ dissections compared to when they were answering problem-solving questions. Teachers had different opinions regarding the attitudes of learners towards animal organ dissections on problem-solving. Some learners had a negative attitude towards animal organ dissections when they assumed that it was just an activity of cutting and drawing. Three teachers (Thato, Tia and Yvonne) echoed the fact that initially their learners did not understand the purpose of dissecting, but when they were presented with the challenging questions, it encouraged them to explore the dissected kidney further and participate actively in group discussions. The problem-solving tasks challenged them to become more curious about the organ they were dissecting, to investigate and further research the organ in front of them so as to gather information to solve the problems presented to them. All this was considered by three of the teachers (Thato, Tia and Yvonne) as a positive attitude towards animal organ dissections on problem-solving. The researcher is also of the opinion that this behaviour of learners shows that their positive attitude towards animal organ dissections, irrespective of their fear of blood and squeamishness, was driven by the eagerness to answer the challenging questions through the use of dissections and exploring the animal organ. In agreement with their teachers, 81.70% of the learners acknowledged that animal organ dissections had an important role to help them develop skills to solve real life problems, which can be interpreted as the development of problem-solving skills (See Section 4.2.2.2, Table 4.4). The researcher also noticed that even though some learners were initially grumbling about why they had to come for dissections lessons, especially in the afternoon for Thato, Mark and Tia, once they started they became engrossed in the process. They engaged with the dissections and in some cases they ended up being the self-appointed group leaders in constructive group discussions. Some of their learners realised that answering these questions broadened their knowledge in a different kind of way, and especially developed the problem solving ability. It may then be assumed that the attitudes of the learners towards animal organ dissections on problem-solving was greatly influenced by the challenges presented to them which made them eager to explore the organ and solve the presented problems.

According to the (Mark, Bertha, Mary and Tia) some of their learners were more interested in just cutting and drawing and when the time came for them to answer the problem-solving questions, there was a shift in the attitudes towards the negative because it meant more work and effort was now required which they were not prepared to do. These learners only did the task after a bit of persuasion from their teachers. It was interesting to note that the learners, especially from the well-resourced schools, were the ones which presented a more negative attitude towards the second phase of the lesson which was the answering of problem-solving questions. The researcher assumed this attitude was because of the fact that these learners, especially Mary's, had had a shallow engagement with animal organ dissections due to their being overly dependent on their teacher. Their lack of confidence to work more independently especially on even more challenging work resulted in the negative attitudes. The idea of answering problem-solving questions without the assistance from their teacher was not appealing to them. It can then be asserted that the negative attitudes of some learners towards animal organ dissections and its use in problem-solving may be due to the level of engagement with the animal organ dissections and they will therefore not be well-equipped to answer the challenging questions related to the dissected organ.

The teachers' opinion on the attitudes and perceptions of learners towards animal organ dissections and its use in problem-solving also referred to other factors which they assumed caused negative attitudes, like being vegetarian, and therefore some of their learners could not touch the fresh animal organ. In some cases the emotional effect caused by the touching of blood and the organ resulted in some learners having a negative attitude towards animal organ dissections as well as its use problem solving. The teachers' opinion was supported by the responses of 24.10% of learners who confirmed that they experienced emotional difficulties during the dissections of fresh animal organs and would prefer to dissect artificial animal organs (See Table 4.4). As a teacher, it is important to be understanding to the attitudes of the learners towards dissections, and adjust practical activity accordingly. The teacher can either offer them alternative ways of dissections like virtual or artificial organ dissections if particular learners feel strongly against dissections of fresh organs. The possibility of offering alternatives to fresh animal organ dissections depends mostly on affordability. Most of the South African schools cannot afford to buy the artificial organs or some do not have access to the internet to use online dissections. It is best that the teachers let the learners know that they understand their feelings towards dissections. They should let them know that the teacher will to the best of their ability, make the dissections practical more bearable. It would be counterproductive to force them to dissect against their will.

It can be assumed that when such learners have a negative attitude towards the dissections of the animal organ, then they would also not like the idea of being tested after carrying out or observing other learners dissect, as discussed in Section 6.2.2. Bertha explained how her learners' attitude made a turnaround:

> "Well I know that they are very interested when they do practicals. They are very excited when you announce that the practical will be done. So I think their attitudes are very positive and I just think, they also think that their knowledge will be broadening in a different kind of way. So it is definitely positive and it works, it let them think of it further, it is not just a question and an answer. It is something that they can discuss and talk about, share their experiences and so they definitely think further and maybe if you give them a little bit of research to do with it, then it also helps to solve their problems. Ja they definitely want to cut and draw. I think for all of us actually it is the more boring part or the effort part. So I think during the dissection it is if they have a positive attitude, but yes if they must do work afterwards, they are always a bit negative. You know it is extra work after the dissection".

Mark added by acknowledging that even though the learners were initially not so keen to answer the questions, when they saw how challenging they were, they were encouraged to explore the organs even more and solve the presented problems:

> "You know after the dissection they were initially not keen to answer the questions but after encouraging them to try, I really found that it worked the way I wanted it to because you know even those learners who tended to be negative before you know were eager to answer most of the questions after the dissection. It means it helped them a lot and performed even better than in the previous test which made them so excited".

It is imperative to note that the majority (two thirds) of the learners had a positive attitude towards animal organ dissections on problem-solving even though it was a process they were not used to, because they realised how useful it was in developing their problem-solving skill. Almost a third of the learners (27.13%) had negative attitudes towards animal organ dissections mainly because of a lack of confidence to work independently. This is a problem which can be solved if teachers allow the learners to work independently when they are dissecting the animal organs and during group discussions.

6.3.5 Problems learners experience with animal organ dissections and its use in problem-solving as viewed by the teachers

The fifth research sub-question: *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?* was addressed by the data that came from the semi-structured interviews of the teachers, lesson observations and the questionnaire. The question was intended to obtain data to establish what problems learners experienced in doing animal organ dissections and in its use in problem-solving, according to the teachers' perspective. The discussions on these problems according to the learners' perspective were discussed in Section 6.2.3. According to the teachers' responses, the problems or difficulties faced by learners started with the animal organ dissection itself and some of those problems led to the problems they experienced in problem-solving.

6.3.5.1 Problems regarding manipulation of instruments

One of the main problems the learners experienced was with the *manipulation of instruments* which resulted in them cutting wrongly or just being scared of cutting themselves. This problem was confirmed by 38.84% of the learners in Table 4.4 who acknowledged the difficulties they faced in manipulating the animal organ dissection instruments. It may be assumed that this problem of instrument manipulation is an issue which can be solved by making the learners dissect the animal organs more often so that they can improve the dissection skills. Once the learners are confident with the manipulation of instruments, it may lead to correct dissections which will enable them to observe the parts clearly and be able to solve the given problems. Thato, Mark and Tia blamed the lack of sufficient, adequate dissection equipment as the root cause of problems faced by their learners during animal organ dissections because some of the improvised instruments like razor-blades were too small to manipulate. The researcher noticed that insufficient dissections instruments did not deter the learners from carrying out good dissections; they only had to focus more to avoid cutting wrongly or cutting themselves. Mark was quoted saying:

> "You know if you don't have the necessary and enough equipment, you know like children find it difficult to actually to make use of the inefficient scalpels. This makes manipulation and the dissection itself difficult. And to a certain extent you will find that learners are somehow afraid of actually opening up an organ. You see some of this is due religious beliefs like in my class, I have

> learners that are Seventh Day Adventist members and they can't touch meat because they are vegetarians but as an educator you need to actually explain the importance of the practical before, so that this whole practical can go on and we improvise the dissection instruments as well".

The teachers' opinions on how the learners struggled to use the inefficient dissection instruments were supported by two learners who were quoted saying:

> "My problem was that the animal organ was very soft, so we wasted so much time on trying to dissect the kidney correctly". [Respondent: 302]

> "Texture was more slippery than what I thought from the book diagrams. This made it so difficult to cut using a small razor-blade". [Respondent: 304]

Bertha said her learners sometimes struggled to use the scalpels or they used their hands instead of the dissecting instruments and they "make a mess of the organ". Tia's learners struggled with where to start the cut and how to cut; in some cases, instead of making the long continuous cut, they made short little stabs at the organs, resulting in them failing to see what they were supposed to observe. The researcher noted that Tia's response was ironical. She was aware of how the learners were supposed to carry out the animal organ dissections and she was also aware of her learners' dissecting skill problem but, she did not demonstrate the dissections to them before they started dissecting, showing them how to make the long continuous cut which was considered to be a good dissection. This may be taken as evidence that some teachers have a tendency of theorising their demonstrations instead of carrying them out practically, which then results in learners carrying out wrong dissections.

6.3.5.2 Fear, phobia and squeamishness problems

Yvonne, Mark, Tia and Mary said that some of their learners failed to focus more on the dissections of the animal organs because of problems like being *scared or squeamish about touching the fresh organ, feeling nauseous, blood and smell phobia*. Their learners were scared to touch the fresh organ due to the slippery texture of the kidney and they also concurred that some of their learners felt nauseous due to the smell of the fresh organ and their blood phobia. Yvonne was quoted saying:

> "I think the problem they experience is they all want gloves, the reason being that they are scared to touch the organ. The other problems I think they experience are that some of them are afraid of the sight of blood or afraid of actually dissecting an organ, they are a bit squeamish yes. But what's nice with the group work is that it is variable, in a group you will always find one or two learners that are quite prepared to get stuck in and the other learners are quite prepared to participate but not maybe actually physically touch it themselves".

The same observations were highlighted by Barr and Herzog (2000) in their study on high school dissections experience, finding that 29.41% of the learners could not stand to touch the organs because they did not like to touch blood or they were squeamish about touching the slippery organs. They also observed that some of the learners preferred to use gloves although they acknowledged that the texture was not the same when one had gloves on.

This showed that the problems faced by learners include: the lack of technical skills to dissect, emotionally being affected by the dissection procedure, being blood phobic, nauseous and squeamish. The researcher is of the opinion that the learners facing such problems fail to engage well enough with animal organ dissections which may affect the development of the problem-solving skills in them. According to the researcher's observations, some learners felt more comfortable to dissect whilst putting on gloves but apparently, since the slipperiness increased when one was wearing gloves, some ended up taking the gloves off and forced themselves to touch the organ. This showed great will-power to carry out the animal organ dissections despite their fears to touch the organs.

6.3.5.3 Failure to follow instructions

Another problem which Thato (teacher of School A) highlighted, and was also observed by the researcher during the lesson observation, was that some learners *did not follow instructions* even when they were given step by step guidance. As a result they ended up cutting wrongly or cutting themselves. The researcher noticed that the learners were too impatient to wait for the teachers' instructions and were too eager to start the dissections of the organs before the teachers' finished explaining the objectives of the lesson. To avoid such problems, Mary (teacher of School C) gave her learners the instructions before they moved from the classroom side to the dissecting tables. This was possible at School C because it had enough laboratory facilities and smaller classes, unlike Schools A and D.

6.3.6 The extent to which Learning Outcomes 1, 2 and 3 (NCS) were achieved by animal organ dissections in Grade 11 according to the teachers

Since the National Curriculum Statement of the Department of Education stipulates that all learning areas must fulfill the Learning Outcomes 1, 2 and 3, the researcher deemed it necessary to ask the teachers during the interviews how they ensured that the three learning outcomes were fulfilled during the animal organ dissections. She also took note of the extent to which animal organ dissections were fulfilling the three learning outcomes during the lesson observations in which the learners wrote a pre-test, carried out animal organ dissections and then wrote the post-test. Learning Outcome 1 (LO1) is scientific inquiry and problem-solving skills where the learner is able to confidently explore and investigate phenomena relevant to Life Sciences by using inquiry, problem-solving, critical thinking and other skills. Learning Outcome 2 (LO2) is construction and application of Life Sciences knowledge. The learner is able to access, interpret, construct and use Life Sciences concepts to explain phenomena relevant to Life Sciences. Learning Outcome 3 (LO3) is to relate the Life Sciences knowledge acquired to technology, culture and society.

The researcher noticed that five teachers, Thato, Mark, Bertha, Mary and Tia, concurred in that the LO 1 was fulfilled by hands-on dissections (dissecting skill) which the learners carried out. The teachers' response was in agreement with what the researcher had observed during the lesson. Most learners, depending on the group sizes and how keen they were to touch the fresh organ, actively participated in the hands-on dissections which allowed them to explore the organ and its parts. Yvonne was the only teacher who did not manage to answer how she ensured that LO 1 was fulfilled because apparently she had forgotten what the learning outcomes were in their order. She asked the researcher to remind her what each learning outcome consisted of. After the reminder she then concurred with the other five teachers that the learners constructed their own knowledge through dissections, which is LO 2. They ensured that the learners observed the dissected organ, identified parts, related the structure to function, interpreted the diagram, and discussed in small groups. They also tested the learners' knowledge by giving them a worksheet to complete individually. For this particular lesson, the researcher noticed that the learners were given a worksheet which had the dissections instructions and some questions related to the dissected organ. According to the researcher's opinion, these questions were not sufficient to fulfil LOs 2 and 3. Fortunately the researcher had developed the pre-test and the post-test which ensured that all the learning outcomes were fulfilled to the full extent. As for LO 3, Yvonne, Bertha, Mary and Tia said that the learners constructed knowledge by solving practical situations that were linked to society, which meant that the worksheets the learners received would include questions that related the dissected kidney to real life situations. Thato argued that:

> "When we dissect we have a particular task. We don't just dissect for the sake of dissecting. They dissect, they must complete a task and then it counts towards their year mark. It is a formal task, ja".

Bertha also argued that:

> "Well they definitely need to be able to draw a diagram afterwards and know all the labels. Maybe they will have to answer questions about the organ, maybe some of the functions and when you walk around they must be able to show you the structure, name it, and identify it. Ja and maybe have some real life questions on how it works in real life. I think that is the only way you know".

It was noted with great interest that Bertha's response was based on what may be included in the worksheet, like real life situations questions, but she did not say that was exactly what she was doing. It can be argued that in some cases the teachers might be aware of what they could do to ensure that all the learning outcomes are fulfilled but it does not mean they do it. This might mean that the learners are not adequately acquiring all the skills they could derive from one activity, for instance, the learning gains for her classes were inconsistent between the variable: The LO 1 questions had the lowest learning gain of 4.09 in comparison to other schools whilst problem-solving and LO 3 questions were the second best with learning gains of 18.89 and 8.83 respectively. As for LO 2 questions, the learning gain was the best relative to other schools. It may be argued that the performance of learners at a school which has very good laboratory facilities and apparatus could have been more consistent, if the teacher had a more positive attitude and was also putting the theory she expressed into practice.

Mary strongly argued that:

> "Basically learning outcome one they are physically dissecting, cutting it open and they acquire that skill to do that otherwise you can't see the different parts. The second one is knowledge; they applied their knowledge to what they had learnt in the book to the real life or to the situation in front of them. And then learning area or learning outcome three they basically applied the knowledge to real life situations, which they did by discussing diseases to do with the kidney. So they have to say, okay but this is where you find the nephron and if the nephron was damaged, what disease they would have or what part of the kidney were damaged if you had blood or glucose in the urine? And they correlated with the kidney that they had in front of them. What parts were damaged by what diseases"?

All six teachers showed that they were knowledgeable about how the learners can fulfil LOs 1 and 2. As for the LO 3, only four teachers confidently mentioned how they made sure that it was fulfilled during the animal organ dissections. Bertha showed that she knew what she was supposed to do so as to have the learners fulfil LO 3 as well, but she just did not give them the opportunity to do so. It can be argued that some learners can be disadvantaged if the teacher does not give them enough challenging situations, their full potential is not achieved. Only Mark responded to how he ensured that the first two learning outcomes were fulfilled but could not explain to what extent LO 3 was fulfilled by his learners during animal organ dissections.

Thato and Yvonne argued that, besides the three learning outcomes, there were other outcomes learners achieved during dissection which included handling of apparatus, cleaning up afterwards and obtaining good task marks. It may then be argued that animal organ dissections do not only fulfil the National Curriculum Statement requirements but also other unintended learning outcomes which are also important to develop in a learner. From the researchers' point of view, this particular dissections lesson fulfilled all three learning outcomes and it served as an eye-opener to the teachers that it was possible to use animal organ dissections to fulfil the three learning outcomes.

6.4 SUMMARY OF THE DISCUSSIONS AND ANALYSIS OF THE FINDINGS OF THE STUDY

This chapter integrates the collective results emanating from both the quantitative and qualitative studies in detail. The research questions were revisited to determine to what extent they have been answered. The integration of the collective results was divided into two sections:

(i) Discussion, analysis and interpretation of the data of the learners

(ii) Discussion, analysis and interpretation of the data of the teachers

6.4.1 Summary of the discussions, analysis and interpretation of the data of the learners

The data of the learners was gathered through the questionnaire they completed, the pre-test they wrote before the intervention, and the post-test they wrote after the intervention. In the animal organ dissection lessons, the learners used a worksheet to guide them and constructive group discussions with the teachers' guidance took place. The interviews carried out with the Life Sciences teachers and the lesson observations during which animal organ dissections were carried out, also contributed to the data of the learners. The data collected was then used to address the research sub-questions which were expressed as themes.

6.4.1.1 Learners' engagement and usage of animal organ dissections in the development of problem-solving skills

The learners wrote a pre-test which predominantly consisted of problem-solving questions and they carried out animal organ dissections as the intervention, and they wrote the post-test. The test consisted of 49 marks of the 75 marks being allocated to problem-solving questions.

- Firstly, it was established that learners had improved significantly in the post-test they wrote after carrying out animal organ dissections, in comparison with the pre-test they had written before carrying out the animal organ dissections. The aim of these tests was to find out if learners had engaged with animal organ dissections to develop problem-solving skills. This improvement was confirmed by the Matched T-test results which showed a p-value < 0.0001 showing that there was a statistically significant learning gains between the pre-test and the post-test for all the six variables. The researcher could therefore argue that the learners' engagement with dissections may have resulted in the improvement of their scores in the test overall. These results may be used to argue that even though 57.14% were engaging with hands-on animal organ dissections for the first time, they still managed to generally engage with the animal organ dissections. This resulted in them improving their performance in the test which had predominantly problem-solving questions. Authors like Nakleh, Malina and Polles (2002), as well as Wang and Coll (2005), support the researcher's findings that learners learn more by effectively engaging with the practical activities like animal organ dissections where they have the opportunity to gain an in-depth knowledge of animal organs morphology which results in gaining skills like problem-solving.

6.4.1.2 The learners' perceptions and attitudes towards the animal organ dissections in general and its use specifically in problem-solving

- The majority (more than 90%) of learners showed a positive attitude towards animal organ dissections and they acknowledged that it would help them as Life Scientists. (Section 4.2.1.3, p. 115). In their study on the prospective Life Sciences teachers' attitudes towards animal dissections, De Villiers and Sommerville (2005) also established that more than two-thirds (70%) of the students had positive attitudes towards animal dissections. The researcher established that even though the majority had a positive attitude towards animal organ dissections, some of them were not so keen to carry out the hands-on dissections of the fresh organs themselves.

- About a quarter (26.34%) of the learners had a negative attitude towards animal organ dissections in problem-solving because the idea of being tested after carrying out animal organ dissections was not appealing to them. Reasons for this attitude may be assumed to be due to lack of sufficient engagement with animal organ dissections and hence, they were not prepared to answer the challenging questions or they were just not prepared to work more.
- According to the teachers' opinions, some learners had a negative attitude towards animal organ dissections when they assumed that it was just an activity of cutting and drawing. When they were presented with the challenging questions, however, it encouraged them to further explore the dissected kidney and participate actively in group discussions.
- According to the teachers, some of their learners were more interested in just cutting and drawing. When the time came for them to answer the problem-solving questions, there was a shift of the attitudes towards the negative. This may be because it meant that more work and effort was now required which they were not prepared to do.

6.4.1.3 Problems learners experience in doing animal organ dissections in general and its use in problem-solving

- It was established that about two-fifths of the learners found it difficult to manipulate the dissection instruments and some of them feared cutting themselves because the scalpels were too sharp. In some schools it was because the improvised instruments were too small, blunt or old. This may be interpreted as the lack of experience in the animal dissections skill, since 57.14% of the learners were dissecting for the first time. It may be argued that the inadequacy and ineffectiveness of the dissection instruments could be considered a hindrance to good animal organ dissections by the learners and the slipperiness of the organs is another factor which was an impediment to the learners' progress during the animal organ dissections. It is imperative to note that all these problems did not discourage the learners from carrying out the dissections of the organs. Some groups dissected more than one organ until they had a good dissection.
- Some of their learners, especially the female learners, failed to focus more on the dissections of the animal organs because of problems like being scared or squeamish about touching the fresh organ, feeling nauseous, blood and smell phobia. This observation was confirmed by Hart et al. (2008) who say that some learners cannot

withstand the smell of the organs, sight of blood, and some are squeamish. Nabi (2002) also argues that the effects of dissections on learners may differ between genders; he is of the opinion that there is some degree of disgust especially salient for women.

6.4.1.4 The extent to which Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) are being achieved by animal organ dissections in Grade 11

- A Matched T-test was used to establish if there was a significant difference between the means of the pre-test and the post-test for each learning outcome. Analysis of Variance (ANOVA) was used to establish if the differences between the means of the four schools was statistically significant. For LO 1, 2 and 3 there were indications of statistically significant differences between the means. This showed that there was a great achievement of these learning outcomes. It may be inferred that the significant changes in the test scores for these learning outcomes were due to the effectiveness of the animal organ dissections as the intervention to achieve these learning outcomes.
- All six teachers were aware of how animal organ dissections can achieve LO 1 and 2 but some were not very confident on how animal organ dissections could achieve LO 3.
- The majority (five) of the teachers concurred in that LO 1 was fulfilled by hands-on dissections (dissecting skill) which the learners carried out. The teachers' response was in agreement with what the researcher had observed during the lesson. Most learners actively participated in the hands-on dissections which allowed them to explore the organ and its parts.
- Teachers ensured that the learners observed the dissected organ, identified parts, related the structure to function, interpreted the diagram, and discussed in small groups. They also tested the learners' knowledge by giving them a worksheet to complete individually. Hofstein, Navon, Kipnis, and Mamlok (2005), Krajcik, Mamlok and Hug (2001) agree that learners who perform various ways of enquiry, challenged by appropriate questions, can find and synthesise information through investigations like animal organ dissections, as in the case of this study. The enquiry or investigative skills can help the learners to find information they can use to develop problem-solving skills.
- All six teachers showed that they were knowledgeable about how the learners can achieve LO 1 and 2. As for LO 3, only four teachers confidently mentioned how they

made sure that it was achieved during the animal organ dissections.

- From the researchers' point of view, this particular dissection lesson fulfilled all three learning outcomes and it served as an eye-opener to the teachers that it was possible to use animal organ dissections to achieve the three learning outcomes.

6.4.2 Summary of the discussions, analysis and interpretation of the data of the teachers

The data of the teachers was gathered through the interviews carried out with the Life Sciences teachers and from the lesson observations during which animal organ dissections were carried out.

6.4.2.1 The teachers' understanding and how well-acquainted they are with problem-solving strategies

- The researcher established that not all teachers were clear on what problem-solving strategies were. In one instance, Mark (teacher 2 of School A) showed a complete lack of understanding of the problem-solving strategy. The majority of the teachers seemed to have a common understanding of problem-solving strategies which revolved around application of knowledge acquired in class, or during dissections in this case, to solve real life problems. Even though they could not state or name specific strategies, most teachers explained how they would implement them in different Life Sciences topics.

6.4.2.2 The improvement of the teachers' teaching strategies and the problem-solving skills of learners by using animal organ dissections

- It was noted that some teachers were satisfied with just having their learners dissect, draw, label the diagrams and then relate the observed structure to functions. The researcher considered this as insufficient to develop problem-solving skills in learners.
- The majority (five) of the teachers acknowledged that when their learners had dissected, drawn and labelled the diagram, they would ask them questions related to real life situations regarding the excretory system, and in other topics as well. They also said that their learners would be expected to answer the problem-solving task given by the teacher which would be related to what was observed on the dissected organ. The learners would thus focus on the important parts of the organ that would help them answer the problem-solving tasks. What these teachers suggested agrees

with Mergendoller, Maxwell and Bellismo (2006) that in some cases, in order to develop problem-solving skills, the teachers should take a facilitative role, moving around between groups. This was essential for the animal organ dissections lesson in monitoring positive and negative behaviour and watching for opportunities to guide the learners towards using the dissected organ to answer the given problem-solving questions or to provide clarifications, when necessary, during group discussions.

- It may be asserted that activities carried out by the researcher with the teachers and their learners served as an eye-opener to the teachers as they realised that it was possible to use animal organ dissections to develop problem-solving and other important skills in their learners.

6.4.2.3 The teachers' perceptions and attitudes towards animal organ dissections in general and its use in problem-solving specifically

- Some teachers may have a negative attitude towards animal organ dissections due to lack of confidence in carrying out the dissections. As a result, they do not actively assume their roles of guiding their learners during the activity to avoid exposing their inexperience in dissections of animal organs to the learners.
- Even though some teachers had a negative attitude towards animal organ dissections, all of them had a positive attitude towards the use of animal organ dissections and acknowledged that it was significant in problem-solving. With this attitude, there is hope that the teachers may use animal organ dissections to improve their teaching strategies.

The final chapter (Chapter 7) presents a summary, conclusions and recommendations for future interventions and research in this field.

CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 OVERVIEW OF THE CHAPTER

This chapter provides an overview of the study which includes the summary of the findings of the study, the conclusions based on the findings of the study, recommendations for policy makers and practice, significance of the study, suggestions for future research, limitations of the study and it ends with final remarks.

7.2 OVERVIEW OF THE STUDY

The aim of this study was to determine the use of animal organ dissections in problem-solving as a teaching strategy in Grade 11 Life Sciences education. In order to achieve this aim, it was essential to determine the contribution of animal organ dissections to the development of teachers' teaching strategies and Grade 11 Life Sciences learners' problem-solving skills in diverse environments. The contribution of animal organ dissections was established through answering of six research sub-questions which have been summarised in 7.3.

In Chapter 1, the problem statement, rationale of the study and the research questions were presented. The data answering the research question and the six research sub-questions was presented and analysed in Chapters 4, 5 and 6. The use of animal organ dissections by teachers in problem-solving, the level of engagement of learners with animal organ dissections and its use to develop skills like problem-solving, attitudes and perceptions of teachers and learners towards dissections internationally and locally in South Africa, were investigated through the literature review in Chapter 2. A literature study covering the use of animal dissections internationally and nationally was initially taken so as to place this study within a broader framework of knowledge. The experiences provided in the literature review were compared with the findings of this study so as provide confirmation for existing findings about teachers' and learners' experiences regarding animal dissections in problem-solving as a teaching strategy. There was limited literature linking animal dissections with problem-solving but there was some literature linking investigative or enquiry methods (like animal dissections) with the development of skills like problem-solving. The benefits and problems of animal dissections were discussed, based on the findings and opinions of a number of researchers. All the factors highlighted in Chapter 2 were perceived to have possible effects on how animal organ dissections could be used to develop the teachers' teaching strategies and the development of Grade 11 Life Sciences learners' problem-solving skills.

Chapter 3 reported on the field study and described the research strategies that were used for the study that eventually developed responses to the research questions. This included the research design, sampling procedures, data collection strategies and instrumentation, the pilot study, the main study and the ethical considerations. It also included a brief introduction to data analysis theory, followed by a description of quantitative and qualitative data analysis. In this study, a mixed method design was used with concurrent application of both quantitative and qualitative approaches. A questionnaire to the learners, pre-test written by learners before the intervention which was animal organ dissections, and post-test, were used to collect quantitative data. Lesson observations and interviews with the teachers were used to collect qualitative data.

Chapter 4 presented and discussed findings derived from the quantitative data originating from the questionnaire to 224 learners, pre-test and post-test written by the same learners. It was established that the use of animal organ dissections had contributed to the development of problem-solving skills of the learners. This was confirmed by significant differences between the pre-test and post-test means through the Matched T-test and Analysis of Variance (ANOVA). It was also established that most of the learners had positive attitudes towards animal organ dissections and acknowledged that it was essential for the development of their problem-solving skills and as Life Scientists. A few learners had negative attitudes towards animal organ dissections due to moral, blood phobia, religious and cultural reasons but they still acknowledged the usefulness of animal organ dissections.

Chapter 5 presented and discussed findings derived from the qualitative data originating from the lesson observations during which learners wrote a pre-test, carried out animal organ dissections and wrote a post-test, and from interviews with the Grade 11 Life Sciences teachers of the selected schools. It was established that not all teachers were well-acquainted with problem-solving strategies which made it difficult for them to use animal organ dissections in problem-solving as a teaching strategy. Most teachers have positive attitudes towards animal organ dissections. Only one teacher had negative attitudes towards animal organ dissections due to blood phobia and lack of confidence in the dissection skill since she had never dissected during her schooling. All teachers acknowledged the usefulness of animal organ dissections and its contribution to the development of teaching strategies.

Chapter 6 was used for analysis and integration convergence and triangulation of findings from the quantitative and the qualitative approaches, giving an in-depth understanding of the study. Both quantitative and qualitative data showed that animal organ dissections contributed to the development of teaching strategies according to the teachers. It also contributed to the development of problem-solving skills according to the significant differences between the pre-test and post-test means. Both teachers and learners acknowledged the usefulness of animal organ dissections in the development of problem-solving skills, in the teachers' interviews and according to the responses of the learners to the questionnaire.

7.3 SUMMARY OF THE FINDINGS OF THE STUDY

The study was guided by one main research question: What is the contribution of animal organ dissections to the development of teachers' teaching strategies and Grade 11 Life Sciences learners' problem-solving skills in diverse environments? This main question was addressed through the findings of the study which addressed six research sub-questions:

1. *What is the teachers' understanding and how well-acquainted are they with problem-solving strategies?*
2. *How do teachers use animal dissections to improve their teaching strategies and the problem-solving skills of Grade 11 learners?*
3. *How does learners' engagement with animal organ dissections aid in developing problem-solving skills?*
4. *What are the teachers' and learners' perceptions and attitudes towards animal organ dissections in general and its use specifically in problem-solving?*
5. *What problems are learners experiencing in doing animal organ dissections in general and in its use in problem-solving?*
6. *To what extent are Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) being achieved by animal organ dissections in Grade 11?*

The findings of this study are summarised below in the form of addressing the research sub-questions which are expressed as themes:

7.3.1 Learners' engagement with animal organ dissections and its use in developing problem-solving skills

Firstly, it was established that learners had improved significantly in the post-test they wrote after carrying out animal organ dissections in comparison with the pre-test they had written before carrying out the animal organ dissections. The aim of these tests was to find out if the learners' engagement with animal organ dissections could have contributed to the development of problem-solving skills. This improvement was confirmed by the Matched T-test results which showed a p-value < 0.0001 showing that there was a statistically significant difference between the means of the pre-test and the post-test. The researcher could therefore argue that the learners' engagement with animal organ dissections contributed to an improvement in their scores in the test overall. These results may be used to argue that even though 57.14% were carrying out hands-on animal organ dissections for the first time, they still managed to engage with it and generally improve their performance in the test which had predominantly problem-solving questions. Authors like Nakleh, Malina and Polles (2002), as well as Wang and Coll (2005) support the researcher's findings that learners learn more by effectively engaging with the practical activities like animal organ dissections where they have the opportunity to gain an in-depth knowledge of animal organs morphology which results in gaining skills like problem-solving.

The pre-test and post-test questions consisted of six variables which included: rote learning, problem-solving, LO 1, 2 and 3 questions, and the sixth variable was a combination of the questions. Each of the variables had a T-test run on the scores of the pre-test and post-test and in all cases, they showed that there were statistically significant differences between the means of the pre-test and post-test affirming the researcher's argument that the engagement of learners with animal organ dissections had influenced the significant improvement of the learners in responding to the test questions which were predominantly problem-solving (See Section 4.2.2.1). Armbruster et al. (2009), in their study, also observed that learners improve significantly (91%) in their high-order problem-solving skills if the instructional design is active and learner-centred, which may be animal organ dissections.

During the lesson observations, the researcher also noticed that the learners did not just cut and draw but they engaged in constructive discussions and arguments with the guidance of their teachers in some cases. Some teachers asked questions which guided the learners' thoughts towards solving given problems, by engaging more with dissections. It may therefore be argued that the difference in the means of the pre-test and the post-test was caused not only by just going through the intervention which was animal organ dissections but also because of the nature of the problem-solving activities and questions. The Life Sciences teachers and that were interviewed also acknowledged that their learners had improved significantly after carrying out animal organ dissections and problem-based activities. (See Appendix III & V).

7.3.2 The learners' perceptions and attitudes towards animal organ dissections in general and its use in problem-solving specifically

The majority (more than 90%) of learners showed a positive attitude towards animal organ dissections and they acknowledged that it would help them as Life Scientists (Page 123 paragraph 2). The learners' reasons for this attitude towards animal organ dissections included: their knowledge regarding animals was broadened, the hands-on experience prepared them for their medical or Life Sciences careers and some had managed to overcome their blood phobia through the dissections of animal organs they had done. In their study on the prospective Life Sciences teachers' attitudes towards animal dissections, De Villiers and Sommerville (2005) also established that more than two-thirds (70%) of the students had positive attitudes towards animal dissections. The researcher established that even though the majority had a positive attitude towards animal organ dissections, some of them were not so keen to carry out the hands-on dissections of the fresh organs themselves. Some acknowledged that the idea of touching blood and the slippery texture, made them hesitant to do the dissections themselves. The interviewed teachers also confirmed that some of the learners suffered from blood phobia and squeamishness and this resulted in them having a negative attitude towards animal organ dissections. The negative attitudes of the learners show that, in as much as the learners acknowledge the usefulness and importance of the animal organ dissections, it does not necessarily mean that they are keen to touch and dissect the fresh animal organs.

Less than a quarter (21.88%) of the learners had a negative attitude towards animal organ dissections due to religion, culture or emotions. Another aspect which showed that it had a great influence on the learners' attitudes was the moral issues. The majority of the learners showed that they were morally *for* animal organ dissections but 31 learners were consistently against animal organ dissections, which may have had an influence on their ability to answer problem-solving questions given.

Close to a quarter (26.34%) of the learners had a negative attitude towards animal organ dissections in problem-solving because the idea of being tested after carrying out animal organ dissections was not appealing to them (See Section 4.2.2.2, Table 4.4). Reasons for this attitude may be assumed to be due to lack of sufficient engagement with animal organ dissections, hence, they were not prepared to answer the challenging questions or they were just not prepared to work more.

According to the teachers' opinions some learners had a negative attitude towards animal organ dissections when they assumed that it was just an activity of cutting and drawing. When they were presented with the challenging questions, however, it encouraged them to further explore the dissected kidney and participate actively in group discussions (See Table 5.22) The researcher is also of the opinion that this behaviour of learners shows that their positive attitude towards animal organ dissections (irrespective of their fear of blood and squeamishness) was driven by the eagerness to answer the challenging questions through the use of dissections to explore the animal organ. In agreement with their teachers, the majority of the learners acknowledged that animal organ dissections had an important role to help them develop skills to solve real life problems, which can be interpreted as the development of problem-solving skills.

Some of their learners realised that answering these questions broadened their knowledge in a different kind of way and especially the problem-solving ability. It may then be assumed that the attitudes of the learners towards animal organ dissections on problem-solving was greatly influenced by the challenges presented to them, which made them eager to explore the organ and solve the presented problems.

According to some teachers, some of their learners were more interested in just cutting and drawing. When the time came for them to answer the problem-solving questions, there was a shift of the attitudes towards the negative because it meant more work and effort was now required which they were not prepared to do. It may be assumed that the negative attitudes of some learners towards animal organ dissections on problem-solving may be due to the level of engagement with the animal organ dissections and they will therefore not be well-equipped to answer the challenging questions related to the dissected organ.

Other factors which the teachers assumed caused learners' negative attitudes were: being vegetarian and therefore some of their learners could not touch the fresh animal organ, emotional effects caused by the touching of blood and the organ. It can be assumed that when such learners have a negative attitude towards the dissections of the animal organ, then they would also not like the idea of being tested after carrying out animal organ dissections.

It is encouraging to note that the majority (two thirds) of the learners had a positive attitude towards animal organ dissections on problem-solving, even though it was a process they were not used to, because they realised how useful it was in developing their problem-solving skill. About a third of the learners had negative attitudes towards animal organ dissections mainly because of a lack of confidence to work independently. This is a problem that can be solved if teachers allow the learners to work independently when they are dissecting the animal organs and during group discussions.

7.3.3 Problems learners experience with animal organ dissections in general and in its use in problem-solving

It was established that about two-fifths (38.84%) of the learners found it difficult to manipulate the dissection instruments and some of them feared cutting themselves because the scalpels were too sharp (See Tables 4.4 and 4.8). In some schools it was because the improvised instruments were too small, blunt or old. This may be interpreted as the lack of experience in the animal dissections skill, since 57.14% of the learners were dissecting for the first time (See Section 4.2.2.2, Figure 4.8). It may be argued that the inadequacy and ineffectiveness of the dissection instruments could be considered a hindrance to a good animal organ dissection by the learners and the slipperiness of the organs is another factor which was an impediment to the learners' progress during the animal organ dissections. It is imperative to note that all these problems did not discourage the learners from carrying out the dissections of the organs. Some groups dissected more than one organ until they had a good dissection.

The teachers also confirmed that the learners struggled with the manipulation of instruments which resulted in them cutting wrongly or just being scared of cutting themselves. It may be assumed that this problem of instrument manipulation is an issue which can be solved by making the learners dissect the animal organs more often so that they can improve the dissection skills. Once the learners are confident with the manipulation of instruments, it may lead to correct dissections which will enable them to observe the parts clearly and be able to solve the given problems. The researcher also observed that the improvised dissection instruments were either too small, blunt or too old to do a nice dissection.

The other problem which the researcher observed was that some learners just started dissecting the organ without reading the instructions on the worksheet that was given to them. As a result, they dissected the organ wrongly or cut themselves and could not observe the parts of the organ they were supposed to observe. Thato (a teacher from School A) also confirmed what the researcher had observed during the lesson observation, that some learners did not follow instructions even when they were given step by step guidance. As a result they ended up cutting wrongly or cutting themselves (Section 5.3.2.3, paragraph 4).

Another problem was that learners struggled to relate the diagram in the textbook with the real organ due to size, colour and texture differences. Some only realised for the first time how slippery the kidney was. This is an experience that one cannot have by just looking at the organ in the textbook.

Some learners were scared to touch the fresh organ due to being squeamish of the slippery texture of the kidney. Some of the learners felt nauseous due to the smell of the fresh organ and their blood phobia. The teachers concurred that their learners, especially the females, learners failed to focus more on the dissections of the animal organs because of problems like being scared or squeamish about touching the fresh organ, feeling nauseous, or blood and smell phobia. This observation was confirmed by Hart et al. (2008) who say that some learners cannot withstand the smell of the organs, sight of blood, and some are squeamish. Nabi (2002) argues that the effects of dissections on learners may differ between genders; he is of the opinion that there is some degree of disgust especially salient for women.

The problems faced by learners include: the lack of technical skills to dissect, emotionally being affected by the dissection procedure, being blood phobic, nauseous and squeamish. The researcher is of the opinion that the learners facing such problems fail to engage well enough with animal organ dissections which may affect the development of the problem-solving skills in them.

7.3.4 The extent to which Learning Outcomes 1, 2 and 3 of the National Curriculum Statement (NCS) are being achieved by animal organ dissections in Grade 11

A Matched T-test was used to establish if there was a significant difference between the means of the pre-test and the post-test for each learning outcome. For LO 1, the $p < 0.0001$ indicated a statistically significant difference between the means (Page 136, Table 4.21). This showed that there was great achievement of this learning outcome. It may be inferred that the significant changes in the test scores for LO 1 may have been due to the effectiveness of the animal organ dissections as the intervention to achieve this learning outcome.

The Analysis of Variance (ANOVA) which was used to establish if the different learning gains between the four schools was statistically significant per variable also confirmed that the intervention resulted in significant differences between the schools for LO 1.

During the lesson observations, the researcher also noticed that the learners carried out the hands-on dissections with a high level of engagement and as a result managed to score significantly higher marks in the post-test. It is very important to note that LO 1 is considered to be a variable which can be enhanced by engaging in practical activities like animal organ dissections, as confirmed by the teachers in their interviews. In terms of LO 1, the greatest impact was observed on School A due to the fact that, as a disadvantaged school, they seized the opportunity to engage with the animal organ dissections and as result developed the problem-solving skills. This is evidenced by a significant difference between their pre-test and post-test means. Besides what the researcher observed with School A, School D had an added advantage of small numbers compared to School A. This resulted in more teacher guidance whenever it was necessary, and there was maximum participation since there were fewer learners in each group.

Results of LO 2 also showed a statistically significant difference between the means. It may also be assumed that the significant changes in the test scores for LO 2 were due to the effectiveness of the animal organ dissections as the intervention to achieve this learning outcome. During the lesson observations, the researcher noticed that most of the learners observed the dissected organ, identified the parts and had group discussions relating the structure to function, which achieved LO 2. This was evidenced by the significant differences between the means for this learning outcome. The six teachers concurred with the researcher's observations that LO 2 was achieved by the learners constructing their knowledge by observing, identifying parts, relating structure to function, interpretation of diagram and group discussions.

LO 3 was also achieved by the animal organ dissections as evidenced by the p-value < 0.0001 for the Matched T-test. This showed that the change in the means of the test scores for this learning outcome questions was not by chance but due to the effectiveness of the interventions which were the animal organ dissections carried out by learners. The researcher acknowledges that in this lesson, LO 3 was achieved. During the interviews however, not all the teachers showed confidence on how they used animal organ dissections to achieve this learning outcome.

The majority (five) of the teachers concurred that LO 1 was achieved by hands-on dissections (dissecting skill) which the learners carried out. The teachers' responses were in agreement with what the researcher had observed during the lesson. Most learners actively participated in the hands-on dissections which allowed them to explore the organ and its parts.

One teacher had forgotten what each learning outcome was about and was mixing up the learning outcome number with the wrong outcome. After the reminder, she then concurred with the other five teachers that the learners constructed their own knowledge through dissections, which is LO 2. They ensured that the learners observed the dissected organ, identified parts, related the structure to function, interpreted the diagram, and discussed in small groups. They also tested the learners' knowledge by giving them a worksheet to complete individually. Hofstein et al. (2005), as well as Krajcik, Mamlok and Hug (2001) agree that learners who perform various ways of enquiry, challenged by appropriate questions, can find and synthesise information through investigations like animal organ dissections, as in the case of this study. The enquiry or investigative skills can help the learners to find information they can use to develop problem-solving skills.

With regard to LO 3, four of the teachers, Yvonne, Bertha, Mary and Tia, said that the learners constructed knowledge by solving practical situations given, linked to society which meant that the worksheets the learners received would include questions that related the dissected kidney to real life situations. In some cases the teachers might be aware of what they could do to ensure that all the learning outcomes are achieved but it does not mean they do it. This might mean that the learners are not adequately acquiring all the skill they could derive from one activity.

All six teachers showed that they were knowledgeable about how the learners can achieve LOs 1 and 2. As for LO 3, only four teachers confidently mentioned how they made sure that it was achieved during the animal organ dissections. One teacher, Bertha, showed that she knew what she was supposed to do so as to have the learners achieve LO 3 as well, but she just did not give them the opportunity to do so. It can be argued that some learners can be disadvantaged if the teacher does not give them enough challenging situations; their full potential is not achieved.

From the researchers' point of view, this particular dissection lesson achieved all three learning outcomes and it served as an eye-opener to the teachers that it was possible to use animal organ dissections to achieve the three learning outcomes.

7.3.5 The teachers' understanding and how well-acquainted they are with problem-solving strategies

The researcher established that not all teachers were clear on what problem-solving strategies were. In one instance, Mark (teacher 2 of School A) showed a complete lack of understanding of the problem-solving strategy. As far as he was concerned problem-solving strategy was linked to how he as the teacher would solve behaviour problems amongst the learners. Issues of concern came up regarding how teachers like Mark would assist their learners to develop problem-solving skills if they were not well-acquainted with the problem-solving strategies.

The majority of the teachers seemed to have a common understanding of problem-solving strategies which revolved around application of knowledge acquired in class, or during dissections in this case, to solve real life problems. Even though they could not state or name specific strategies, most teachers explained how they would implement them in different Life

Sciences topics. The teachers' sketchy understanding of problem-solving strategies, as well as the incorporation of inquiry and inquiry-based strategies like animal organ dissections was an issue of concern as it meant that these strategies were not being explored fully thereby compromising the teaching and learning of Life sciences

7.3.6 The improvement of the teachers' teaching strategies and problem-solving skills of learners by using animal organ dissections

It was noted that some teachers were satisfied with just having their learners dissect, draw, label the diagrams and then relate the observed structure to functions. The researcher considered this as insufficient to develop problem-solving skills in learners.

The majority (five) of the teachers acknowledged that when their learners had dissected, drawn and labelled the diagram, they would ask them questions related to real life situations regarding the excretory system. They also said that their learners would be expected to answer the problem-solving task given by the teacher which would be related to what was observed on the dissected organ. Some acknowledged that it was possible to use animal organ dissections to improve teaching strategies in problem-solving but it required a lot of guidance of the learners by the teachers towards the development of the skill as they dissected. The learners would thus focus on the important parts of the organ that would help them answer the problem-solving tasks. What these teachers suggested agrees with Mergendoller, Maxwell and Bellismo (2006) that in some cases, in order to develop problem-solving skills, the teachers should take a facilitative role, moving around between groups. This was essential for the animal organ dissections lesson in monitoring positive and negative behaviour and watching for opportunities to guide the learners towards using the dissected organ to answer the given problem-solving questions or to provide clarifications, when necessary, during group discussions.

According to the researcher's opinion, the activities she carried out with the teachers and their learners served as an eye-opener to the teachers as they realised that it was possible to use animal organ dissections to develop problem-solving skills in their learners. They were not only going to use the animal organ dissections for problem-solving in the excretory system, which was very encouraging. It was interesting to note that the pre-test, the post-test the researcher developed for the learners, and the interviews with the teachers, got them to think of approaching the animal organ dissections from a new perspective. This approach could enable them to use it to develop problem-solving skills not only in the excretory system topic but in other topics as well, which was gratifying.

It is then interesting to note that, even though the Grade 11 Life Sciences teachers were not yet using animal organ dissections to improve teaching strategies in problem-solving, the pre-test, the animal dissections lessons and the post-test which was predominantly problem-solving, opened a new door of possible teaching and learning method which they had not yet explored even with an average of 15 years teaching experience. They acknowledged that if the problem-solving skill was well-developed in learners, it would help them in higher education levels and even in real life.

7.3.7 The teachers' perceptions and attitudes towards animal organ dissections in general and its use in problem-solving specifically

Some teachers, like Thato and Bertha, showed they still had reservations with animal organ dissections especially because of their being blood phobic and they understood why their learners feared to touch the organs.

Some teachers may have a negative attitude towards animal organ dissections due to lack of confidence in carrying out the dissections. As a result, they detached themselves from the activity so that they would not expose their inexperience in dissections of animal organs to the learners. Even though some teachers had a negative attitude towards animal organ dissections, all of them acknowledged that it was significant in problem-solving. This shows that even though teachers may have a negative attitude towards animal organ dissections for different reasons, including lack of experience and fear, they still acknowledge that it is important in improving skills like problem-solving, which is encouraging.

The teachers are of the opinion that seeing the real organ and its parts can make learners think in a different way and solve presented problems better than if they were just using theoretical knowledge to answer the same questions. They argue that there will be an improvement in their complex skills thereby improving their problem-solving skills. This shows that the teachers were convinced of the usefulness of animal organ dissections in problem-solving.

7.4 CONCLUSIONS BASED ON THE FINDINGS OF THE STUDY

Having analysed the data and reflected on the whole study, the researcher came to the following conclusions:

As long as the teacher does not have confidence with the use of alternatives to animal organ dissections, the learners who are not comfortable with fresh organs dissections due to a variety of reasons that include being vegetarian, blood phobic, religion or moral reasons, will always be disadvantaged. This should not be an issue, especially when the school can afford it, in this world of technological advancement.

Some teachers admitted that during their school time, they only dissected because they were not given any alternatives to fresh organ dissections; they had no choice but to dissect otherwise they would forfeit their marks. In as much as these teachers understand the learners that are uncomfortable with fresh animal organ dissections, they feel they have no choice but to force their learners to carry out the dissection or else they forfeit the marks. Oakley (2012) observed the same tendency with teachers that were not giving their learners any alternatives to dissections such as 3D models or online dissections. They would force them to dissect or watch others dissect the real organ because they believed that alternatives to dissections were not as good as real organ dissections.

The attitude of the teachers may be reflected on the learner behaviour as was observed with the negative attitude of one of the classes of School B. Bertha, a teacher in this school, exhibited a negative attitude towards animal organ dissections by not being involved at all and the learners were misbehaving, mutilating the organs, playing on their cellphones and rushing through the post-test. This affected their performance in spite of having all the resources and apparatus for the dissections. Their performance was generally less than that of the under-resourced schools.

When a teacher is not well-versed with animal organ dissections, she will not be confident to demonstrate to the learners how to dissect properly. She will also not be comfortable to get involved as the learners will be dissecting, let alone to use the animal organ dissections in problem-solving as a teaching strategy. The implications disadvantage the learners as they will not have any guidance to engage with animal organ dissections and develop problem-solving skills.

When a teacher is not well-acquainted with problem-solving strategies, it will be very difficult for that teacher to use investigative or enquiry methods like animal organ dissections to develop teaching strategies and problem-solving skills in learners. This results in learners merely dissecting for the sake of complying with the National Curriculum Statement requirement without developing more skills that can be acquired through the dissections of animal organs.

If animal organ dissections are used effectively, they can fulfil LOs 1, 2 and 3 of the National Curriculum Statement of the Department of Education.

A few problem-solving strategies may be deduced and be linked to problem-solving and be used to develop problem-solving skills as the learners will be dissecting. The researcher deduced a problem-solving strategy model in Figure 7.1 which links animal organ dissections with problem-solving.

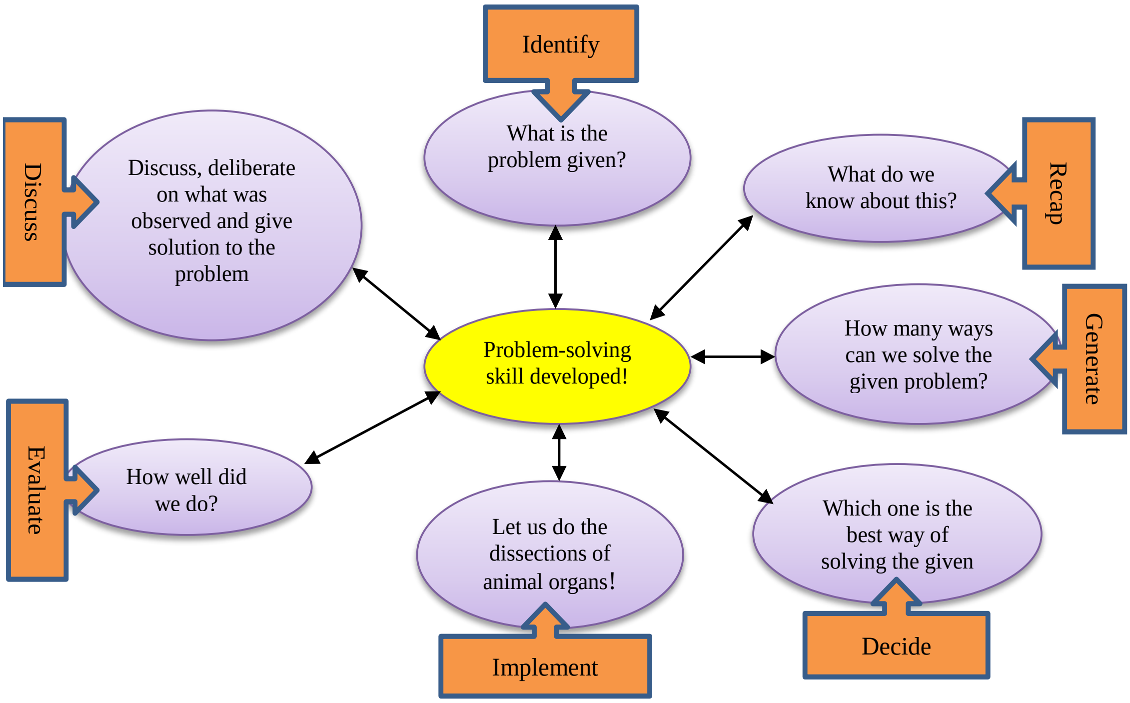


Figure 7.1: Problem-solving strategy model using animal organ dissections

Learners may be given a problem or a situation to solve regarding anatomy and morphology of animal organs. According to the problem-solving strategy model in Figure 7.1, learners must firstly *identify* the problem and define what the problem is so that they start seeking answers for the right problem. For the learners to manage to solve the given problem by engaging in the scientific enquiry, which is animal organ dissections, learners must have an idea of what to look out for. When they engage with the dissected organ, they can then use the prior knowledge linking it with new knowledge to solve the given problem. By doing so, the learners *recap* the previously acquired knowledge, according to Bruner (in Ellis, 2004). Learners then brainstorm and *generate* possible ways to solve the given problem and they *decide* on the best way to solve the problem. The learners *implement* the best way of solving the problem and, in this case with the guidance of the teacher, they carry out the dissections of the animal organs. Carrying out the dissections is not enough, they have to *evaluate* their work as a group and then discuss and deliberate on the best solution to the given situations according to the knowledge they will have generated from the dissected organ and linking it with the previously acquired knowledge. The learners may successfully find solutions to given scientific problems if they some theoretical background. They then derive other facts by dissecting and engaging with the organ. They observe and discuss and generate their own knowledge which they can use to answer the given problem-solving questions. This is the reason why all six teachers said that they preferred to let their learners dissect either in the middle of the topic or as a way of consolidating the topic.

In the problem-solving strategy model in Figure 7.1, learners are given opportunities to make decisions regarding the various dimensions of their learning process. By learning actively through animal organ dissections, learning becomes a personalised process which is a more long-term learning process. Human beings face problems that are multidimensional in real life and always try to solve them in a particular way in the light of the previously acquired knowledge and experiences. Taking this into consideration, it is essential for the learners to be prepared for future or near-future problems by being challenged with real life or real-like problems in their learning environment. They try to find solutions to these problems practically as illustrated by this study. From the researcher's point of view, the most important aspect to developing problem-solving skills using animal organ dissections is the teacher guidance towards the right directions, otherwise the whole 1 to 2-hour process will be a total waste of time and resources. Taking this into consideration, there is need for teacher acquaintance with problem-solving strategies and animal organ dissection skills.

As animal organ dissection is used to develop problem-solving skills, there are some contributing factors which can affect development as the learners are dissecting. These include attitudes and perceptions of teachers and learners towards animal organ dissections and its use in problem-solving, the scientific process skills, previously acquired knowledge of the learner on the topic, achievement of learning outcomes, level of acquaintance with problem-solving strategies on the part of the teacher, level of engagement with animal organ dissections on the part of the learners. This is illustrated in Figure 7.2, deduced from the conceptual framework in Chapter 2.

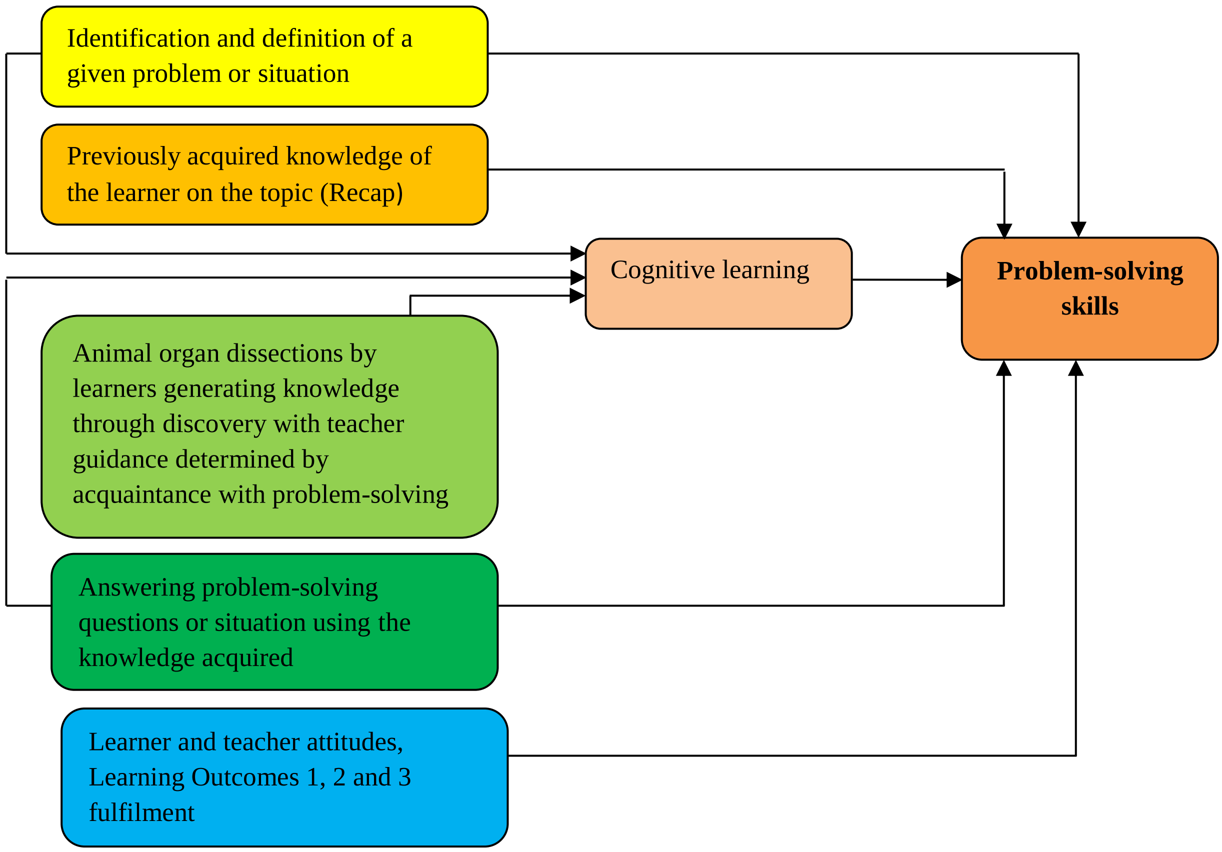


Figure 7.2: Contributing factors to the development of problem-solving skills

7.5 RECOMMENDATIONS

Policy makers wanting to promote problem-solving learning may like to consider the following measures:

- The Department of Education may work together with the school administrators and subject facilitators to encourage Life Sciences teachers and learners to include hands-on dissections of animal organs coupled with challenging relevant situations, as a way of consolidating anatomy concepts and develop problem-solving skills in the process.

- There is a need for subject facilitators from the Department of Basic Education (DBE) to determine the extent to which teachers may need to develop in problem-solving strategies and animal organ dissection skills.
- Subject facilitators should organise and encourage staff members to participate in professional development activities aimed at structuring animal organ dissections to promote problem-solving.

Life Sciences lectures for teacher training may promote problem-solving learning by considering the following measures:

- Teacher training curriculum should include exposing the trainee teachers and the already qualified teachers to dissections alternatives or virtual dissections, if the school can afford it, so that they can use them with the learners who for some reason are not comfortable with fresh animal organ dissections.
- Teacher educators should include in the curriculum as many dissections practicals as possible so that the trainee teachers can master the hands-on dissection skills, thereby boosting the confidence levels in classroom demonstrations and supervision.
- Teacher educators should include in the curriculum the various ways in which enquiry methods like animal organ dissections may be used to develop and integrate skills like problem-solving, practical and critical thinking.

Life Sciences teachers may also consider the following measures to promote problem-solving:

- It is suggested that teachers should consider animal organ dissections in more topics since significant differences could be noted after just one dissection. Learners may develop more problem-solving skills if the animal organ dissection is used in problem-solving as a teaching strategy.
- Life Sciences teachers should emphasise active, enquiry-based learning and engage their students in the dissections of animal organs.
- Hands-on exercises like dissections should be pursued but not at the expense of the learners' beliefs and emotional well-being. Various ways exist for achieving exciting, engaging, hands-on dissections for learners including virtual, online, artificial organ dissections.
- Teachers should discourage dependency syndrome on the part of the learners and learners may then engage more with animal organ dissections, developing the required

skills which include investigative, enquiry and problem-solving skills.

7.6 SIGNIFICANCE OF THE STUDY FOR FUTURE RESEARCH

The study contributes directly to the body of knowledge in the use of animal organ dissections to develop skills which include inquiry, investigative and, most importantly, problem-solving skills.

- It is ventured that the findings of this study may assist policy makers, Life Sciences lecturers and Life Sciences teachers to maximise the use of animal organ dissections rather than just to use it to comply with the requirements of the National Curriculum Statement (NCS) of the Department of Education (DoE).
- This study and those of Das and Sinha (2000), Nakhleh et al. (2002) and Smiley (2002) confirm that investigative or inquiry methods like animal organ dissections are linked to the development of skills like problem-solving.
- According to the researcher's opinion, the activities she carried out with the teachers and their learners served as an eye-opener to the teachers as they realised that it was possible to use animal organ dissections to develop problem-solving skills in their learners.
- The pre-test, the post-test the researcher developed for the learners which had predominantly problem-solving questions, and the interviews with the teachers, got them to think of approaching the animal organ dissections from a different perspective. This approach could enable them to use it to develop problem-solving skills not only in the excretory system topic but in other topics as well, which was gratifying.
- The Grade 11 Life Sciences teachers of the participating schools were not yet using animal organ dissections to improve teaching strategies and problem-solving. However, the pre-test, the animal dissections lessons and the post-test which had predominantly problem-solving questions opened a new door of possible teaching and learning method which they had not yet explored, even for some teachers with an average of 15 years teaching experience.
- The study and its findings may have enhanced the professional development and experience of the teachers that participated.
- The findings (if implemented) may also help increase learners' interest and achievement in Life Sciences by developing in them a positive attitude towards the

subject. This is important because practical work in the sciences helps acquire scientific skills, as well as scientific attitudes and values needed in solving everyday problems, especially in the courses related to Life Sciences at tertiary institutions

- Finally, the results may serve as valuable guides to further study in other areas of research such as enquiry-based learning and learner application of problem-solving skills to the learning of Life Sciences.

7.7 LIMITATIONS OF THE STUDY

There are some limitations associated with this study.

- This study was limited to a small number of Life Sciences teachers in Pretoria East. An implementation in different environmental settings like the rural areas may not necessarily result in similar findings since factors like culture have a stronger influence in rural areas and there is minimal cultural diversity.
- The lesson observation data may to an unavoidable extent be skewed due to the presence of the researcher and the video recording in the classroom- the Hawthorne effect, to minimise this, the camera was stationed at the back of each classroom and filmed as unobtrusively as possible.

FINAL REMARKS

The researcher considered it appropriate to end this study with the same remark with which she started the study:

> "…… it is better that you should learn the manner of cutting by eye and touch than by reading, listening and observing. For reading alone has never taught anyone how to sail a ship, to lead an army, to compound a medicine, which is done rather by use of one's own sight and training of one's own hands" (Sylvius, J. as cited in Baker, 1909, p. 329)

"Merely telling is not teaching and simply listening is not learning." (Ali et al. 2010. p. 67).

The findings of this study have confirmed that merely reading and listening is not enough to develop an independent scholar who is a problem-solver but an independent scholar learns by doing, which steers the brain towards development of manipulative, investigative and problem-solving skills.

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APPENDIX I: Lessons observation checklist

Title: The use of animal organ dissection in problem-solving as a teaching strategy

School: (pseudonym) ________ Teacher: (pseudonym) ______ Date:______ Time:_____

Class Observed:______ Number of Learners:______________

Topic of the Lesson: Animal organ dissections, pre-test and post-test

Lesson Objectives:

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Comments by the researcher:

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Teacher's activities	Ticks	Learners' activities	Ticks	Notes/Comments
Classroom organisation				
• Teacher stands in front of the class		Learners attentive		
• Learners sit in groups		Learners waiting for the teacher's introduction		
• Dissection instruments set up on working tables				
Lesson introduction				
• Teacher reviews previous work by asking questions		Learners participate by answering questions based on the previous work		
• Teacher provides an overview of the lesson		Learners attentive		
Teaching method: Teacher				
• Reviews learners' knowledge of animal organs		Learners contribute the theoretical knowledge acquired on animal organs		
• Provides worksheet with dissection instructions		Learners receive the worksheet and read it carefully before starting the dissections		
• Provides learners with the organ to be dissected		Learners receive the organ and place it on the dissecting table and wait for further Instructions		
• Demonstrates the step by step dissection procedure • Teacher well–skilled in dissections		Learners pay attention to the dissection demonstration by the teacher		
• Employs learner–centred approaches (learners dissect the organs in small groups) Teacher discipline management (has not distracted other groups' dissections)		Learners carry out dissections in small groups Learners handle scalpel, dissection scissors, dissection pins with caution Learners use tools as indicated Learners show respect for the specimen, not fooling around with it		
• Teacher invites the small groups to discuss the observed		Learners initiate discussions and participate actively		
• Teacher provides learners with well–structured problem-solving questions		Learners answer the questions individually		

to answer individually				
Teacher–learner interaction: Teacher				
• Teacher moves around assisting learners with the dissections when necessary		Learners ask the teacher for assistance when necessary		
• Ensures and encourages all learners in the group participate actively		Learners actively participate in the dissections		
• Provides dissections alternatives to learners uncomfortable with real organs dissections		Some learners uncomfortable to dissect with real organs		
Content:Teacher				
• Links the observed with anatomy and morphology concepts		Learners participate actively		
• Relates the observed with real life health situations		Learners manage to link the observed with how to solve real life health situations		
Other points (post observation)				
• English language used in discussions		Learner discussions carried out in English		
• Relevant content covered by the practical		Learners had many learning moments through the practical and discussions		
• Meets the curriculum expectations		Learning Outcomes 1, 2 and 3 achieved by this lesson		

APPENDIX II: Coding of the data from the lessons observations

Teachers' activities	Activities codes	Teacher code name	Specific Comments
1. Classroom organisation	1.1 Learners settled down • >5min to settle down • 5-10min to settle down	 T3, T5 T1, T2, T4, T6	School A: More time to settle learners. because of large numbers and lesson after school. School B: Bertha's classes had a casual attitude, both learners and the teacher dragging their feet. School D: lesson after normal school hours.
	1.2 Learners attentive	T1, T2, T3, T5,	Learners were eagerly waiting for further instructions
	1.3 Learners inattentive	T4, T6	As the researcher was placing the organ, some started fiddling with the organ.
	1.4 Learners late	T4, T6	School B: Some learners dragged their feet to get to the lesson in Bertha's class. School D: Some learners were approximately 10 minutes late from lunch.
	1.5 Learners distracted by latecomers	T4, T6	Latecomers distracted others as they joined their groups.
	1.6 Learners sit in groups	T1, T2, T3, T4, T5, T6	Thato and Mark's groups 5-7 learners. Yvonne and Bertha's groups 3-4 learners. Yvonne assigned the learners into groups separating naughty ones . Mary's learners were in pairs and Tia's learners were in 3s. Female students complaining about the smell of the kidneys.
	1.7 Learners waiting for the teacher's introduction	T1, T2, T3, T4, T5, T6	Mark and Bertha's learners impatiently waited, eager to start dissecting.
	1.8 Teacher stands in front of the class	T1, T2, T3, T4, T5, T6	Teacher introduced the researcher and explained why she was at their lesson.
	1.9 Dissection instruments set up on working tables by the teacher	T1, T3, T5	The practical was set up before the lesson.
	1.10 Dissection instruments set up on working tables by the researcher	T2, T4, T6	School A and D: Researcher brought the kidneys to be dissected and teachers helped her to set up. Researcher set up for Bertha to save time because she had not set up before the lesson.

2. Lesson introduction	2.1 Teacher reviews previous work by asking questions	T3, T5	Thato, Mark and Tia: Previous work was not discussed due to time pressure.
	2.2 Learners participate by answering questions based on the previous work	T3, T5	Learners' participation enabled the lesson to progress on time.
	2.3 Teacher provides an overview of the lesson (expected Outcome)	T1, T2, T3, T5	Teachers summarised the objectives and expectations of the lesson. Bertha and Tia did not give overview of the lesson.
3. Teaching method	3.1 Teacher reviews learners knowledge of animal organs	T1, T3, T5	Thato, Yvonne and Mary encourage learners to discuss their knowledge in their small groups and poses questions to remind them of their theoretical kn
	3.2 Learners contribute the theoretical knowledge acquired on animal organs	T1, T2, T3, T4, T5, T6	Learners debated their theoretical knowledge in their groups. In Tia's class the less-casual learners contributed to the discussions constructively.
	3.3 Provides worksheet with dissection instructions	T1, T2, T3, T4, T5, T6	Learners were instructed to read the worksheet carefully.
	3.4 Learners receive the worksheet and read it carefully before starting the dissections	T1, T2 ,T3, T4, T5, T6	Thato, Yvonne, Mary and Tia read and explained the worksheet together with the learners.
	3.5 Provides learners with the organ to be dissected.	T3, T4, T5	School A and D: Researcher provided the kidney due to financial constraints; some learners brought their own kidneys. Mary's learners requested gloves to avoid touching blood.
	3.6 Learners receive the organ and place it on the dissecting table and wait for further instructions	T1, T2, T3, T5	Bertha and Tia did not offer any further instructions, some learners had started handling and pricking the organ.
	3.7 Demonstrates the step by step dissection procedure	T1, T3, T5	Mark and Tia explained theoretically with the aid of a diagram how the dissection was to be done. Bertha did not explain or demonstrate the dissection.
	3.8 Teacher well-skilled in dissections	T1, T3, T5	Yvonne and Mary showed a lot of expertise in dissections. Thato struggled with the dissection as she was using improvised cutting instruments.
	3.9 Learners pay attention to the dissection demonstration by the teacher	T1, T3, T5	Mark, Bertha and Tia's learners were impatient and restless, wanted to start without explanations.
	3.10 Employs learner-centred approaches (learners dissect the organs in small groups)	T1, T2, T3, T4, T5, T6	Thato, Yvonne, Mary and Tia used a teacher-facilitated learner-centred approach.

			Mark, Bertha used a completely learner centred approach. Learners helped each other in handling the organs and cutting, in all the classes.
	3.11 Teacher discipline management (ensure groups not distracting each other)	T1, T3, T5,	Mark, Bertha and Tia were not very involved. Bertha and Mark were seated at their desks marking and just shouting for learners to keep quiet and discuss quietly. Tia's learners moved between groups, some fiddled with dissection instruments and some were on their cellphones.
	3.12 Learners carry out dissections in groups.	T1, T2, T3, T4, T5, T6	Mary: Dissections were carried out in pairs since they have adequate dissection tools and ensured maximum participation, in discussions as well.
	3.13 Learners handle scalpel, dissection scissors, dissection pins with caution	T1, T2, T3, T4, T5, T6	School A and D: Scalpel handling was problematic because of improvised instruments like razor-blades and knives, no dissection boards and pins. Some school D learners fiddled with their dissection instruments.
	3.14 Learners use tools as indicated	T3, T4, T5	School B and C: adequate instruments, some learners handled the dissection tools as per instructions. In all four schools: there were some neatly done dissections but removal of capsules was problematic.
	3.15 Learners show respect for the specimen, not fooling around with it	T1, T2, T3, T5	Bertha: Some learners started mutilating the organs after dissecting them.
	3.16 Teacher invites the small groups to discuss what was observed	T1, T2, T3, T4, T5, T6	Teacher encouraged learners to discuss what was observed, on the dissected organ. Thato, Yvonne and Mary ensured that constructive debates were taking place by moving around the groups. Tia assisted the learners in their discussion while seated at her desk, standing up when necessary.
	3.17 Learners initiate discussions and participate actively	T1, T2, T3, T4, T5, T6	Learners showed great enthusiasm irrespective of the apparatus limitations in schools A and D; discussions were orderly.
	3.18 Teacher provides learners with ill-structured problem-solving questions to answer individually	T1, T2, T3, T4, T5, T6	Questions formulated by the researcher were given to each learner.

	3.19 Learners answer the questions individually	T1, T2, T3, T4, T5, T6	Some learners in Bertha's class rushed through their work leaving lots of unanswered questions.

APPENDIX III: Interview schedule for teachers

I am interested in finding out how animal organ dissections can be used in problem-solving as a teaching strategy in Grade 11 Life Sciences education. Organ morphology and anatomy is one of the topics in the Grade 11 syllabus in which it is a requirement to carry out dissections on organs like kidneys, hearts or livers of animals. The learners are expected to then link the structure of the dissected organ to function of the different parts observed. The findings will assist in designing of curriculum and teacher education programmes pertaining to this topic.

For office use

Respondent number [| |] V 1

<u>Please answer each question by putting a cross (X) in the appropriate shaded box, or by writing your answer in the shaded space provided</u>

Section A: Biographical Information

1. What is your gender?

Male	1
Female	2

[ ] V 2

3. What is your age in years?

[|] V 3

4. What is your religion? (Please select one answer)

Christian	1
Muslim	2
Hindu	3
Jewish	4
Buddhism	5
No religion	6
Other (specify)	7

[|] V 4

5. What is your culture group? (Please select one answer)

Afrikaans	1
English	2
Ndebele	3
North-Sotho	4
South-Sotho	5
Swazi	6
Tsonga	7
Tswana	8
Venda	9
Xhosa	10
Zulu	11
Other (specify)	12

[|] V 5

6. What is your highest academic qualification? (Please select one answer)

V 6

Doctor's degree	1
Master's degree	2
Honour's degree	3
Postgraduate Certificate in Education	4
Postgraduate Diploma in Education	5
Bachelor's degree	6
Diploma	7
Certificate	8
Senior Secondary Certificate/Matric	9
Other (specify)	10

7. For how many years have you been teaching Life Sciences?

V 7

8. In which level of your education did you carry out dissections?

V 8

University	1
College	2
High school	3
Never carried out dissections	4

Section B: Interview questions

1. Please tell me what the dissections in the Life Sciences curriculum in Grade 11 are?

2. How many opportunities are there for dissections in the current Life Sciences curriculum?

3. How easy or difficult are the dissections of different organs on the part of your learners?

4. At which point of the topic do you carry out dissections with your learners? as introduction, investigative or as a way of consolidating the topic.

5. How do you ensure that the intended learning outcomes are fulfilled on the part of the learners?

6. To what extent do dissections fulfil all the 3 NCS Learning Outcomes for the Grade 11 curriculum?

7. What is the source of organs you use for dissections?

8. Any reservation on dissections in terms of time consumption/constraints?

9. What are the advantages of hands-on group work during dissections?

10 What problems do learners experience in doing animal organ dissection?

11. How do you handle situations where some learners for some reason are not willing to participate in actual dissections e.g. religious, cultural, moral, ethical or being vegetarian?

12 Please recall and describe your reactions/feelings when you first carried out dissections.

13 Please describe your feelings whenever you have to carry out dissections with your learners.

14. What are the financial implications of dissections – actual versus virtual?

15. How do you manage discipline during dissections?

16. What is your preference in dissections: a demonstration or that they do it themselves, in groups or one by one?

17. Are there instances where you as a teacher do not want to dissect?, Do you just let them do it without your involvement?

18. If the school does not have the necessary infrastructure for dissections, how do the dissections take place in the school?

19. How significant is the use of virtual or online dissections?

20. What is your understanding of problem-solving strategies?

21. Which topics in Life Sciences do you use to develop this skill in learners?

22. Is the dissection of organs important or significant in problem solving?

23. Do you think animal organ dissections have any contribution to the development of problem-solving skills of Grade 11 Life Sciences learners? Please explain your view.

24. What are the learners' attitudes towards the use of animal organ dissections in general and towards its use in problem-solving?

25. How do you use animal dissections to improve the problem-solving skills of Grade 11 learners?

Thank you for your participation

APPENDIX IV: Coding of the data from the teachers' interviews

Section A: Biographical Information				
Question	**Categories**	**Codes**	**Teachers**	**Frequency**
1. What is your gender?	Gender Female Male	 F M	 T1, T3, T4, T5, T6 T2	 5 1
2. What is your age in years?	Age 20-29 30-39 40-50	 20-29 30-39 40-50	 T4 T6 T1, T2, T3, T5	 1 1 4
3. What is your religion?	Religion Christian	 Ch	 T1, T2, T3, T4, T5, T6	 6
4. What is your culture group?	Afrikaans English North-Sotho	Af Eng N-S	T4, T5, T3, T6 T1, T2	2 2 2
5. What is your highest academic qualification?	Master's degree Honour's degree Postgraduate Certificate Postgraduate Diploma Bachelor's degree	MSc HD PGCert PGDip	T3, T1, T5, T6 T4 T2	1 3 1 1
6. For how many years have you been teaching Life Sciences?	5-10 11-15 16-20	5-10 11-15 16-20	T4, T6 T3, T5 T1, T2	2 2 2
7. In which level of your education did you carry out dissections?	University College High School Never carried out dissections	Univ Coll HSch Never	T1, T3, T5, T6 T2 0 T4	4 1 0 1
Section B: Semi-structured questions				
Question	**Categories**	**Codes**	**Teachers**	**Frequency**
1.1. Please tell me what the dissections in Life Sciences curriculum in Grade 11 are?	Kidney Heart	O1 O2	T1, T2, T3, T4, T5, T6 T2, T3, T4, T5, T6	6 5
1.2. Any reasons why you dissect specifically the organs you have just mentioned?	Easy to get Cheap Part of the curriculum (pace setter)	Rs1 Rs2 Rs3	T1, T2, T5 T1, T5 T1, T2, T3, T6	3 2 4
2. How many other opportunities are there for dissections in the current Life	Digestive system	Op1	T2	1

Sciences Curriculum?	Animal Diversity e.g. starfish, earthworm, frogs, insects, piglet Skeleton Plant organs Lungs and tissues	Op2 Op3 Op4 Op5	T3, T5, T6 T4, T6 T4, T6 T4	3 2 2 1
3. How easy/difficult are the dissections of different organs on the part of your learners?	Difficulties in instrument manipulation Scared to open the organ Religious beliefs problems Insufficient dissection equipment Learners curious, interested Difficult to observe all the organ parts Easy when given clear instructions	Df1 Df2 Df3 Df4 Df5 Df6 Df7	T1, T2, T4, T6 T2, T6 T2, T3 T1, T2, T6 T1, T2 T3, T4 T4	4 2 2 3 2 2 1
4.1. At which point of the topic do you carry out dissections with your learners?	Consolidation Introduction Investigative	Pt1 Pt2 Pt3	T1, T2, T3, T4 T5, T6	4 0 2
4.2. Any reasons why dissecting at the point mentioned earlier?	Generates interest in the topic Understand the topic more Link the theory given with the real organ Give them background of the organ first before dissecting	Reas1 Reas2 Reas3 Reas4	T2, T6 T2 T3, T4, T6 T3, T4, T5	2 1 3 3
5. How do you ensure that the intended Learning Outcomes are fulfilled?	Hands-on practical Task is given to complete Task related to real life (organ transplant)	LO1 LO2 LO3	T1, T2, T4, T5, T6 T1, T2, T3, T4, T5, T6 T3, T4, T5, T6	5 6 4
6.1. To what extent do dissections fulfil all the 3 NCS Learning Outcomes for the Grade 11 curriculum?	Hands-on dissections(dissecting skill) Construct knowledge by: observe, identify parts, relate structure to function, interpretation of diagram, discuss Solve practical situations given, linked to society	Ex1 Ex2 Ex3	T1, T2, T3, T4, T5 T1, T2, T3, T4, T6 T3, T4, T5, T6	5 5 4
6.2. Any other outcomes learners achieve during dissections?	Handling of apparatus Cleaning up afterwards Good task marks	Ot1 Ot2 Ot3	T1 T1, T3 T1, T3	1 2 2
7.1. What is the source of organs you use for dissections?	Butchery Abattoir Not sure because school orders them	S1 S2 S3	T1, T2, T6 T3, T5, T6 T4	3 3 1
7.2. Besides buying the organs can't you also breed your own animals as	Just Buy	OS1	T1, T2, T3, T4	4

organ sources?	No Lab to breed the animals	OS2	T1, T6	2
8. Any reservation on dissections in terms of time consumption/constraints?	No, practical is done after school	R1	T1, T2	2
	Lab too small, hence need for more time	R2	T1	1
	Time constraints due to lack of proper facilities and instruments	R3	T2, T6	2
	Learners take their time as they will be enjoying it	R4	T2, T5	2
	No time constraints because of long double periods	R5	T3, T4	2
9.1. What are advantages of hands-on group work during dissections?	Link theory with reality	Ad1	T1, T2	2
	They are hands-on	Ad2	T1, T2, T4, T6	4
	Debate enhances understanding	Ad3	T1, T2, T4, T6	4
	Learners focus more	Ad4	T2, T4	2
	Learners from different cultures work together	Ad5	T3, T4, T6	3
	Minimises participation if in groups	Ad6	T5	1
9.2. Importance of group work	Helps struggling learners	G1	T1, T3, T5	3
	Strong learners boost the morale of the group (empathy)	G2	T1, T3, T5, T6	4
	Helpful discussions	G4	T1, T6	2
9.3. Are discussions allowed?	Discussion per group allowed	Ds1	T1, T3, T5, T6	4
	Individual work after discussion	Ds2	T1	1
10. What problems do learners experience in doing animal organ dissections?	Do not follow instructions	P1	T1	1
	Cutting wrongly/themselves	P2	T2, T3, T4	3
	Need for step by step guidance	P3	T1	1
	Some not willing due to religion	P4	T1, T2, T6	3
	Scared/squeamish to touch the organ	P5	T3, T2, T5	3
	Blood and smell phobia, nauseous	P6	T3, T4, T6	3
11.1 How do you handle situations where some learners for some reason are not willing to participate in actual dissections e.g. religious, cultural, moral, and ethical or being vegetarian?	They have to participate for marks	H1	T1, T4	2
	Risk of forfeiting marks	H2	T1, T2, T4	3
	No choice curriculum requirement	H3	T1, T4	2
	Encourage them to watch others dissect and discuss	H4	T2, T3, T4	3
	Can do another hands-on practical which is not dissections	H5	T3	1
	Use the internet to watch dissections	H6	T4	1
11.2 Have you had learners that are strongly religious, cultural, moral or	No such problems yet	Hn1	T1, T5	2

ethical and vegetarian saying: I am not touching it?	Most learners are Christians Have encouraged them to just watch others Can use their phones to go on internet or can show them how it is done online, or take a picture	Hn2 Hn3 Hn4	T1 T2, T3, T5, T6 T4, T5, T6	1 4 3
12.1 Please recall and describe your reactions/feelings when you first carried out dissections.	Scared, blood phobia Had no choice, it was for marks Very interesting, fun, worth it	Rc1 Rc2 Rc3	T1, T4 T1 T2, T3, T4, T5, T6	2 1 5
12.2 In your case, the first time was when you were already working?	Yes, very new, explored and learnt together with the learners	Rcc1	T4	1
13. Please describe your feelings whenever you have to carry out dissections with your learners.	Not bad Understand their fear The preparation is too involving Gratified by their excitement and experience	F1 F2 F3 F4	T1, T3, T4 T1, T4 T5 T1, T2, T3, T4 T5, T6	3 2 1 6
14.1 What are the financial implications of dissections – actual versus virtual?	School cannot afford virtual organs, it is a waste Teacher/Principal improvise/buy organs Most learners needy School has no such facilities	Im1 Im2 Im3 Im4	T1, T6 T1, T2 T1 T1, T2, T3, T6	2 2 1 4
14.2 Have you ever considered using artificial organs instead of real ones?	Not aware of artificial organs which can be dissected Just have models already cut School cannot afford virtual ones Texture not the same as the real organ It is a good idea, will look into it Financially we could get them, we just have not explored that angle	Art1 Art2 Art3 Art4 Art5 Art5	T1, T3, T4, T6 T2, T6 T2 T2, T3 T3 T4	4 2 1 2 1 1
15. How do you manage discipline during dissections?	Motivate them Deduct marks if naughty Become problematic when task is done, give them more work Each group stays at its own table No intergroup communication Make sure they dissect not mutilate Always moving around the tables guiding them	Dsc1 Dsc2 Dsc3 Dsc4 Dsc5 Dsc6 Dsc7	T1, T4 T1, T3 T2, T6 T3, T5, T6 T3, T5 T3, T4 T3, T4, T5, T6	2 2 2 3 2 2 4
16.1. What is your preference in dissections: a demonstration or that they do it	Group work	Pref1	T1, T2, T3, T6	4

themselves, in groups or one by one?	One by one In pairs	Pref2 Pref3	T1, T5, T6 T1	3 1
16.2. Please explain why the preference you mentioned earlier	Group work: we use fewer kidneys: cheaper Encourages group discussion, enhancing understanding Fewer groups easier to monitor and guide Some learners encourage others to be hands-on One by one: each learner gets to dissect In pairs: maximum participation and they help each other in handling the organ	Pref1 Pref2 Pref3 Pref4 Pref5 Pref6	T1 T1, T2, T3, T6 T2, T3 T3 T1, T5, T6 T1	1 4 2 1 3 1
17. Are there instances where you as a teacher do not want to dissect; do you just let them do it without your involvement?	No, I always demonstrate Always enjoy dissections I force myself for the sake of learners' marks	Inst1 Inst2 Inst3	T1, T2, T5 T2, T3, T5, T6 T4	3 4 1
18.1. If the school does not have the necessary infrastructure for dissections, how do the dissections take place in the school?	Use knives in place of scalpels Use card box in place of dissection board School adopted by UP, can book their labs Organise with neighbouring schools with better facilities School has the necessary infrastructure If it did not have, would show on the internet, have never done online dissections so pictures only	Hw1 Hw2 Hw3 Hw4 Hw5 Hw6	T1, T2, T5 T1, T2, T6 T2 T2 T3, T4, T5 T4	3 3 2 1 3 1
18.2. How are the dissection results after improvising the instruments?	They are good Internal parts clear	Res1 Res2	T1, T2, T6 T1	3 1
19. How significant is the use of virtual/online dissections?	Never use virtual/online dissections No online, smart computers, or projectors Learners enjoy seeing and touching the real organ not on paper or computer It must be very good because you can zoom in and out Have done frog dissection on a smart board but it is expensive and not the same as the real organ	Sign1 Sign2 Sign3 Sign4 Sign5	T1, T3, T4, T5 T1, T2 T2, T5, T6 T4, T6 T6	4 2 3 2 1

20.1. What is your understanding of problem-solving strategies	Apply knowledge acquired in class/during dissections to solve real life problems	Und1	T1, T3, T4, T5, T6	5
	Tasks that can help them think of alternative ways to solve problems	Und2	T3, T4, T5, T6	4
	No understanding of problem-solving strategies	Und3	T2	1
20.2. Do you have any specific problem-solving strategies that you develop in Life Sciences lessons?	Always link the theory of each organ with the practical problems associated with it	Strat1	T1, T4, T5, T6	4
	If learners come across the problems in real life situations, they will be skilled and can solve them	Strat2	T1, T4	2
	No strategies since there is lack of understanding of the problem-solving strategies	Strat3	T2	1
21. Which topics in Life Sciences do you use to develop this skill in learners?	Skeleton Topic: Diseases associated with bones e.g. Osteoporosis, Gout, Arthritis	Top1	T1	1
	Excretion Topic: Kidney, Lungs functions, relating to structure and function and how to take care of their bodies	Top2	T1, T4, T5	3
	Circulatory system,	Top3	T2, T4, T6	3
	Viruses, bacteria and related diseases, cure, prevention etc	Top4	T3	1
	Nutrition: They design how to determine which enzyme is in saliva and its role	Top5	T5	1
22. Is the dissection of organs important or significant in problem solving?	Yes it is, clear understanding of kidney and how to solve problems associated with its structure and function	Sign1	T1, T3, T6	3
	Yes, seeing the real organ and its parts can make learners think from a different perspective and solve presented problems in a better way	Sign2	T4, T6	2
	Yes it is, learners develop listening, observation and cooperative skills	Sign2	T2	1
23. Do you think animal organ dissections have any contribution to make to the development of problem-solving skills of Grade 11 Life Sciences learners? Please explain your view.	It does especially to those aspiring to pursue a medical or Life Sciences career They can apply the same knowledge to	Contr1	T1, T6	2

	other organs or how to investigate them, the same way they did with the kidney	Contr2	T1, T2, T3, T4, T6	5
	It does because they did much better in the post-test than before they dissected	Contr3	T2, T5	2
24. What are the learners' attitudes towards the use of animal organ dissections on problem-solving?	Initially they did not understand the purpose of dissecting	Att1	T1, T4	2
	When presented with challenging questions, they were encouraged to explore more the dissected kidney and discuss as a group.	Att2	T1, T3, T4	3
	They became more curious, challenges them to think further and research more	Att3	T1, T2	2
	Positive, Learners were eager to discuss and answered most questions	Att4	T2, T4, T6	3
24.1 Is the keenness during dissections the same as when answering problem- solving questions?	They are more interested in cutting and drawing	Kn1	T2, T4	2
	A bit negative because it is more work and effort	Kn2	T2, T4, T5	3
	Some were keen all the way	Kn3	T1, T5	2
25. How do you use animal dissections to improve the problem-solving skills of Grade 11 learners?	When I make them dissect, they master the concepts much more than just theory and diagrams	Hw1	T1, T6	2
	When they dissect, I ask them to name and relate structure to function	Hw2	T1, T2	2
	Ask them to draw and I ask them questions relating to real life situations related to excretion.	Hw3	T1, T3, T4	3
	Guide learners towards development of the skill as they dissect, rather than leave them to just cut unguided	Hw4	T3, T4	2
	Give them an organ and ask them to dissect and identify all features and answer the related problem-solving task	Hw5	T5, T6	2

APPENDIX V: Problem-based learning activities lesson plans

Problem-based lessons and activities

Topic: Urinary System

Prior Knowledge: Excretory System

Time for Instruction: 11 class periods (45 minute classes)

Date: March 2012 **Grade:** 11

Competency: Analyse the anatomy and physiology of the urinary system.

Specific Objectives: Describe the structure of the urinary system
Analyse the function of the urinary system.
Analyse characteristics and treatment of common urinary disorders.

Overall Expectations:

- demonstrate scientific investigation skills and problem solving (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

- analyse the social or economic impact of dialysis technology used in cases of kidney problems and the impact of lifestyle choices on human health.

- investigate, through laboratory inquiry, animal organ dissection or computer simulation, the anatomy of the kidney

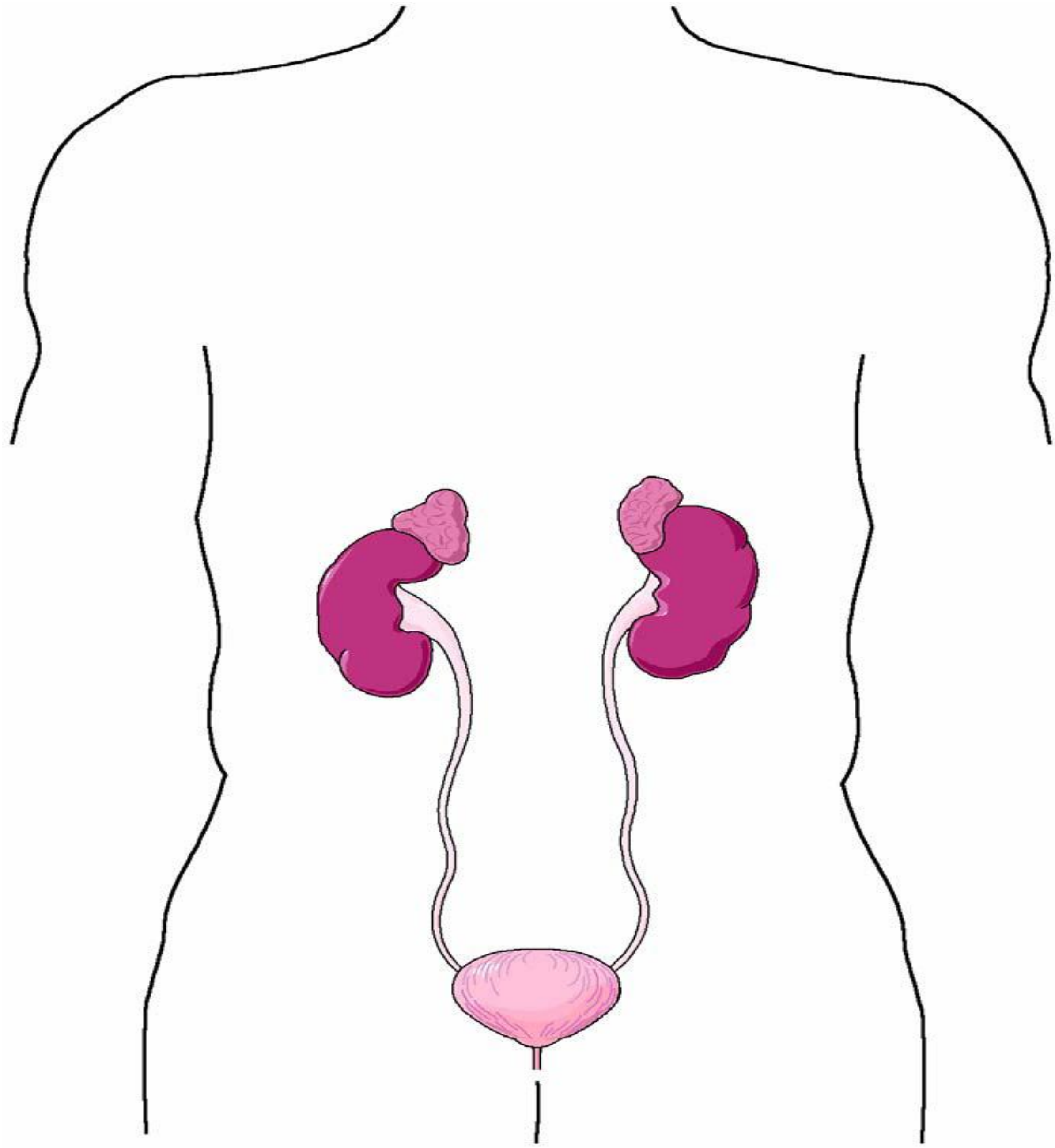
- demonstrate an understanding of the structure, function, and interactions of the urinary system organs of mammals.

Lessons 1-4

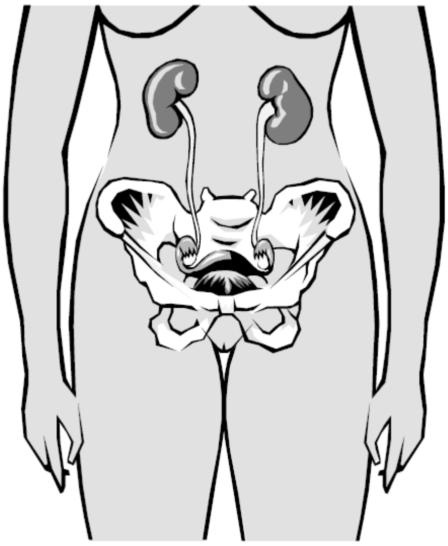
Objective 1: Describe the structure of the urinary system.

Teaching/Learning Activities

• **Basic Skills**
Have learners read the urinary system chapter in Body Structures and Functions. Give students a copy of the terminology list, and have them make flash cards on terms associated with the structure of the urinary system. Instruct learners to write the term on one side of the card, and the definition on the other side of the card.



• **Cognitive**
Have learners label the illustrations of the kidney and male/female urinary organ systems. *(below)*



Draw a line from the term to the related structure on each torso.

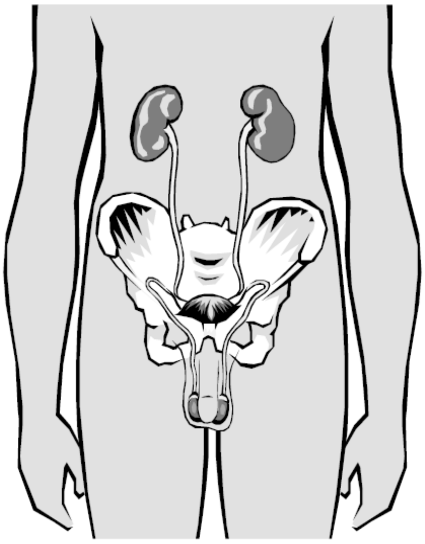
Bladder

Kidney

Ureter

Renal pelvis

Urinary meatus



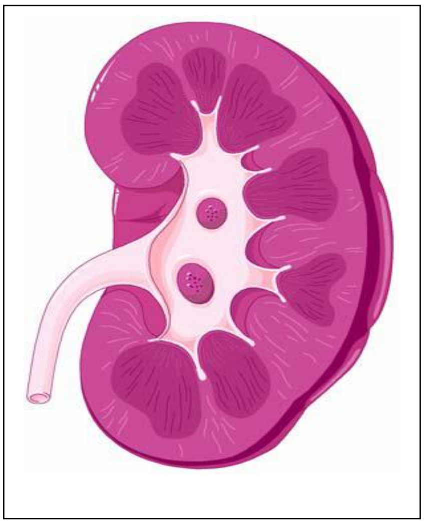
• **Teamwork**
Assign learners in groups of 2-3 to create a three-dimensional model of the urinary system. They should label the different urinary system structures. Evaluation should be based on accuracy, color, neatness, and originality.

• **Special Needs**
Each learner will reach the highest level of mastery in the least restrictive environment since it is active learning.

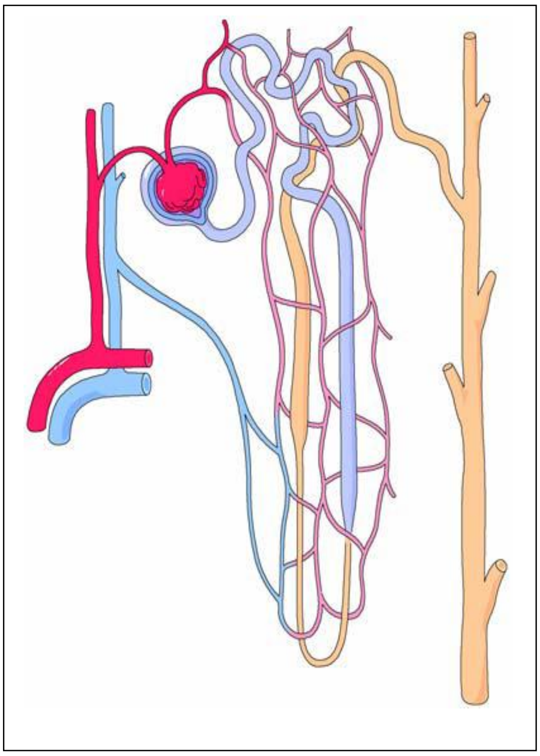
A. Kidney

1. Bean-shaped
2. Located between peritoneum and the back muscles (retroperitoneal)
3. Renal pelvis – funnel-shaped structure at the beginning of the ureter
4. Medulla

a. Inner, striated layer
b. Striated cones are renal pyramids
c. Base of pyramids empty into cuplike cavities



called calyces
5. Cortex – composed of millions of microscopic nephrons
Label the following structures: on the kidney diagram.
1. Cortex
2. Medulla
3. Ureter
4. Pyramid
5. Renal pelvis
6. Hilum



B. Nephron – functional unit of kidney
1. Bowman's capsule
2. Glomerulus
3. Proximal convoluted tubule
4. Loop of Henle
5. Distal convoluted tubule
6. Collecting tubule
Label the above-mentioned structures: on the nephron

C. Ureters
1. One from each kidney
2. Smooth muscle tube with mucous membrane lining

D. Urinary bladder
1. Hollow, muscular organ
2. Made of elastic fibers and involuntary muscle
3. Stores urine – about 500cc

E. Urethra
1. Connects bladder with urinary meatus
2. Urinary meatus is opening to body

Lessons 5-8

Objective 2: Analyse the function of the urinary system

Teaching/Learning Activities

• Cognitive
Have learners complete the matching exercise related to the function of the urinary system.

Urinary System Matching

______1.	Retroperitoneal	A.	The process of removing nitrogenous waste material, certain salts, and excess water from the blood.
______2.	Excretion	B.	Performs filtration
______3.	Nephron	C.	The opposite of reabsorption
______4.	Glomerulus	D.	The basic structural and functional unit of the kidney.
______5.	Filtrate	E.	Located behind the peritoneum.
______6.	Secretion	F.	Under the control of the hypothalamus, this hormone increases the permeability of water in distal and collecting tubules
______7.	Urinalysis	G.	A hormone released by the kidneys when blood pressure drops.
______8.	Aldosterone	H.	A fluid consisting of water, glucose, amino acids, some salts and urea.
______9.	Diuretics	I.	An examination of the urine
______10.	Renin	J.	Stores urine until about 500cc has accumulated
______11.	Proximal convoluted tubules	K.	The first step in urine formation
______12.	Filtration	L.	Adrenal hormone that controls urinary secretion
______13.	Bladder	M.	Contains
______14.	ADH	N.	Where 80% of the water filtered out of the blood by the glomerulus is reabsorbed
______15.	Cortex	O.	They increase urinary output by inhibiting the reabsorption of water.

• **Critical Thinking**
Using the flash cards created in the first objective, have learners put their cards in an order that illustrates the correct path of urine formation.

• **Employability Skills**
To help learners understand the function of the kidneys, use the provided dialysis illustrations (provided) to show the class the: filtration, reabsorption and secretion – related to the functioning kidney and in hemodialysis.

• **Basic Skills**
Following discussion of the functions of the urinary system, have learners keep an accurate record of their intake and output for a 24 hour period, as assigned by the teacher. They should complete the "Intake and Output Diary" and then bring it to class for analysis and discussion. (Note: Teachers may wish to modify the measurement of output from cc to counting number of times the learner voids. Modifications are at the teacher's discretion.) An important part of the above exercise is the debriefing and data analysis. Teachers may ask questions about the comparison of data (female output frequency compared to male), comparison of intake mean, median and range, etc. Ask learner to make observations and draw conclusions from the data.

Intake and Output Diary

For one day (24 hours) you are to keep an accurate diary of your fluid intake and output. Be sure you include what you drank (under intake) and the total number of cc. Date to collect data ____________

Time	Intake	Output
0800		
0900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
2200		
2300		
2400		
0100		
0200		
0300		
0400		
0500		
0600		
0700		
Total		

• **Special Needs**

Each learner will reach the highest level of mastery in the least restrictive learning environment as it is a learner focused approach.

<u>A. Four main functions</u>

1. Excretion – removing nitrogenous wastes, certain salts and excess water from blood.
2. Maintain acid-base balance
3. Secrete waste products in the form of urine
4. Eliminate urine from bladder

<u>B. Nephron</u> – functional unit of the kidney – for urine formation

1. Filtration

a. First step in urine formation
b. Blood from renal artery enters glomerulus
c. Blood pressure in glomerulus forces fluid (filtrate) to filter into Bowman's capsule
d. Filtrate does not contain plasma proteins or RBCs – they are too big

2. Reabsorption

a. Water (90%) and useful substances are reabsorbed
b. If blood levels of certain substances are high (glucose, amino acids, vitamins, sodium) then those substances will NOT be reabsorbed

3. Secretion

a. Opposite of reabsorption

b. Secretion transports substances from blood into collecting tubules
c. Electrolytes are selectively secreted to maintain body's acid-base balance

C. Urinary output
1. Ave = 1500 ml/day
2. Urinalysis – examination of urine to determine presence of blood cells, bacteria, acidity level, specific gravity and physical characteristics

D. Ureters
1. Carry urine from kidney to bladder
2. Peristalsis pushes urine down ureters

E. Urinary bladder
1. Stores urine – usually about 500cc
2. Emptying urine (voiding) is involuntary but controlled through nervous system (voluntary)

F. Control of urinary secretion
1. Chemical control
a. Reabsorption of H_2O in distal convoluted tubule controlled by ADH (antidiuretic hormone)
b. Secretion and regulation of ADH controlled by hypothalamus
c. Diuretics inhibit reabsorption of H_2O

2. Nervous control
a. Direct control through nerve impulses on kidney blood vessels
b. Indirect control through stimulation of endocrine glands

Lessons 9-11

Objective 3: Analyse characteristics and treatment of common urinary disorders.

Teaching/Learning Activities

• Problem-solving
Divide learners into groups of 3-4, and have them complete the exercise "Medical Decision" using the creative problem-solving guidelines.

"Medical Decisions"
You have been assigned to a Medical Decisions Board for Pretoria East Hospital. Today, your decision involves a very common dilemma: one kidney and four patients in complete renal failure, all in need of a kidney transplant.
Work with your group using the problem-solving process to determine who gets the kidney. Present your decision and rationale to a group of judges or your class. The kidney donor was a 17-year-old male who was killed in a car crash. The parents have requested that the kidney be transplanted in a teenager.

Name, Age and Occupation	Renal Status	Other Medical factors	Financial Status	Social Factors
Mary Greaves 54 Housewife	Dialysis: 15 years Transplant waiting list: 7 years	Arthritis – Mod. Post-menopausal hormone replacement Hypertension – Mod. Overall health – Fair	$46,000/yr Medicaid	▪ Has 6 grown kids, all supportive ▪ Husband is reformed alcoholic with stable income and in good health, age 60
Michelle Mantle 35 Former tennis pro	Dialysis: 1 year Transplant waiting list: 6 months	Multiple sclerosis – 2 years – Mod. Overall health – Fair	Net worth – 20 million dollars No insurance	▪ High profile patient would bring much media attention to the medical center ▪ Potential exists for financial gain for the medical center, publicity for organ donations
Gary Puckett 19 College student	Dialysis: 2 years Transplant waiting list: 9 months	Overall health – Good Regularly uses cocaine, other illegal substances have been present in blood specimens	Parents: $120,000/yr Blue Cross/Blue Shield	▪ Parents are supportive ▪ Patient resists medical regimen as prescribed by physicians
Gerald Ford 43 Auto mechanic	Dialysis: 7 years Transplant waiting list: 2 years	Overall health – Excellent	$25,000/yr Managed care – will cover 50% of costs	▪ Has 16 year old son in school who lives in the home ▪ Wife died of Leukemia in 1995

•Problem-solving skills
Have learners complete the assignment to be discussed in class “What Happened?”

What Happened?
Read each scenario and, based on your understanding of the anatomy and physiology of the urinary system, what do you think has happened?

1. Kgomotso is on the track team at school. After just having run a mile on a very hot day, Kgomotso goes to the bathroom to urinate, and is concerned that there is a very small amount and the color is deep amber. What happened?

2. Mbali was playing football this afternoon and was hit pretty hard in his right flank. Tonight, he goes to the bathroom to urinate, and notices the water in the toilet bowl is a light pink. What happened?

3. Mbuyi’s grandmother had a stroke and has been hospitalised. When Mbuyi goes to visit her grandmother, there is a clear plastic bag filled with urine hanging on the side of the bed, and a tube leading from the bag to her grandmother. What happened?

4. Vele goes to camp. After a few days there, she begins to have dysuria (painful urination), and notices that her urine smells funny and is cloudy. What happened?

• Hands-on Activity
Learners to perform urinalysis procedures. Use reagent strips such as Bayer's *Multistix*.
Learners can check their own urine, or if desired, the teacher can make urine with water and the provided food colouring, and then add a little acetone, sugar, and other kitchen ingredients that will give interesting results. Learners must interpret the results on the strips.
A. Kidney (renal) failure

1. Acute kidney failure
    i. Caused by nephritis, shock, injury, bleeding, sudden heart failure or poisoning
    ii. Symps – oliguria (scant urine) or anuria (no urine produced)
2. Chronic kidney failure – gradual loss of function of nephrons

B. Renal calculi (kidney stones)
    i. Made of calcium and uric acid crystals
    ii. Gradually they get larger until they block ureters
    iii. First symptom – severe pain
    iv. Other symps – nausea and vomiting, frequency, chills, fever, hematuria
    v. Diagnosis – by symptoms, ultrasound or x-ray
    vi. Remedy – increase fluids, medications, and lithotripsy

C. Lithotripsy
    i. Surgical procedure to remove kidney stones
    ii. Shock waves hit dense stones and break them up
    iii. Done on outpatient basis

D. Nephritis – infection or inflammation of the kidney

E. Cystitis
    i. Bladder infection, usually caused by E. Coli bacteria
    ii. Symps – dysuria (painful urination) and frequency
    iii. More often in females (shorter urethra)
    iv. Treatment – antibiotics

F. Incontinence – involuntary urination

G. Dialysis (hemodialysis)
    i. Treatment for kidney failure
    ii. Involves the passage of blood through a semipermeable membrane
    iii. Dialysis serves as substitute kidney
    iv. Can be done at home or in clinic
    v. Usually takes 2-4 hours, 2-3 times a week

H. Kidney transplant
    i. As a last resort to treat kidney failure
    ii. Involves donor organ from someone with a similar immune system
    iii. Main complication – rejection

I. Terminology and Treatments
    i. Glycosuria – sugar in urine
    ii. Polyuria – large amounts of urine
    iii. Anuria – no urine
    iv. Dysuria – painful urination
    v. Hematuria – blood in urine
    vi. Diuretic – a drug or substance that increases the amount of urine secreted

Lesson 12

Topic: Dissection of a kidney

Prior Knowledge: Urinary system

Time for Instruction: 1 double period (90 minutes)

Date: March 2012 **Grade:** 11

Objective 4: **Dissections of a mammalian kidney based on worksheet provided.**

Competency: Dissect the lamb kidney, analyse the anatomy and relate to physiology of the urinary system, answer related ill-structured problem-solving questions

Specific Objectives: Investigate the external and internal structure of the kidney
Dissect the lamb kidney, draw and label
Discuss the observed structure of the kidney in groups
Analyse the function of the kidney parts.
Answer the given challenging questions related to the dissected kidneys and possible disorders before and after the animal organ dissections

Teaching/Learning Activities

- **Basic Skills**
  Dissection skills
  Communication skills, during group discussions

- **Cognitive**
  Identify kidney structures and relate to function
  Answer the given challenging question

- **Teamwork**
  Assign learners in small groups

- **Hands-on Activity**
  Learners to perform animal organ dissection

- **Problem-solving**
  Learners solve the given problem-solving questions after carrying out animal organ dissection

Lesson structure:

1) Learners settle down and Introduction of the researcher - < 5 minutes
2) Learners write the pre-test ≤ 25 minutes
3) Learners perform animal organ dissection following the worksheet instructions, analyse the kidney parts and group discussions ≤ 30 minutes
4) Learners write the post-test ≤ 25 minutes
5) Answer scripts are collected by the researcher for marking

APPENDIX VI: Dissection worksheets **Schools A and B**

Dissection of the kidney

Material:

- A fresh sheep kidney
- A sharp knife or scalpel
- Petri dish or any flat plastic container
- A hand lens
- A glass rod

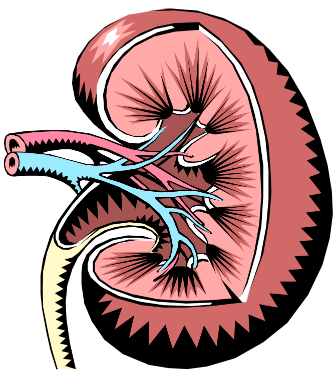
Instruction

1. Observe the shape, colour and the size of the kidney.

2. Remove any fat.

3. Identify the renal capsule.

4. Use a sharp knife or scalpel to slice the kidney across the middle as shown below.



5. Draw a neat diagram of what you see. The diagram should be the actual size of the kidney**.**

Identify and label the different parts. Relate the different parts to their functions.

Answer the following questions:

5.1 What is the colour of the cortex and medulla?

5.2 How many pyramids can you identify in one half of the kidney?

5.3 Using the hand lens identify and name the tiny dots in the cortex region

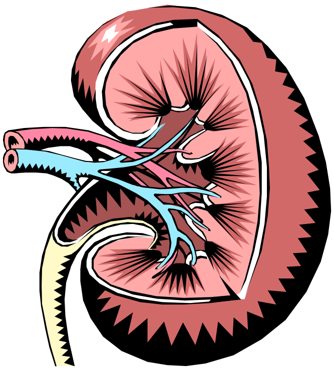
Dissection worksheet: Schools C and D

Aim:
To investigate the external and internal structure of the kidney.

Apparatus/Material:

- Fresh sheep kidney
- Dissection tray/cutting board
- Dissection kit/cutting knife
- Hand lens
- Laboratory coat (or any old clothing)

Method:
1. Observe the shape, colour and the size of the kidney.
2. Remove any fat.
3. Identify the ureter, renal capsule and renal artery.
4. Use a sharp knife or scalpel to slice the kidney across the middle as shown below.
5. Identify the different layers, using the hand lens.



Precautions:
- Make sure that you wash your hands with warm soapy water afterwards.
- Cut on the dissection/cutting board and take care not to cut yourself.

Observations:

Draw a neat diagram of what you see. The diagram should be the actual size of the kidney. Identify and label the different parts, write down the functions of each labelled part

1. What is the colour of the cortex and medulla? ___________________________
2. How many pyramids can you identify in one half of the kidney? ________________

APPENDIX VII: Questionnaire for the learners

For office use

Respondent number V 0

I am interested in finding out how animal organ dissections can be used as a teaching strategy in problem-solving in Grade 11 Life Sciences education. Organ morphology and anatomy is one of the topics in the Grade 11 curriculum in which it is a requirement to carry out animal organ dissections on kidneys, hearts or livers. The learners are expected to then link the structure of the dissected organ to the functions of the different parts observed. The findings will assist in designing of curriculum and teacher education programmes pertaining to this topic.

In *Section A* you will be required to indicate your answer by putting an X in the appropriate box for your chosen answer. In *Section B* you will be required to cross with an X the number corresponding to your preference and in *Section C* you will be required to write your answers in the spaces provided. It is important to note that there is no "wrong" or "right" answer to any of the questions and there is no need to write your name. Thank you for completing this questionnaire.

Please answer each question by putting a cross (X) in the appropriate shaded box, or by writing your answer in the shaded space provided.

SECTION A: BIOGRAPHICAL INFORMATION

1. What is your gender?

Male	1
Female	2

V 1

2. What is your age in years?

V 2

3. What is your religion? (Please select one answer only)

Christian	1
Muslim	2
Hindu	3
Jewish	4
Buddhism	5
No religion	6
Other (specify)	7

V 3

4. What cultural group do you belong to? (please select one answer)

V 4

Afrikaans	1
English	2
Ndebele	3
North-Sotho	4
South-Sotho	5
Swazi	6
Tsonga	7
Tswana	8
Venda	9
Xhosa	10
Zulu	11
Other (specify)	12

SECTION B RATING OF STATEMENTS ABOUT DISSECTIONS

5. For the following items, please indicate the extent to which you agree or disagree with the given statements.

Please respond to all the statements. Put a cross (X) in the appropriate shaded box to indicate your answer.

	Statement	Strongly agree	Agree	Disagree	Strongly disagree	For official use	
1	I understand what dissection is	4	3	2	1		V 5.1
2	I have been exposed to animal organ dissections through demonstrations	4	3	2	1		V 5.2
3	I have carried out animal organ dissections in previous Grades	4	3	2	1		V 5.3
4	Dissection is useful in the learning of animal organ structure and function	4	3	2	1		V 5.4
5	Dissection helps me to understand structure and function of the animal organ	4	3	2	1		V 5.5
6	Animal organ dissection helps me to improve my investigative skills	4	3	2	1		V 5.6
7	Animal organ dissection helps me develop skills which I can use to solve real life problems	4	3	2	1		V 5.7
8	I feel comfortable with the idea of doing an animal organ dissection myself	4	3	2	1		V 5.8
9	I would rather use alternatives like artificial organs to carry out dissection	4	3	2	1		V 5.9
10	I would rather observe others doing animal organ dissection than doing dissection myself	4	3	2	1		V 5.10
11	I find it emotionally difficult to dissect a fresh animal organ	4	3	2	1		V 5.11
12	I find it difficult to manipulate (handle) dissection instruments	4	3	2	1		V 5.12
13	Animal organ dissection is the only way to help me develop manipulative (handling) skills	4	3	2	1		V 5.13
14	My religion *restricts* me from dissecting real tissue animal organs	4	3	2	1		V 5.14
15	My culture *restricts* me from dissecting real tissue animal organs	4	3	2	1		V 5.15
16	I find animal organ dissection disgusting	4	3	2	1		V 5.16
17	I will do animal organ dissections because I am interested in finding out first-hand about the anatomy of the organ I am studying	4	3	2	1		V 5.17
18	It is compulsory for me to carry out animal organ dissection	4	3	2	1		V 5.18

19	I prefer to dissect an animal organ rather than the whole body	4	3	2	1		V 5.19
20	Dissection is necessary because textbook information is generally limited	4	3	2	1		V 5.20
21	The idea of dissecting animal organs increases my respect for animals	4	3	2	1		V 5.21
22	I can learn more about my own body by dissecting mammalian organs	4	3	2	1		V 5.22
23	The use of additional information resources helps me understand more of the animal organ morphology	4	3	2	1		V 5.23
24	To test my knowledge, I prefer to be given a test after animal organ dissection rather than just drawing and labelling	4	3	2	1		V 5.24

SECTION C: OPEN–ENDED QUESTIONS

6. Tick the animal organs that you have dissected in school during Grade 1 to Grade 10. (You may tick more than one option)

Eye	1		V 6.1
Brain	2		V 6.2
Liver	3		V 6.3
Heart	4		V 6.4
Kidney	5		V 6.5
Lung	6		V 6.6
Other, specify	7		V 6.7 V 6.8

7. Are you morally **for** or **against** animal organ dissections? (Please tick your answer in the shaded area)

1	For	2	Against

V 7

7.1 If your answer is **For**, please explain why in the shaded area below. (You may write down more than one reason in the shaded area)

		V 7.1.1
		V 7.1.2
		V 7.1.3
		V 7.1.4

7.2 If your answer is **Against**, please explain why in the shaded area below. (You may write down more than one reason in the shaded area)

		V 7.2.1
		V 7.2.2
		V 7.2.3
		V 7.2.4

8. What experiences have you had with animal organ dissections? Please specify whether your experiences are based on any of the following. (You may tick more than one option)

Doing the dissections yourself	1		V 8.1
Watching others dissecting	2		V 8.2
Seeing dissections on a TV programme	3		V 8.3
Seeing dissections on an internet programme	4		V 8.4
Other, specify	5		V 8.5
			V 8.6

9. What problems do you as a learner face when carrying out animal organ dissections? Please write your answer in the shaded area. (You may write down more than one problem)

		V 9.1
		V 9.2
		V 9.3
		V 9.4

10. Does dissection help you to develop as a Life Scientist? (Please tick your answer in the shaded area) V 10

1	Yes	2	No

10.1 If your answer is **Yes**, please explain why in the shaded area below. (You may write down more than one reason)

		V 10.1.1
		V 10.1.2
		V 10.1.3
		V 10.1.4

10.2 If your answer is **No**, please explain why in the shaded area below. (You may write down more than one reason)

		V 10.2.1
		V 10.2.2
		V 10.2.3
		V 10.2.4

11. Describe and explain your feelings when carrying out animal organ dissections.

		V 11.1
		V 11.2
		V 11.3
		V 11.4

12. How did **animal organ dissections** help you clarify any confusion or misconceptions relating to animal organ morphology?

		V 12.1
		V 12.2
		V 12.3
		V 12.4

13. How did the problem-based learning approach in the **topic Excretion** help you to clarify any confusion or misconceptions relating to animal organ morphology?

		V 13.1
		V 13.2
		V 13.3
		V 13.4

Thank you for your time and co-operation

APPENDIX VIII: Pre-test for the learners

PRE-TEST ON THE KIDNEY

For office use

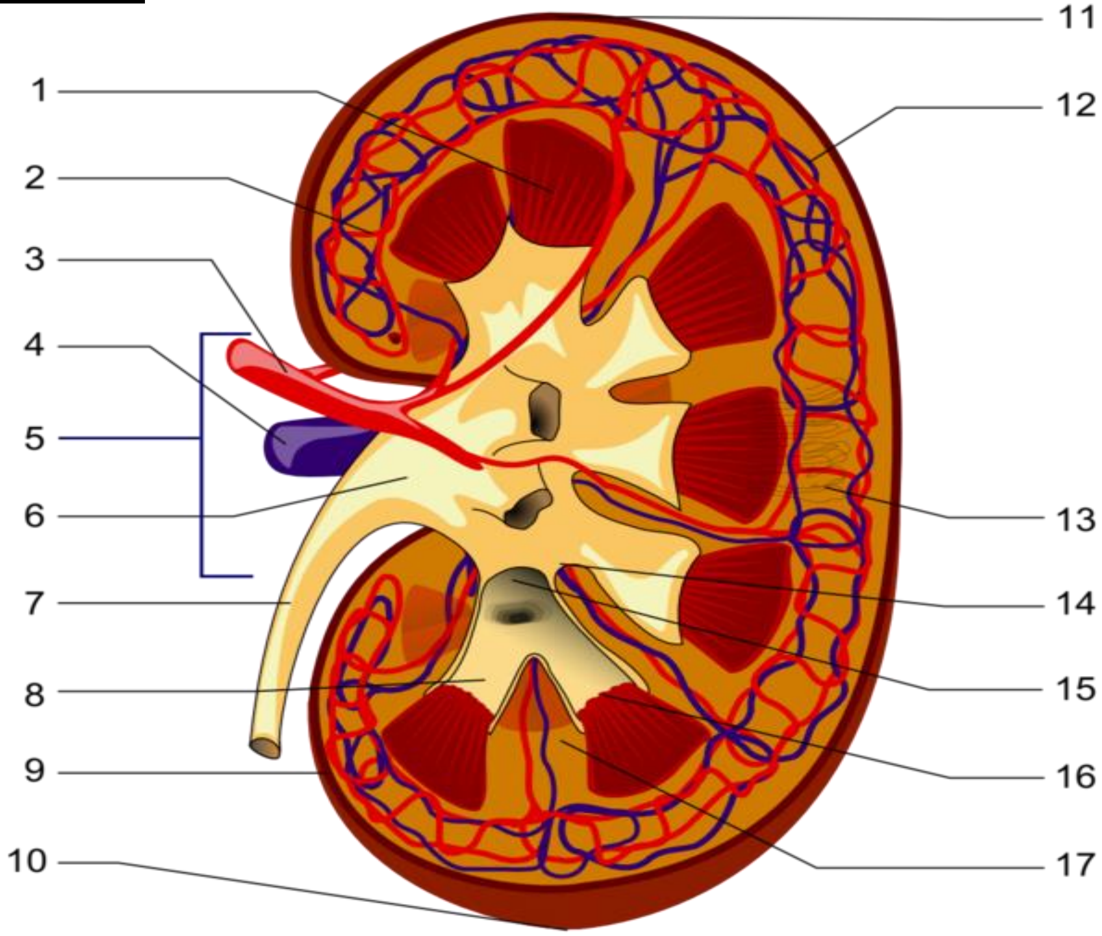
Respondent number | | | | **V 0**

Test number

Pre-test	1
Post-test	2

Instruction: Study the kidney of a lamb and answer the following questions.

Question 1



V 1.1

1.1 Label the parts 1-17 as observed on the kidney diagram. (10)

V 1.2

1.2 Relate the structure to the function of each of the parts you observed on the kidney diagram (10)

V 1.3

1.3 Why is there difference in colour between the cortex and medulla? (2)

V 1.4

1.4 How many pyramids can you identify in one half of the kidney? (1)

V 1.5

1.5 Using the hand lens identify and name the tiny dots in the cortex region (2)

V 1.6

1.6 (a) What is the purpose of the renal artery and (b) what results if there is blockage in this vessel? (2)

1.7 According to your observation of the kidney on the diagram and the attached photo of a human kidney, what differences did you notice between the two kidneys? (1)

V 1.7

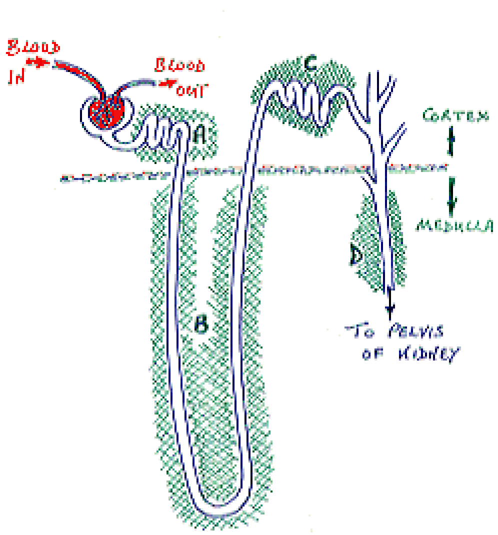
1.8 On the dissected organ identify the ureter. What results if there is blockage in this vessel? (2)

V 1.8

1.9 Pretend you are a metabolic waste molecule. Illustrate on the kidney diagram the route through the excretory system within the kidney until urine is formed and sent to the bladder. Make sure you include all the important parts of the kidney that you will come into contact with as you make your journey. Then write a paragraph describing this journey which includes the nephron. (10)

V 1.9

<u>Question 2</u>



2.1 Label parts A – D and relate the structure to its function. (8)

V 2.1

2.2 People with severe renal failure can be treated by **dialysis**, using a kidney dialysis machine, to purify the blood. (a) What are the signs of a failing kidney?

V 2.2a

(b) Which part of the kidney causes this problem? (2) **V2.2b**

2.3 When a person takes a drug, the drug will eventually be eliminated from the body. One of the primary mechanisms for this removal is tubular secretion. What problems of the kidneys would produce the greatest reduction in the ability of our kidneys to remove drugs? (2) **V2.3**

Question 3

A group of Grade 11 Life Sciences learners carried out **urinalysis** (**UA**) which is an array of tests performed on urine, and one of the most common methods of medical diagnosis on different urine samples using urine test strips, in which the test results can be read as color changes.

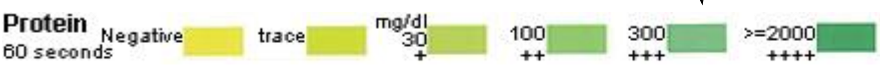
Different sets of results came out of the different urine samples and the learners had to interpret the meaning of each urine test strip and deduce what could be the renal problem that the owner of each sample had and how it could be treated. Suppose you were one of these learners and you obtained the results below, present in a form of a table what would have been 1) your interpretation of the meaning of each urine test strip 2) the renal problem linked to the result and 3) how it could be treated.
Each strip represents the ticked colour code of a different aspect, consider the ticked colour for sample a, b and c when answering your questions

a) √ **V 3a**

√ **V3b**

b)

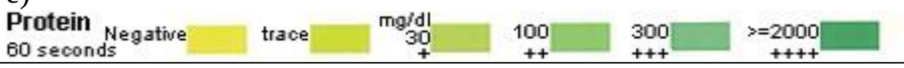

√ **V3c**

c)


(9)

Question 4

4. Match the following words in column A with those terms in column B; just write down the corresponding letter in column B to the number in column A. (6) **V 4.0**

Column A	Column B
1)Kidney stones	a) Inflammation in the glomeruli which disturbs the filtration process.
2) Renal failure	b) Small crystals and protein which form in the renal medulla and pass into the urine collection system.
3) Polycystic kidney disease	c) Blood supply to the kidneys becomes blocked or damaged.
4) Glomerulonephritis	d) Dilations (cysts) form at the junction of the distal convoluted and collecting tubule.
5) Hemoglobinuria or myoglobin.	e) 
6) Proteinuria glomerular filtration barrier problems	f) 

4.1 Of the diseases mentioned in table above, choose one that directly affects the renal medulla which you have observed on your dissected kidney and answer the following:
- Background information on the disease and treatment.
- Economic impact.
- Social impact.
- Lifestyle change needed to improve overall health. (6) **V 4.1**

4.2 Discuss multiple possible lifestyle modifications that could be achieved to improve the overall health of the individual suffering from a kidney disease, and helping disease prevention. (2) **V 4.2**

[Total: 75]

MEMORANDUM FOR THE PRE-TEST

Question 1

1.1 Learners will write the names which correspond to each numbered part e.g 1) Renal pyramids 2) Interlobular artery 3) Renal artery 4) Renal vein 5) Hilum 6) Renal pelvis 7) Ureter 8) Minor calyx 9) Renal capsules 10) Inferior renal capsule 11) Superior renal capsule 12) Interlobular veins 13) Nephron 14) Minor calyx 15) Major calyx 16) Renal papilla 17) Renal column (1 mark for each identified part) (10)

1.2 **Renal capsule:** a fibrous capsule which is the outer cover of the kidney

The cortex: A reddish brown layer of tissue below the capsule and contains major portions of the nephron

Medulla: lighter in color due to microscopic blood vessels, composed of 8-10 triangular renal pyramids separated by renal columns

Papilla: point on the pyramids which projects into the funnel shaped area known as the calyx.

Calyx (calyces): funnel shaped cavity with smooth muscles in their walls that collect urine from the papillae and propels it to the pelvis.

Renal Hilum: the concave point at which the renal artery enters the kidney and the renal vein and ureter leave

Renal pelvis: A large area which contains smooth muscles lined with transitional epithelium into which all the major calyces join together and drain urine into.

Ureter: the tube with three layers of tissue which receives urine from the renal pelvis and drains it into the bladder by peristaltic contraction of the smooth muscle layer.

Nephron: the functional unit of the kidney responsible for the formation of urine consists of tubules and associated small blood vessels (glomerula capsule, a proximal convoluted tubule, descending loop of Henle and ascending loop of Henle and a distal convoluted tubule.

Renal artery: the artery through which arterial blood enters the kidney then divides into *interlobar arteries* that pass between the pyramids through the renal columns.

Renal vein: the blood vessel through which blood is drained from the kidney (1 mark for each function) (10)

1.3 The cortex is reddish brown layer of tissue below the capsule and contains major portions of the nephron and the medulla is lighter in color due to the arrangement of microscopic blood vessels, composed of 8-10 triangular renal pyramids separated by renal columns. (2)

1.4 7 pyramids are observed in each half kidney (1)

1.5 Nephron (2)

1.6 a) Renal artery transports blood rich in oxygen and nutrients to the kidney.

b) If there is a blockage on it the whole excretory system will collapse because the kidney cells will die due to lack of nutrients and oxygen therefore the elimination of metabolic wastes will fail and they will accumulate in the body and become toxic to the body. (2)

1.7 The human kidney is larger and has more papillae than the lamb kidney. (1)

1.8 If there is a blockage on the ureter the urine cannot leave the kidney which will result i in kidney damage, pain and infection. (2)

1.9 The metabolic waste moves through the following path: Renal artery → smaller arterioles → efferent arterioles → afferent arteriole → glomerulus → capsule of bowman → podocytes → proximal convoluted tubule → descending loop of Henle → ascending loop of Henle → distal convoluted tubule → collecting duct → duct of Bellini → papilla in minor calyx → Major calyx → renal pelvis → ureter → bladder → urethra (10)
(1 mark for each correct sequence)

<u>Question 2</u>

2.1 A. Proximal convoluted tubule
B. Loop of Henle
C. Distal convoluted tubule
D. Collecting duct (2 marks for each identified part) (8)

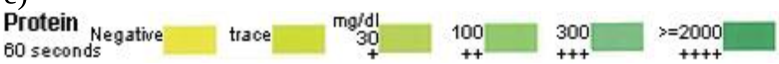
2.2 a) Signs of kidney failure include: little or no urine, pain, nausea, water retention and swelling. (1)
b) Part of the kidney is the Malphigian body consisting of the glomerulus and Bowman's capsule. (1)

2.3 Chronic kidney disease like polycystic kidney disease, glomerulonephritis can affect glomerular blood flow and filtration, tubular secretion and reabsorption, and renal bioactivation and metabolism. These problems can reduce the ability of our kidneys to eliminate drugs from our body. (2)

Question 3 (9)

	Interpretation	The renal problem linked	Treatment
3a	Glucosuria: glucose in urine✓	Improper function of the renal tubules of the nephron✓	Medication to alter renal tubule reabsorption. Manage glucose levels and consumption. Kidney transplant✓
3b	Hemoglobinuria or Haematuria: blood in urine✓	Kidney stones or urinary tract infections✓	Surgical removal of the kidney stones. Antibiotics✓
3c	Proteinuria: protein in urine✓	Glomeruli disease resulting in filtration barrier problems or low reabsorption by the proximal convoluted tubule✓	Low protein intake. Medication to alter the reabsorption ✓

Question 4

Column A	**Column B**
1) Kidney stones	b) Small crystals and protein which form in the renal medulla and pass into the urine collection system. ✓
2) Renal failure	c) Blood supply to the kidneys becomes blocked or damaged. ✓
3) Polycystic kidney disease	d) Dilations (cysts) form at the junction of the distal convoluted and collecting tubule. ✓
4) Glomerulonephritis	a) Inflammation in the glomeruli which disturbs the filtration process. ✓
5) Hemoglobinuria or myoglobin. ✓	f) 
6) Proteinuria glomerular filtration barrier problems ✓	e) 

4.1 A kidney stone is a hard, crystalline mineral material formed within the kidney or urinary tract.

Symptoms of a kidney stone include flank pain (which can be quite severe) and blood in the urine (hematuria).

- Kidney stones form when there is a decrease in urine volume (dehydration) and/or an excess of stone-forming substances in the urine.
- People with certain medical conditions, such as gout, and those who take certain medications or supplements are at risk for kidney stones.
- Dietary and hereditary factors are also related to stone formation.
- Kidney stones may not produce symptoms until they begin to move down the tubes (ureters) through which urine empties into the bladder. When this happens, the stones can block the flow of urine out of the kidneys. This causes swelling of the kidney or kidneys, causing pain. The pain is usually severe.✓✓

Treatment: The goal of treatment is to relieve symptoms and prevent further symptoms. Treatment varies depending on the type of stone and how severe the symptoms are. People with severe symptoms might need to be hospitalised. Pain relievers can help control the pain of passing the stones (renal colic). For severe pain, you may need to take narcotic pain killers or nonsteroidal anti-inflammatory drugs (NSAIDS) such as ibuprofen. ✓

Surgery is usually needed if: the stone is too large to pass on its own; the stone is growing; the stone is blocking urine flow and causing an infection or kidney damage.

Economic Impact
Hospital costs are very expensive since they include: operation fees, hospital-stay fees, medicine expenses during operation, pre and post operation, transport expenses. ✓

Social Impact
It may result in the loss of wages of the patient and the children might not have the basic needs if the patient is the breadwinner in the family. ✓

Lifestyle change

Drink more fluids. Try to drink enough water to keep your urine light yellow or clear like water, about 8 to 10 glasses of water a day.

Change your diet. This may be helpful, but it depends on what is causing your kidney stones. Your doctor may do more tests before deciding whether changing your diet will help reduce your risk of getting another stone.✓ (6)

4.2 Drink enough fluids, eat healthy – balanced diet, exercise regularly, urinate when you must and seek treatments for kidney infections immediately. ✓✓ (2)

[Total: 75]

APPENDIX IX: Post-test for the learners

POST-TEST ON THE KIDNEY

For office use

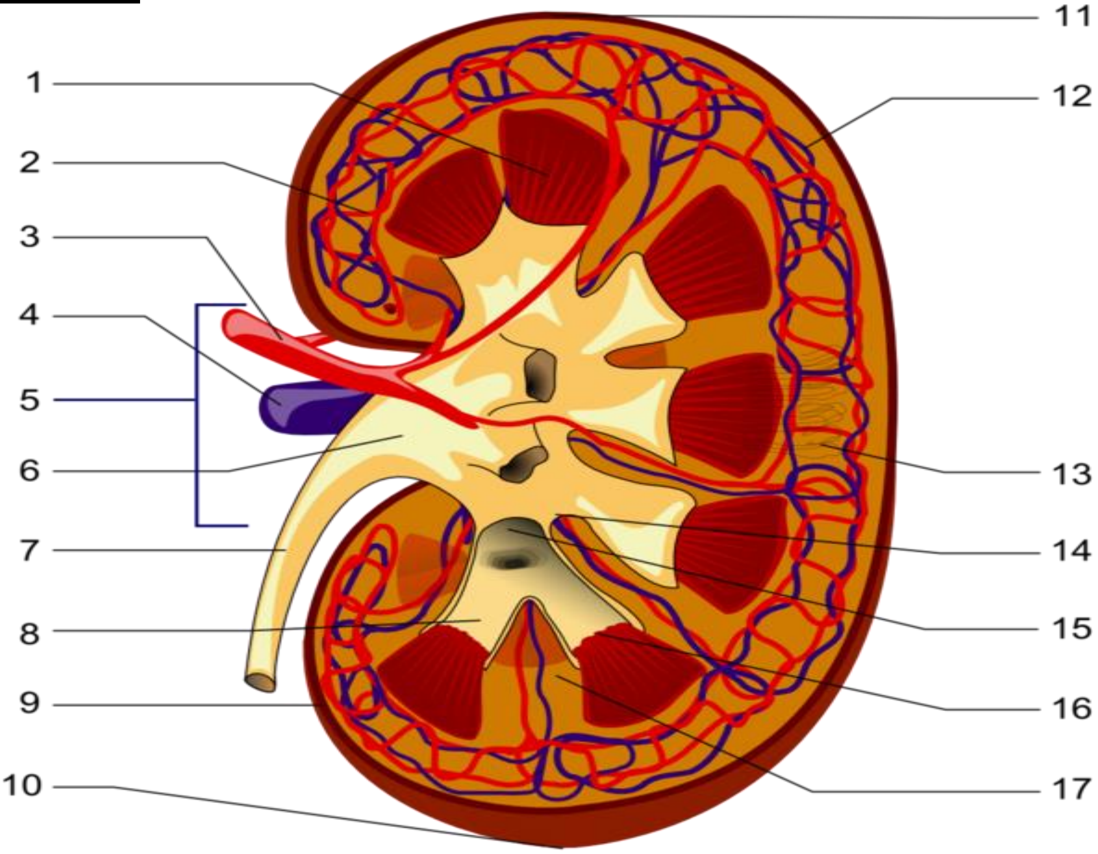
Respondent number — V 0

Test number

Pre-test	1
Post-test	2

Instruction: Study the kidney of a lamb and answer the following questions.

Question 1



V 1.1

1.1 Label the parts 1- 17 as observed on the kidney organ you dissected, use the provided blank flags on a toothpick to write the names of the observed parts of the kidney you have dissected and stick the toothpick onto the correct part. (10)

V 1.2

1.2 Relate the structure to the function of each of the parts you observed on the kidney organ you dissected (10)

V 1.3

1.3 Why is there difference in colour between the cortex and medulla?

V 1.4

1.4 How many pyramids can you identify in one half of the kidney? (1)

V 1.5

1.5 Using the hand lens identify and name the tiny dots in the cortex region (2)

V 1.6

1.6 (a) What is the purpose of the renal artery and (b) what results if there is blockage in this vessel? (2)

V 1.7

1.7 According to your observation of the dissected kidney and the attached photo of a human kidney, what differences did you notice between the two kidneys? (1)

V 1.8

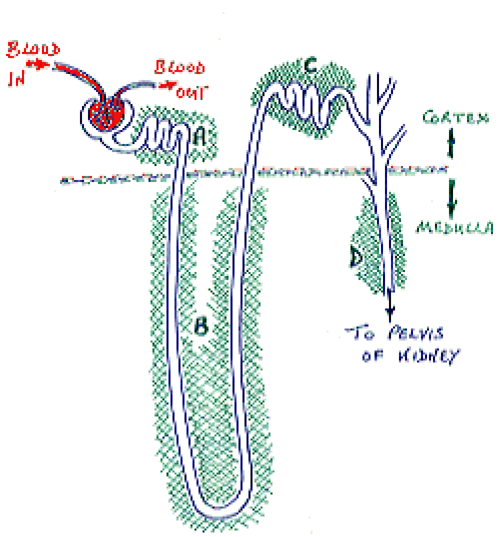
1.8 On the dissected organ identify the ureter. What results if there is blockage in this vessel? (2)

1.9 Pretend you are a metabolic waste molecule. Use the provided kidney and red coloured and numbered flags already glued on toothpicks. Illustrate on the dissected kidney the route through the excretory system within the kidney until urine is formed and sent to the bladder. Make sure you include all the important parts of the kidney that you will come into contact with as you make your journey. Then write a paragraph describing this journey which includes the nephron

V 1.9

. (10)

Question 2



2.1 Label parts A – D and relate the structure to its function. (8) **V 2.1**

2.2 People with severe renal failure can be treated by **dialysis**, using a kidney dialysis machine, to purify the blood. (a) What are the signs of a failing kidney? **V 2.2a**

(b) Which part of the kidney causes this problem? (2) **V2.2b**

2.3 When a person takes a drug, the drug will eventually be eliminated from the body. One of the primary mechanisms for this removal is tubular secretion. What problems of the kidneys would produce the greatest reduction in the ability of our kidneys to remove drugs? (2) **V2.3**

Question 3

A group of Grade 11 Life Sciences learners carried out **urinalysis** (**UA**) which is an array of tests performed on urine, and one of the most common methods of medical diagnosis on different urine samples using urine test strips, in which the test results can be read as color changes.

Different sets of results came out of the different urine samples and the learners had to interpret the meaning of each urine test strip and deduce what could be the renal problem that the owner of each sample had and how it could be treated. Suppose you were one of these learners and you obtained the results below, present in a form of a table what would have been 1) your interpretation of the meaning of each urine test strip 2) the renal problem linked to the result and 3) how it could be treated.
Each strip represents the ticked colour code of a different aspect, consider the ticked colour for sample a, b and c when answering your questions

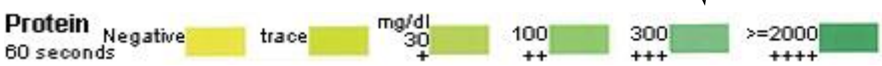
a) √ **V 3a**

√ **V3b**

b)

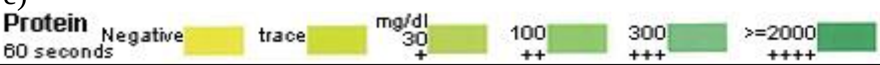
√ **V3c**

c)



(9)

4. Match the following words in column A with those terms in column B; just write down the corresponding letter in column B to the number in column A. (6) **V 4.0**

Column A	Column B
1)Kidney stones	a) Inflammation in the glomeruli which disturbs the filtration process.
2) Renal failure	b) Small crystals and protein which form in the renal medulla and pass into the urine collection system.
3) Polycystic kidney disease	c) Blood supply to the kidneys becomes blocked or damaged.
4) Glomerulonephritis	d) Dilations (cysts) form at the junction of the distal convoluted and collecting tubule.
5) Hemoglobinuria or myoglobin.	e) 
6) Proteinuria glomerular filtration barrier problems	f) 

4.1 Of the diseases mentioned in table above, choose one that directly affects the renal medulla which you have observed on your dissected kidney and answer the following:

- Background information on the disease and treatment.
- Economic impact.
- Social impact.
- Lifestyle change needed to improve overall health. (6) **V 4.1**

4.2 Discuss multiple possible lifestyle modifications that could be achieved to improve the overall health of the individual suffering from a kidney disease, and helping disease prevention. (2) **V 4.2**

[Total: 75]

MEMORANDUM FOR THE POST-TEST

Question 1

1.1 Learners will write the names which correspond to each numbered part and stick the toothpick with the name on the correct part e.g. 1) Renal pyramids 2) Interlobular artery 3) Renal artery 4) Renal vein 5) Hilum 6) Renal pelvis 7) Ureter 8) Minor calyx 9) Renal capsules 10) Inferior renal capsule 11) Superior renal capsule 12) Interlobular veins 13) Nephron 14) Minor calyx 15) Major calyx 16) Renal papilla 17) Renal column (10)

1.2 **Renal capsule:** a fibrous capsule which is the outer cover of the kidney

The cortex: A reddish brown layer of tissue below the capsule and contains major portions of the nephron

Medulla: lighter in color due to microscopic blood vessels, composed of 8-10 triangular renal pyramids separated by renal columns

Papilla: point on the pyramids which projects into the funnel shaped area known as the calyx.

Calyx (calyces): funnel shaped cavity with smooth muscles in their walls that collect urine from the papillae and propels it to the pelvis.

Renal Hilum: the concave point at which the renal artery enters the kidney and the renal vein and ureter leave

Renal pelvis: A large area which contains smooth muscles lined with transitional epithelium into which all the major calyces join together and drain urine into.

Ureter: the tube with three layers of tissue which receives urine from the renal pelvis and drains it into the bladder by peristaltic contraction of the smooth muscle layer.

Nephron: the functional unit of the kidney responsible for the formation of urine consists of tubules and associated small blood vessels (glomerula capsule, a proximal convoluted tubule, descending loop of Henle and ascending loop of Henle and a distal convoluted tubule.

Renal artery: the artery through which arterial blood enters the kidney then divides into *interlobar arteries* that pass between the pyramids through the renal columns.

Renal vein: the blood vessel through which blood is drained from the kidney (10)

1.3 The cortex is reddish brown layer of tissue below the capsule and contains major portions of the nephron and the medulla is lighter in color due to the arrangement of microscopic blood vessels, composed of 8-10 triangular renal pyramids separated by renal columns. (2)

1.4 7 pyramids are observed in each half kidney (1)

1.5 Nephron (2)

1.6 a) Renal artery transports blood rich in oxygen and nutrients to the kidney.

b) If there is a blockage on it the whole excretory system will collapse because the kidney cells will die due to lack of nutrients and oxygen therefore the elimination of metabolic wastes will fail and they will accumulate in the body and become toxic to the body. (2)

1.7 The human kidney is larger and has more papillae than the lamb kidney. (1)

1.8 If there is a blockage on the ureter the urine cannot leave the kidney which will result in kidney damage, pain and infection. (2)

1.9 The metabolic waste moves through the following path: Renal artery → smaller arterioles → efferent arterioles → afferent arteriole → glomerulus → capsule of bowman → podocytes → proximal convoluted tubule → descending loop of Henle → ascending loop of Henle → distal convoluted tubule → collecting duct → duct of Bellini → papilla in minor calyx → Major calyx → renal pelvis → ureter → bladder → urethra (10)

Question 2

2.1 A. Proximal convoluted tubule
B. Loop of Henle
C. Distal convoluted tubule
D. Collecting duct (8)

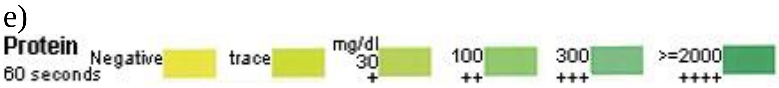
2.2 a) Signs of kidney failure include: little or no urine, pain, nausea, water retention and swelling. (1)
b) Part of the kidney is the Malphigian body consisting of the glomerulus and Bowman's capsule. (1)

2.3 Chronic kidney disease like polycystic kidney disease, glomerulonephritis can affect glomerular blood flow and filtration, tubular secretion and reabsorption, and renal bioactivation and metabolism. These problems can reduce the ability of our kidneys to eliminate drugs from our body. (2)

Question 3

	Interpretation	The renal problem linked	Treatment
3a	Glucosuria: glucose in urine	Improper function of the renal tubules of the nephron	Medication to alter renal tubule reabsorption. Manage glucose levels and consumption. Kidney transplant
3b	Hemoglobinuria or Haematuria: blood in urine	Kidney stones or urinary tract infections	Surgical removal of the kidney stones. Antibiotics
3c	Proteinuria: protein in urine	Glomeruli disease resulting in filtration barrier problems or low reabsorption by the proximal convoluted tubule	Low protein intake. Medication to alter the reabsorption

Question 4

Column A	**Column B**
1) Kidney stones	b) Small crystals and protein which form in the renal medulla and pass into the urine collection system.
2) Renal failure	c) Blood supply to the kidneys becomes blocked or damaged.
3) Polycystic kidney disease	d) Dilations (cysts) form at the junction of the distal convoluted and collecting tubule.
4) Glomerulonephritis	a) Inflammation in the glomeruli which disturbs the filtration process.
5) Hemoglobinuria or myoglobin.	f) 
6) Proteinuria glomerular filtration barrier problems	e) 

4.1 A kidney stone is a hard, crystalline mineral material formed within the kidney or urinary tract.

Symptoms of a kidney stone include flank pain (which can be quite severe) and blood in the urine (hematuria).

- Kidney stones form when there is a decrease in urine volume (dehydration) and/or an excess of stone-forming substances in the urine.
- People with certain medical conditions, such as gout, and those who take certain medications or supplements are at risk for kidney stones.
- Dietary and hereditary factors are also related to stone formation.
- Kidney stones may not produce symptoms until they begin to move down the tubes (ureters) through which urine empties into the bladder. When this happens, the stones can block the flow of urine out of the kidneys. This causes swelling of the kidney or kidneys, causing pain. The pain is usually severe.

Treatment: The goal of treatment is to relieve symptoms and prevent further symptoms. Treatment varies depending on the type of stone and how severe the symptoms are. People with severe symptoms might need to be hospitalised. Pain relievers can help control the pain of passing the stones (renal colic). For severe pain, you may need to take narcotic pain killers or nonsteroidal anti-inflammatory drugs (NSAIDS) such as ibuprofen.

Surgery is usually needed if: the stone is too large to pass on its own; the stone is growing;. the stone is blocking urine flow and causing an infection or kidney damage.

Economic Impact
Hospital costs are very expensive since they include: operation fees, hospital-stay fees, medicine expenses during operation, pre and post operation, transport expenses.

Social Impact
It may result in the loss of wages of the patient and the children might not have the basic needs if the patient is the breadwinner in the family.

Lifestyle change

Drink more fluids. Try to drink enough water to keep your urine light yellow or clear like water, about 8 to 10 glasses of water a day.

Change your diet. This may be helpful, but it depends on what is causing your kidney stones. Your doctor may do more tests before deciding whether changing your diet will help reduce your risk of getting another stone. (6)

4.2 Drink enough fluids, eat healthy – balanced diet, exercise regularly, urinate when you must and seek treatments for kidney infections immediately. (2)

[**Total: 75]**

APPENDIX X: Sample of the pilot study results

GRADE	LEARNER	TESTS	V1_1	V1_2	V1_3	V1_4	V1_5	V1_6	V1_7	V1_8	V1_9	V2_1	V2_2A	V2_2B	V2_3	V3A	V3B	V3C	V4	V4_1	V4_2	TOTAL
10	1	1	5	4	0	1	.	2	1	0	0	2	0	0	1	.	.	1	0	.	2	19
		2	6	4	1	1	.	2	1	1	2	2	.	1	1	.	.	1	1	1	2	27
10	2	1	7	2	0	0	0	1	1	0	.	4	1	1	0	0	0	0	2	0	2	21
		2	8	3	1	1	1	2	1	2	4	5	1	1	1	.	.	.	2	3	1	37
10	3	1	2	0	0	1	0	1	0	0	0	4	0	0	0	0	0	0	1	0	0	09
		2	4	1	0	1	1	1	1	1	.	4	.	.	0	.	.	.	2	3	1	20
10	4	1	4	0	0	0	0	1	0	1	0	2	1	1	1	0	0	0	4	0	0	15
		2	5	1	2	1	1	1	1	2	1	2	1	0	1	.	.	.	4	1	1	25
10	5	1	7	0	0	0	0	1	0	0	0	4	1	0	2	0	0	0	2	0	0	17
		2	8	2	.	1	1	2	1	.	.	5	2	0	.	.	.	.	2	.	.	24
11	6	1	7	4	1	1	2	2	1	2	2	4	1	1	0	2	2	2	3	0	1	38
		2	9	6	0	1	2	2	1	2	8	8	1	1	2	2	2	3	6	3	2	61
11	7	1	6	0	0	1	2	1	.	1	.	5	0	0	1	0	0	0	1	0	1	23
		2	8	3	1	1	1	2	1	2	5	6	1	1	2	.	.	.	2	3	1	40
11	8	1	8	0	0	1	0	0	0	0	1	6	1	1	0	0	0	0	3	4	2	27
		2	9	5	1	1	2	2	1	2	6	6	0	0	0	3	1	3	1	6	2	51
11	9	1	7	0	0	1	1	0	1	1	0	6	1	1	0	0	0	0	5	4	0	28
		2	8	9	2	1	1	2	2	1	.	8	1	1	1	1	2	2	5	4	2	53
11	10	1	7	2	0	1	0	0	0	0	0	8	1	0	0	0	0	0	3	3	2	27
		2	8	5	1	1	2	2	1	2	6	6	0	0	0	1	1	3	1	6	2	48

Key: Test column - 1 = pre-test

2 = post-test

. = missing number

APPENDIX XI: Informed consent letter to the Gauteng Department of Education

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education
Cell: 0743183055
Email: alcidezz@yahoo.com

The Senior Manager,
Department of Education
Tshwane South District

Dear Sir/Madam,

I am requesting permission to conduct research in some secondary schools in the Tshwane South District.

I am enrolled as a doctoral student with the University of Pretoria. The research is on the use of animal organ dissections in problem-solving as a teaching strategy in Grade 11 Life Sciences education. I have been granted permission to conduct this research in the schools you are managing by the **Gauteng Education Department.**

Data will be collected in 2012. I intend to work with 4 secondary schools and the Life Sciences teachers in the schools. Data will be collected in the following manner:

- Interviews with the Grade 11 Life Sciences teachers.
- Classroom observations of the dissections practical by learners.
- Pre-test and Post-test to be written by the learners.
- Questionnaires for learners in the Grade 11 Life Sciences classes.

You are assured that the identity of the school and the participants, as well as their responses will be regarded as extremely confidential at all times and will not be made available to any unauthorised user. I will also not interfere with any class activities during classroom observations.

Yours sincerely,

_______________ _______________

Portia Kavai Date

Supervisor

_______________ _______________

Dr J J R de Villiers Date

APPENDIX XII: Research approval from Gauteng Department of Education

education
Department: Education
GAUTENG PROVINCE

Reference : Policy and Planning: Partnerships
Enquiries : Sello George Ngwenya
Telephone : 012 401 6322
Fax : 012 401 6323
Fax-2-email: 0865 674 276
E-mail : Sello.Ngwenya@gauteng.gov.za
26 August 2011

Kavai P,
103A Overton Flats,
DeBoulevard Road,
Silverton,
Pretoria,
0184

(T) 012 804 7747; (F) 012 804 9170; (Mobile) 074 318 3055
E-mail : alcidezz@yahoo.com

Cc: The Principal and SGB

Dear Sir/ Madam

PERMISSION TO CONDUCT RESEARCH: KAVAI P

Your research application has been approved by Head Office. The full title of your Research: **"The use of animal organ dissection on problem-solving skills in Life Science Education".** You are advised to communicate with the school principal/s and/or SGB/s of the four schools targeted regarding your research and time schedule.

Our commitment of support may be rescinded if any form of irregularity/ no compliance to the terms in this letter or any other departmental directive/ if any risk to any person/s or property or our reputation is realised, observed or reported.

Terms and conditions

1. The safety of all the learners and staff at the school must be ensured at all times.
2. All safety precautions must be taken by the researcher and the school. The Department of Education may not be held accountable for any injury or damage to property or any person/s resulting from this process. The school/s must ensure that sound measures are put in place to protect the wellness of the researcher and his/ her property.

NB Kindly submit your report including findings and recommendations to the District at least two weeks after conclusion of the research. You may be requested to participate in the Department of Education's mini-research conference to discuss your findings and recommendations with departmental officials and other researchers.

The District wishes you well.

Yours sincerely

Mrs. H.E Kekana
Director: Tshwane South District

Making education a societal priority

Office of the District Director: Tshwane South District
(Mamelodi/Eersterust/ Pretoria East/Pretoria South/Atteridgeville/Laudium)
265 Pretorius Street, Pretoria 0001
Private Bag X 27825, Sunnysie, 1322 .Tel: (012) 401 6317. Fax: (012) 401 6318
Website: www.education.gpg.gov.za

APPENDIX XIII: Informed consent letter to the Principal

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education
Cell: 0743183055
Email: alcidezz@yahoo.com

Dear Principal,

I am currently conducting a research in some schools in the Tshwane South District. I am investigating the use of animal organ dissections in problem-solving as a teaching strategy in Life Sciences education. I have been granted permission to conduct this research in the school you are managing by the **Gauteng Education Department** and the **Tshwane South District Education Department.**

Data will be collected in 2012 in the following manner:

- Interviews with the Grade 11 Life Sciences teachers.
- Classroom observations of the dissections by learners.
- Pre-test and Post-test to be written by the learners
- Questionnaires for learners in the Grade 11 Life Sciences classes.

You are assured that the identity of the school and the participants, as well as their responses will be regarded as extremely confidential at all times and will not be made available to any unauthorised user. I will also not interfere with any class activities during classroom observations.

Should you wish your school to participate in this research, please sign on the next page as a declaration that you give permission for the research to be conducted in your school.

Yours sincerely,

_______________ _________________

Portia Kavai Date

Supervisor

_______________ _________________

Dr J J R de Villiers Date

CONSENT

In terms of ethical requirements of the University of Pretoria, you are now requested to complete the following section:

I, ___________________________ (Principal) have read this letter and understand the terms involved.

On condition that the identity of my school and of the participating teachers and learners, and the information provided by the teachers and learners, are treated as confidential at all times, and that the participants will not be harmed in any way and there will be no risks involved in their partipation, I hereby grant that Ms. P. Kavai may conduct research in my school.

Signature: ______________________

Date: ______________________

Thank you for your time.

APPENDIX XIV: Informed consent letter to the Life Sciences teacher

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

Cell: 0743183055
Email: alcidezz@yahoo.com

Dear Grade 11 Life Sciences teacher,

I am currently conducting a research in some schools in the Tshwane South District. I am investigating the use of animal organ dissections in problem-solving in Life Sciences education. I have been granted permission to conduct this research in the school where you are teaching by the **Gauteng Education Department** and the **Tshwane South District Education Department.**

Data will be collected in 2012 in the following manner:

- Interviews with the Grade 11 Life Sciences teachers.
- Follow-up interviews with the Grade 11 Life Sciences teachers.
- Classroom observations of the dissections by learners.
- Pre-test and Post-test to be written by the learners
- Questionnaires for learners in the Grade 11 Life Sciences classes.

I would like to invite you to participate in this study. Should you wish to participate, I will need to observe your practical lessons on animal organ dissections and determine if dissections can be used for the development of problem-solving skills. I will not interfere with any class activities during these observations. You will also be required to take part in an individual interview which will be audio-recorded. You are assured your identity as well as your responses will be regarded as completely confidential at all times and will not be made available to any unauthorised user. Your participation in this study is completely voluntary. Should you not wish to continue any more with the research, you are free to withdraw at any time. You are assured that you will not be harmed in any way by this research.

Should you wish to participate in the study, please sign below as a declaration of your informed consent and indication that you are willing to participate in this research.

Yours sincerely,

________________ ________________

Portia Kavai Date

Supervisor

________________ ________________

Dr J J R de Villiers Date

CONSENT

In terms of ethical requirements of the University of Pretoria, you are now requested to complete the following section:

I, ______________________ have read this letter and understand that

- my partipation in his research is *voluntary*, and that I can withdraw from the research at any time.
- in line with the regulations of the University of Pretoria regarding the code of conduct for proper research practices for *safety in participation*, I will not be placed at risk or harmed in any way.
- my *privacy* with regard to confidentiality and anonymity as a human respondent will be protected at all times.
- as a research participant, I will at all times be *fully informed* about the research processes and purposes.
- research information will be used for the *purposes of this enquiry*.
- my trust will not be betrayed in the research processes and in dissemination of its published outcomes, and I will not be deceived in any way.

I hereby declare that I give my *informed consent* for participation in this research.

Signature: ____________________

Date: ____________________

Thank you for your time.

APPENDIX XV: Informed consent letter to the Parent or Guardian

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

Cell: 0743183055
Email: alcidezz@yahoo.com

Dear Parent/Guardian

I am requesting your consent to have your child in Grade 11 as a participant in the research I am currently conducting in some schools in the Tshwane South District. I am investigating the use of animal organ dissections in problem-solving as a teaching strategy in Life Sciences education. I have been granted permission to conduct this research in the school your child goes to by the **Gauteng Education Department** and the **Tshwane South District Education Department.**

Data will be collected in 2012 in the following manner:

- Interviews with the Grade 11 Life Sciences teachers.
- Classroom observations of the dissections by learners.
- Pre-test and Post-test to be written by the learners
- Questionnaires for learners in the Grade 11 Life Sciences classes.

I will need to observe the learners' practical lessons during which they will be carrying out dissections which will be video-recorded and I will not interfere with any class activities during these observations. The video-recording will be used strictly for the research purpose and to ensure confidentiality, it will not be distributed to the public. Anonymity is also guaranteed since I do not know any of the learners' names. You also are assured that the identity of the school and the participants, as well as their responses will be regarded as extremely confidential at all times and will not be made available to any unauthorised user.

Yours sincerely,

_______________ _______________

P. Kavai (Ms) Date

Supervisor

_______________ _______________

Dr J J R de Villiers Date

In terms of ethical requirements of the University of Pretoria, you are now requested to complete the following section:

I, ______________________ have read this letter and understand the terms involved.

On condition that the information provided by my child is treated as confidential at all times, I hereby (Please mark with a (**X**) the appropriate section)

☐ **give consent** for my child to participate in the research.

☐ **do NOT give consent** for my child to participate in the research.

Signature: ____________________ Date _______________

APPENDIX XVI: Informed consent letter to the learner

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Education

Cell: 0743183055
Email: alcidezz@yahoo.com

2011-12-06

Dear Grade 11 Life Sciences learner,

I am currently conducting a research in some schools in the Tshwane South District. I am investigating the use of animal organ dissections in problem-solving as a teaching strategy in Life Sciences education. I have been granted permission to conduct this research in the school you are attending by the **Gauteng Education Department, the Tshwane South District Education Department and your Principal.**

I would like to invite you to participate in this study. However, your participation in this study is completely voluntary and from the beginning you have a choice to take part or not to take part. Should you take part and decide not to continue any time during the research, you are free to withdraw. I will need to observe your practical lessons during which you will be carrying out dissections which will be video-recorded but I will not interfere with any class activities during these observations. The video-recording will be used strictly for the research purpose and to ensure confidentiality, it will not be distributed to the public. Anonymity is also guaranteed since I do not know any of the learners' names. You will be required to write a test before carrying out the dissections (pre-test) and another test after carrying out the dissections (post-test). You will also be required to complete a questionnaire which is aimed at assessing if dissection can be used to develop abilities like solving of problems. All the information you will provide will be treated as completely confidential and you will not be asked to write your name or any information that will reveal your identity. The questionnaires should take you 15 – 20 minutes to complete. You are assured that you will not be harmed in any way by this research.

Should you wish to take part in the study, please sign below as a declaration of your willingness to do so.

Yours sincerely,

______________ ________________

Portia Kavai Date

Supervisor

______________ ________________

Dr J J R de Villiers Date

CONSENT

In terms of ethical requirements of the University of Pretoria, you are now requested to complete the following section:

I, ______________________ have read this letter and understand that

- my partipation in his research is *voluntary*, and that I can withdraw from the research at any time.
- in line with the regulations of the University of Pretoria regarding the code of conduct for proper research practices for *safety in participation*, I will not be placed at risk or harmed in any way.
- my *privacy* with regard to confidentiality and anonymity as a human respondent will be protected at all times.
- as a research participant, I will at all times be *fully informed* about the research processes and purposes.
- research information will be used for the *purposes of this enquiry*.
- my trust will not be betrayed in the research processes and in dissemination of its published outcomes, and I will not be deceived in any way.

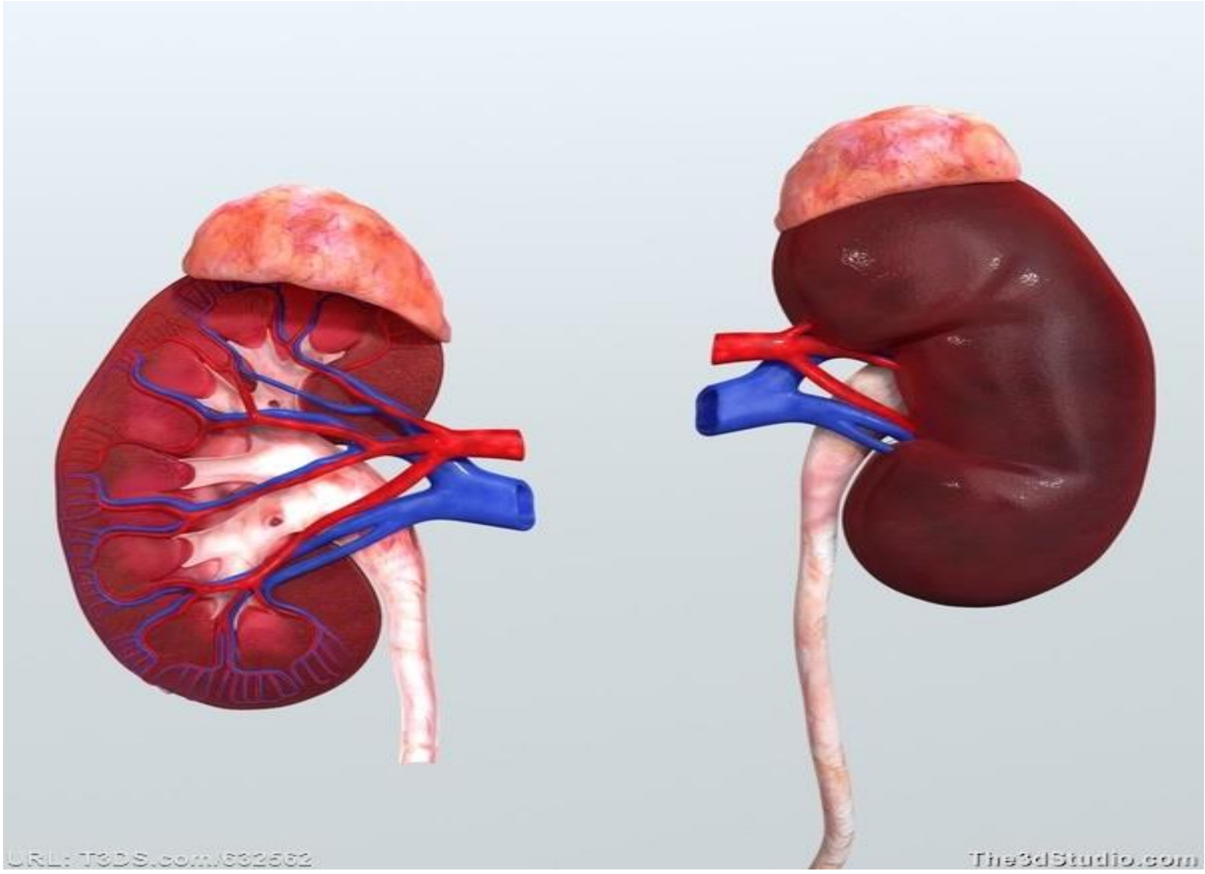
I hereby declare that I give my *informed consent* for participation in this research.

Signature: ________________________________

Date ________________________________

Thank you for your time.

APPENDIX XVII: ALTERNATIVES TO TRADITIONAL DISSECTIONS



1. 3D plasticine kidney models for dissection. www.3dstudio.com

2. Great American bullfrog: a large scale model with numbered parts and a key card, has circulatory, reproductive, excretory systems that can separately be dissected. www.teachkind.org/pdf/animalind.pdf

3. Bodyworks: computer programme that explores the body's systems, structure and functions. www.peta.org/issues/animals-used-for-dissection-lessons-cruelty

4. Dissectionworks: comprises five interactive, computer-dissection simulations, including those of a frog, crayfish, perch fetal pig and animal organs. A digital cat dissection with detailed graphics and information is also available. www.flinnsci.com/Biology/Preserved/Specimens/Vertebrates

5. Froguts: http://www.froguts.com

6. Online dissections: http://scienceman.org/dissection.html

APPENDIX XVIII: Actual tests print-outs

```
BMDP3D - T-TESTS

Copyright 1977, 1979, 1981, 1982, 1983, 1985, 1987, 1988, 1990, 1993
                 by BMDP Statistical Software, Inc.

  Statistical Solutions Ltd.          | Statistical Solutions
  Unit 1A, South Ring Business Park | Stonehill Corporate Center, Suite 104
  Kinsale Road, Cork, Ireland         | 999 Broadway, Saugus, MA 01906, USA
  Phone: + 353 21 4319629             | Phone: 781.231.7680
  Fax:    + 353 21 4319630             | Fax:    781.231.7684
  e-mail:  sales@statsol.ie           | e-mail: info@statsolusa.com
  Website: http://www.statsol.ie      | Website: http://www.statsolusa.com

Release: 8.1  (Windows 9x, 2000, Me, Xp)         Date: 12/13/12  at 13:33:40
 Manual: BMDP Manual Volumes 1, 2, and 3.
 Digest: BMDP User's Digest.
 IBM PC: BMDP PC Supplement -- Installation and Special Features.

PROGRAM INSTRUCTIONS


/ Input
     File = 'S:\Jaqui Sommerville\Kavai T12007\Dec2012\MarksNoMD.csv'.
     Variables = 13.
     Format= CSV.
     Reclen = 77.
/ Variable
     Names = v0,ATotal,ARote,AProblem,ALO1,ALO2,ALO3,
                BTotal,BRote,BProblem,BLO1,BLO2,BLO3.
     Missing = 999,999,999,999,999,999,999,
                 999,999,999,999,999,999.
/ Matched
      First =ATotal,ARote,AProblem,ALO1,ALO2,ALO3.
      Second = BTotal,BRote,BProblem,BLO1,BLO2,BLO3.
      Nonpar.
      Hotelling. / FINISH

PROBLEM TITLE IS
12/13/12                13:33:40

NUMBER OF VARIABLES TO READ . . . . . . . . . . .        13
NUMBER OF VARIABLES ADDED BY TRANSFORMATIONS. .           0
TOTAL NUMBER OF VARIABLES . . . . . . . . . . .          13
CASE FREQUENCY VARIABLE . . . . . . . . . . . .
CASE WEIGHT VARIABLE. . . . . . . . . . . . . .
CASE LABELING VARIABLES . . . . . . . . . . . .
NUMBER OF CASES TO READ . . . . . . . . . . . . . TO END
MISSING VALUES CHECKED BEFORE OR AFTER TRANS. .  BEFORE
BLANKS IN THE DATA ARE TREATED AS    . . . . . . MISSING
INPUT FILE. . .S:\Jaqui Sommerville\Kavai T12007\Dec2012\MarksNoMD.csv
REWIND INPUT UNIT PRIOR TO READING. . DATA. . .     YES
NUMBER OF INTEGER WORDS OF MEMORY FOR STORAGE .  102400

VARIABLES TO BE USED
     1 v0          2 ATotal       3 ARote        4 AProblem     5 ALO1
     6 ALO2        7 ALO3         8 BTotal       9 BRote       10 BProblem
    11 BLO1       12 BLO2        13 BLO3

DATA FORMAT:  CSV

THE LONGEST RECORD MAY HAVE UP TO   77 CHARACTERS.

IF THE FIRST RECORD CONTAINS VARIABLE NAMES,
THEN IGNORE THE MISSING VALUES REPORT BELOW.
```

```
  CASE     1         2         3         4         5         6         7         8         9
10        11        12        13
   NO. v0        ATotal    ARote     AProblem ALO1      ALO2      ALO3      BTotal    BRote
BProblem BLO1      BLO2      BLO3
 ----- -------- -------- -------- -------- -------- -------- -------- -------- --------
-------- -------- -------- --------
     1  MISSING  MISSING  MISSING  MISSING  MISSING  MISSING  MISSING  MISSING  MISSING
MISSING  MISSING  MISSING  MISSING
     2     1.00    22.00    14.00     8.00    10.00     8.00     6.00    53.00    17.00
36.00    16.00    25.00    18.00
     3     2.00    25.00    10.00    15.00     8.00    13.00     5.00    52.00    17.00
35.00    16.00    21.00    21.00
     4     3.00    11.00     3.00     8.00     3.00     8.00     1.00    35.00    13.00
22.00    16.00    11.00    14.00
     5     4.00    15.00     4.00    11.00     5.00     7.00     5.00    48.00    17.00
31.00    16.00    27.00    11.00
     6     5.00    23.00     7.00    16.00     7.00    13.00     4.00    48.00    16.00
32.00    15.00    20.00    19.00
     7     6.00    54.00    20.00    34.00    17.00    27.00    16.00    65.00    18.00
47.00    16.00    32.00    23.00
     8     7.00    23.00     7.00    16.00    10.00    10.00     7.00    29.00    13.00
16.00    13.00    14.00     6.00
     9     8.00    27.00     9.00    18.00     9.00    11.00     7.00    34.00    14.00
20.00    14.00     8.00    16.00
    10     9.00    30.00     9.00    21.00    11.00    13.00     8.00    34.00    14.00
20.00    15.00    17.00     6.00

 NUMBER OF CASES READ. . . . . . . . . . . . . .      225
    CASES WITH EXCESSIVE NUMBER OF MISSING VALUES       1
       REMAINING NUMBER OF CASES . . . . . . . . .    224


    VARIABLE        STATED VALUES FOR          GROUP  CATEGORY     INTERVALS
   NO.    NAME     MINIMUM MAXIMUM MISSING   CODE  INDEX   NAME      .GT.    .LE.
  ---- --------  ------- ------- -------  ------ ----- --------  ------ -------

    1  v0                        999.0

    2  ATotal                    999.0

    3  ARote                     999.0

    4  AProblem                  999.0

    5  ALO1                      999.0

    6  ALO2                      999.0

    7  ALO3                      999.0

    8  BTotal                    999.0

    9  BRote                     999.0

   10  BProblem                  999.0

   11  BLO1                      999.0

   12  BLO2                      999.0

   13  BLO3                      999.0
 ------------------------------------------------------------------------------
```

DESCRIPTIVE STATISTICS OF DATA
----------- ---------- -- ----

NO.	NAME	TOTAL FREQ.	MEAN	STANDARD DEV.	ST.ERR OF MEAN	COEFF OF VAR	SMALLEST VALUE	SMALLEST Z-SCR	SMALLEST CASE	LARGEST VALUE	LARGEST Z-SCR	LARGEST CASE	RANGE
1	v0	224	136.48	96.605	6.4547	.70784	1.0000	-1.40	2	328.00	1.98	225	327.00
2	ATotal	224	23.411	10.841	.72434	.46308	5.0000	-1.70	38	62.000	3.56	52	57.000
3	ARote	224	10.888	4.8309	.32278	.44367	0.0000	-2.25	38	25.000	2.92	121	25.000
4	AProblem	224	12.522	8.4088	.56184	.67151	0.0000	-1.49	15	42.000	3.51	92	42.000
5	ALO1	224	9.4643	3.3547	.22415	.35446	1.0000	-2.52	36	18.000	2.54	58	17.000
6	ALO2	224	11.067	6.6858	.44671	.60412	0.0000	-1.66	15	32.000	3.13	52	32.000
7	ALO3	224	5.2902	4.7343	.31632	.89491	0.0000	-1.12	15	23.000	3.74	58	23.000
8	BTotal	224	45.643	14.157	.94590	.31017	13.000	-2.31	53	70.000	1.72	137	57.000
9	BRote	224	16.996	4.4916	.30011	.26428	4.0000	-2.89	35	24.000	1.56	57	20.000
10	BProblem	224	28.647	10.975	.73328	.38310	0.0000	-2.61	103	49.000	1.85	110	49.000
11	BLO1	224	14.513	2.8045	.18738	.19324	4.0000	-3.75	35	19.000	1.60	141	15.000
12	BLO2	224	22.214	7.7719	.51928	.34986	3.0000	-2.47	47	36.000	1.77	91	33.000
13	BLO3	224	13.549	6.9642	.46531	.51400	0.0000	-1.95	53	26.000	1.79	66	26.000

```
TEST TITLE IS
12/13/12                13:33:40


VARIABLES TO BE ANALYZED. . . . . . . . . ATotal   ARote    AProblem ALO1     ALO2
ALO3      BTotal    BRote     BProblem BLO1
                                          BLO2     BLO3
NUMBER OF MATCHED PAIRS OF VARIABLES. .        6
USE COMPLETE CASES ONLY?. . . . . . . .       NO
PRINT GROUP CORRELATION MATRICES? . . .       NO
COMPUTE HOTELLINGS T SQUARE?. . . . . .      YES
COMPUTE ROBUST STATISTICS?. . . . . . .       NO
COMPUTE NONPARAMETRIC STATISTICS? . . .      YES
GROUPING VARIABLE . . . . . . . . . . .        0

NUMBER OF CASES READ. . . . . . . . . . . . . .       225
   CASES WITH EXCESSIVE NUMBER OF MISSING VALUES        1
      REMAINING NUMBER OF CASES . . . . . . . .       224


MULTIVARIATE STATISTICS
THERE ARE    224 CASES,    224 OF THEM COMPLETE
NULL HYPOTHESIS IS THAT ALL DIFFERENCES IN MEANS OF MATCHED VARIABLES ARE ZERO

DEGREES OF FREEDOM, BELOW, REDUCED BY      1
BECAUSE OF LINEAR DEPENDENCIES AMONG THE VARIABLES TESTED.


  MAHALANOBIS D SQUARE           4.0909
  HOTELLING T SQUARE           916.3520
  F VALUE                      179.9830      P-VALUE     0.0000
    DEGREES OF FREEDOM       5,      219
```

```
ATotal    VS. BTotal      (VAR. NO.    2 VS.    8)
********************************************

       ATotal                  BTotal                      ATotal       BTotal
                                                   -------------------------------
      HH                                           MEAN        23.4107      45.6429
      HH
    HHHHHH                        XX   X           STD DEV     10.8409      14.1569
   HHHHHHH                       XXX XXX XX        S.E.M.       0.7243       0.9459
   HHHHHHHH                     XXXXXXXXXXX        SAMPLE SIZE     224          224
  HHHHHHHHHHHHHH H          XXXXXXXXXXXXXXXX       MAXIMUM     62.0000      70.0000
M--------------------M  M--------------------M     MINIMUM      5.0000      13.0000
I  AN H=     7 CASES  A  I  AN X=     7 CASES  A    Z MAX        3.56         1.72
N     (N=   224)      X  N     (N=   224)      X    Z MIN       -1.70        -2.31
                                                   CASE (MAX)       52          137
                                                   CASE (MIN)       38           53

ATotal   - BTotal    (VAR. NO.    2 -    8)
***************************************

                        ATotal   - BTotal        TEST STATISTICS    P-VALUE  DF
                        -------------------     ---------------------------------
          HHH           MEAN        -22.2322    MATCHED  T     -28.33 0.0000   223
          HHH HH
       HHHHHHHHH        STD DEV      11.7431    SIGN TEST*             0.0000
       HHHHHHHHH        S.E.M.        0.7846    WILCOXON**       30.5 0.0000
     H HHHHHHHHHH       SAMPLE SIZE     224
  HHHHHHHHHHHHHHHH H    MAXIMUM       9.0000    CORRELATION    0.5866 0.0000   222
M--------------------M  MINIMUM     -55.0000    SPEARMAN R     0.5687 0.0000   222
I  AN H=     5 CASES  A  Z MAX         2.66
N     (N=   224)      X  Z MIN        -2.79      * ATotal    > BTotal    IN     1
                        CASE (MAX)       161      CASES OF  223 WITH NONZERO DIFS.
                        CASE (MIN)        34    ** TOTAL OF RANKS WITH LESS
                                                  FREQUENT SIGN =         30.5

ARote     VS. BRote       (VAR. NO.    3 VS.    9)
********************************************

       ARote                   BRote                       ARote        BRote
                                                   -------------------------------
          H                           X  X         MEAN        10.8884      16.9955
       H  H                           X  X
       HHHHH                        X XX XX        STD DEV      4.8309       4.4916
       HHHHH H                     XXXXXXXX        S.E.M.       0.3228       0.3001
     HHHHHHHHHH                  X XXXXXXXX        SAMPLE SIZE     224          224
   HHHHHHHHHHHHHHHH           X XXXXXXXXXXX        MAXIMUM     25.0000      24.0000
M--------------------M  M--------------------M     MINIMUM      0.0000       4.0000
I  AN H=     7 CASES  A  I  AN X=     7 CASES  A    Z MAX        2.92         1.56
N     (N=   224)      X  N     (N=   224)      X    Z MIN       -2.25        -2.89
                                                   CASE (MAX)      121           57
                                                   CASE (MIN)       38           35

ARote    - BRote     (VAR. NO.    3 -    9)
***************************************

                        ARote    - BRote         TEST STATISTICS    P-VALUE  DF
                        -------------------     ---------------------------------
            H           MEAN         -6.1071    MATCHED  T     -20.82 0.0000   223
            H
        H   H           STD DEV       4.3899    SIGN TEST*             0.0000
        H H HHHH        S.E.M.        0.2933    WILCOXON**      238.5 0.0000
      H HHHHHHHHHH      SAMPLE SIZE     224
   H HHHHHHHHHHHHHHH    MAXIMUM       3.0000    CORRELATION    0.5586 0.0000   222
M--------------------M  MINIMUM     -19.0000    SPEARMAN R     0.5627 0.0000   222
I  AN H=     8 CASES  A  Z MAX         2.07
N     (N=   224)      X  Z MIN        -2.94      * ARote     > BRote     IN    12
                        CASE (MAX)       129      CASES OF  210 WITH NONZERO DIFS.
                        CASE (MIN)       198    ** TOTAL OF RANKS WITH LESS
                                                  FREQUENT SIGN =        238.5
```

```
AProblem VS. BProblem (VAR. NO.    4 VS.   10)
********************************************

       AProblem                BProblem                 AProblem     BProblem
                                                   -------------------------------
        H                                          MEAN        12.5223      28.6473
       HH
   HH  HH                        XX  X    X        STD DEV      8.4088      10.9747
  HHHHHHHH                       XXXXX    XX       S.E.M.       0.5618       0.7333
  HHHHHHHHH                     XXXXXXXXXXXX       SAMPLE SIZE     224          224
  HHHHHHHHHHHHHHHH         XXXXXXXXXXXXXXXXXX      MAXIMUM     42.0000      49.0000
M---------------------M  M---------------------M   MINIMUM      0.0000       0.0000
I  AN H=     7 CASES  A  I  AN X=     7 CASES  A   Z MAX        3.51         1.85
N     (N=  224)       X  N     (N=  224)       X   Z MIN       -1.49        -2.61
                                                   CASE (MAX)      92          110
                                                   CASE (MIN)      15          103


AProblem- BProblem (VAR. NO.    4 -   10)
***************************************

                         AProblem- BProblem      TEST STATISTICS   P-VALUE  DF
                         -------------------     --------------------------------
          HH             MEAN        -16.1250    MATCHED  T    -23.95 0.0000  223
          HH
        HHHHHHH          STD DEV      10.0747    SIGN TEST*           0.0000
       HHHHHHHH          S.E.M.        0.6731    WILCOXON**     131.5 0.0000
     HHHHHHHHHH          SAMPLE SIZE      224
  HHHHHHHHHHHHHHHHHH     MAXIMUM      11.0000    CORRELATION    0.4857 0.0000  222
M---------------------M  MINIMUM     -42.0000    SPEARMAN R     0.4663 0.0000  222
I  AN H=     6 CASES  A  Z MAX         2.69
N     (N=  224)       X  Z MIN        -2.57      * AProblem > BProblem IN     6
                         CASE (MAX)       161     CASES OF  221 WITH NONZERO DIFS.
                         CASE (MIN)        50    ** TOTAL OF RANKS WITH LESS
                                                   FREQUENT SIGN =        131.5


ALO1      VS. BLO1       (VAR. NO.    5 VS.   11)
********************************************

       ALO1                    BLO1                     ALO1         BLO1
                                                   -------------------------------
                                     X             MEAN         9.4643      14.5134
                                     X   X
          H  H                       X  XX         STD DEV      3.3547       2.8045
       HHHHHHH                     XXXXXX          S.E.M.       0.2241       0.1874
     HHHHHHHHH                    XXXXXXX          SAMPLE SIZE     224          224
  HHHHHHHHHHHHHHHH            X XXXXXXXXXXXX       MAXIMUM     18.0000      19.0000
M---------------------M  M---------------------M   MINIMUM      1.0000       4.0000
I  AN H=     9 CASES  A  I  AN X=     9 CASES  A   Z MAX        2.54         1.60
N     (N=  224)       X  N     (N=  224)       X   Z MIN       -2.52        -3.75
                                                   CASE (MAX)      58          141
                                                   CASE (MIN)      36           35


ALO1     - BLO1      (VAR. NO.    5 -   11)
***************************************

                         ALO1     - BLO1         TEST STATISTICS   P-VALUE  DF
                         -------------------     --------------------------------
             H           MEAN         -5.0491    MATCHED  T    -21.39 0.0000  223
           HHH
           HHH           STD DEV       3.5323    SIGN TEST*           0.0000
          HHHHH          S.E.M.        0.2360    WILCOXON**     288.0 0.0000
       HHHHHHHHHHH       SAMPLE SIZE      224
 HH HHHHHHHHHHHHHHHH     MAXIMUM       3.0000    CORRELATION    0.3530 0.0000  222
M---------------------M  MINIMUM     -17.0000    SPEARMAN R     0.3516 0.0000  222
I  AN H=     7 CASES  A  Z MAX         2.28
N     (N=  224)       X  Z MIN        -3.38      * ALO1      > BLO1      IN    14
                         CASE (MAX)        84     CASES OF  213 WITH NONZERO DIFS.
```

```
                         CASE (MIN)       38    ** TOTAL OF RANKS WITH LESS
                                                  FREQUENT SIGN =        288.0


ALO2      VS. BLO2      (VAR. NO.   6 VS.  12)
********************************************

       ALO2                     BLO2                        ALO2        BLO2
                                                  ------------------------------
                                        X         MEAN        11.0670     22.2143
       HHH                          X   X
     HHHHH                        X X XXX         STD DEV      6.6858      7.7719
    HHHHHH H                      X XXXXX         S.E.M.       0.4467      0.5193
   HHHHHHHHH                    X XXXXXXXXX       SAMPLE SIZE     224         224
   HHHHHHHHHHHH H              XXXXXXXXXXXXXX     MAXIMUM     32.0000     36.0000
M--------------------M  M--------------------M    MINIMUM      0.0000      3.0000
I  AN H=     7 CASES  A  I  AN X=     7 CASES  A  Z MAX        3.13        1.77
N     (N=  224)       X  N     (N=  224)       X  Z MIN       -1.66       -2.47
                                                  CASE (MAX)      52          91
                                                  CASE (MIN)      15          47


ALO2     - BLO2      (VAR. NO.   6 -  12)
***************************************

                         ALO2     - BLO2        TEST STATISTICS   P-VALUE  DF
                         -------------------    --------------------------------
            H            MEAN        -11.1473   MATCHED  T    -21.35 0.0000  223
          H HHH
        H H HHH          STD DEV       7.8134   SIGN TEST*           0.0000
        HHHHHHH          S.E.M.        0.5221   WILCOXON**     414.5 0.0000
      H HHHHHHHHHH       SAMPLE SIZE      224
    HHHHHHHHHHHHHHHH     MAXIMUM       8.0000   CORRELATION    0.4239 0.0000  222
M--------------------M   MINIMUM     -31.0000   SPEARMAN R     0.4082 0.0000  222
I  AN H=     6 CASES  A  Z MAX         2.45
N     (N=  224)       X  Z MIN        -2.54     * ALO2      > BLO2      IN   17
                         CASE (MAX)      161     CASES OF  224 WITH NONZERO DIFS.
                         CASE (MIN)      116    ** TOTAL OF RANKS WITH LESS
                                                  FREQUENT SIGN =        414.5


ALO3      VS. BLO3      (VAR. NO.   7 VS.  13)
********************************************

       ALO3                     BLO3                        ALO3        BLO3
                                                  ------------------------------
     HH                                           MEAN         5.2902     13.5491
     HH
     HH                                           STD DEV      4.7343      6.9642
    HHHHHH                      X  XX     XX      S.E.M.       0.3163      0.4653
    HHHHHH H                  XXXX XX XX XX       SAMPLE SIZE     224         224
    HHHHHHHHHHHHHHH         XXXXXXXXXXXXXXXXX     MAXIMUM     23.0000     26.0000
M--------------------M  M--------------------M    MINIMUM      0.0000      0.0000
I  AN H=     9 CASES  A  I  AN X=     9 CASES  A  Z MAX        3.74        1.79
N     (N=  224)       X  N     (N=  224)       X  Z MIN       -1.12       -1.95
                                                  CASE (MAX)      58          66
                                                  CASE (MIN)      15          53


ALO3     - BLO3      (VAR. NO.   7 -  13)
***************************************

                         ALO3     - BLO3        TEST STATISTICS   P-VALUE  DF
                         -------------------    --------------------------------
          H  H HH        MEAN         -8.2589   MATCHED  T    -20.28 0.0000  223
          H HH HH
         HH HH HH        STD DEV       6.0953   SIGN TEST*           0.0000
       H HH HH HH        S.E.M.        0.4073   WILCOXON**     214.0 0.0000
    H HHHHHHHHHHHHH      SAMPLE SIZE      224
  HHHHHHHHHHHHHHHHH      MAXIMUM       4.0000   CORRELATION    0.5120 0.0000  222
M--------------------M   MINIMUM     -24.0000   SPEARMAN R     0.4713 0.0000  222
I  AN H=     5 CASES  A  Z MAX         2.01
```

```
N     (N=  224)       X  Z MIN        -2.58      * ALO3      > BLO3      IN    10
                         CASE  (MAX)        84     CASES OF  217 WITH NONZERO DIFS.
                         CASE  (MIN)        32    ** TOTAL OF RANKS WITH LESS
                                                    FREQUENT SIGN =       214.0

NUMBER OF INTEGER WORDS USED IN PRECEDING SUBPROBLEM    5257
```

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM/ANOVA Procedure

Class Level Information

Class	Levels	Values
SCHOOL	4	A B C D
Gender	2	Female Male
V7	2	1 2

Number of Observations Read	224
Number of Observations Used	217

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM/ANOVA Procedure

Dependent Variable: TotalDiff

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	2301.60725	460.32145	3.55	0.0042
Error	211	27378.87201	129.75769		
Corrected Total	216	29680.47926			

R-Square	Coeff Var	Root MSE	TotalDiff Mean
0.077546	51.31563	11.39112	22.19816

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SCHOOL	3	2080.586354	693.528785	5.34	0.0014
Gender	1	92.517542	92.517542	0.71	0.3994
V7	1	82.852156	82.852156	0.64	0.4251

Compare mark differences May 2013
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Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Dependent Variable: RoteDiff

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	99.250912	19.850182	1.01	0.41
Error	211	4127.873512	19.563382		
Corrected Total	216	4227.124424			

R-Square	Coeff Var	Root MSE	RoteDiff Mean
0.02348	72.11135	4.423051	6.133641

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SCHOOL	3	87.38725893	29.12908631	1.49	0.2186
Gender	1	1.16005318	1.16005318	0.06	0.8078
V7	1	3.28901946	3.28901946	0.17	0.6822

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Dependent Variable: ProblemDiff

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1924.73164	384.94633	4.1	0.0014
Error	211	19792.36513	93.80268		
Corrected Total	216	21717.09677			

R-Square	Coeff Var	Root MSE	ProblemDiff Mean
0.088627	60.28926	9.685178	16.06452

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SCHOOL	3	1735.561139	578.52038	6.17	0.0005
Gender	1	114.397177	114.397177	1.22	0.2707
V7	1	53.125885	53.125885	0.57	0.4525

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Dependent Variable: LO1Diff

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	194.382972	38.876594	3.21	0.0082
Error	211	2556.58477	12.116515		
Corrected Total	216	2750.967742			

R-Square	Coeff Var	Root MSE	LO1Diff Mean
0.07066	68.29572	3.480879	5.096774

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SCHOOL	3	174.2043525	58.0681175	4.79	0.003
Gender	1	12.4266487	12.4266487	1.03	0.3124
V7	1	0.4345778	0.4345778	0.04	0.85

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Dependent Variable: LO2Diff

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1396.94462	279.38892	5.06	0.0002
Error	211	11645.87566	55.19372		
Corrected Total	216	13042.82028			

R-Square	Coeff Var	Root MSE	LO2Diff Mean

0.107104		67.08892	7.429248	11.07373

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SCHOOL	3	1242.963334	414.321111	7.51	<.0001
Gender	1	71.2594	71.2594	1.29	0.2571
V7	1	44.600981	44.600981	0.81	0.3697

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Dependent Variable: LO3Diff

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	267.311921	53.462384	1.43	0.2135
Error	211	7870.715729	37.30197		
Corrected Total	216	8138.02765			

R-Square	Coeff Var	Root MSE	LO3Diff Mean
0.032847	73.91717	6.107534	8.262673

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SCHOOL	3	261.8961637	87.2987212	2.34	0.0744
Gender	1	6.9770687	6.9770687	0.19	0.6658
V7	1	0.3784976	0.3784976	0.01	0.9199

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Scheffe's Test for TotalDiff

This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	211
Error Mean Square	129.7577
Critical Value of F	2.64739

Comparisons significant at the 0.05 level are indicated by *.**

SCHOOL Comparison	**Difference Between Means**	**Simultaneous 95% Confidence Limits**		
D - B	1.804	-5.787	9.394	
D - A	4.216	-2.794	11.225	
D - C	9.803	1.92	17.685	***
B - D	-1.804	-9.394	5.787	
B - A	2.412	-3.102	7.927	
B - C	7.999	1.41	14.588	***
A - D	-4.216	-11.225	2.794	
A - B	-2.412	-7.927	3.102	
A - C	5.587	-0.323	11.497	

C - D	-9.803	-17.685	-1.92	***
C - B	-7.999	-14.588	-1.41	***
C - A	-5.587	-11.497	0.323	

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Scheffe's Test for ProblemDiff

This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	211
Error Mean Square	93.80268
Critical Value of F	2.64739

Comparisons significant at the 0.05 level are indicated by *.**

SCHOOL Comparison	**Difference Between Means**	**Simultaneous 95% Confidence Limits**		
D - B	1.076	-5.377	7.53	
D - A	4.527	-1.433	10.486	
D - C	8.451	1.749	15.153	***
B - D	-1.076	-7.53	5.377	
B - A	3.451	-1.238	8.139	
B - C	7.375	1.773	12.977	***

A - D	-4.527	-10.486	1.433	
A - B	-3.451	-8.139	1.238	
A - C	3.925	-1.1	8.95	
C - D	-8.451	-15.153	-1.749	***
C - B	-7.375	-12.977	-1.773	***
C - A	-3.925	-8.95	1.1	

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Scheffe's Test for LO1Diff

This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	211
Error Mean Square	12.11652
Critical Value of F	2.64739

Comparisons significant at the 0.05 level are indicated by *.**

SCHOOL Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
A - D	1.498	-0.6439	3.64	
A - C	1.7556	-0.0504	3.5616	
A - B	2.0333	0.3483	3.7184	***

D - A	-1.498	-3.64	0.6439	
D - C	0.2575	-2.1512	2.6663	
D - B	0.5353	-1.7842	2.8547	
C - A	-1.7556	-3.5616	0.0504	
C - D	-0.2575	-2.6663	2.1512	
C - B	0.2778	-1.7356	2.2911	
B - A	-2.0333	-3.7184	-0.3483	***
B - D	-0.5353	-2.8547	1.7842	
B - C	-0.2778	-2.2911	1.7356	

Compare mark differences May 2013
Portia Kavai T12007 21 May 2013
Compare Post-Pre differences - missing scored as 0 - include v7

The GLM Procedure

Scheffe's Test for LO2Diff

This test controls the Type I experimentwise error rate, but it generally has a higher Type II error rate than Tukey's for all pairwise comparisons.

Alpha	0.05
Error Degrees of Freedom	211
Error Mean Square	55.19372
Critical Value of F	2.64739

Comparisons significant at the 0.05 level are indicated by *.**		
SCHOOL Comparison	**Difference Between Means**	**Simultaneous 95% Confidence Limits**

B - D	0.741	-4.21	5.691	
B - A	3.383	-0.213	6.979	
B - C	6.907	2.61	11.204	***
D - B	-0.741	-5.691	4.21	
D - A	2.642	-1.929	7.214	
D - C	6.166	1.025	11.307	***
A - B	-3.383	-6.979	0.213	
A - D	-2.642	-7.214	1.929	
A - C	3.524	-0.331	7.379	
C - B	-6.907	-11.204	-2.61	***
C - D	-6.166	-11.307	-1.025	***
C - A	-3.524	-7.379	0.331	