A MERISTEMIC APPROACH TO THE DESIGN OF SMALL RUMINANT MODULES IN VETERINARY EDUCATION

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Declaration

I, RHODA LEASK, solemnly declare this thesis entitled: A MERISTEMIC APPROACH TO THE DESIGN OF SMALL RUMINANT MODULES IN VETERINARY EDUCATION is original and the result of my own work. It has never, on any previous occasion, been presented in part or whole to any institution or Board for the award of any degree. I further declare that all information used and quoted has been duly acknowledged by means of complete reference.

Signature: _____ Date:_____

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Lastly, to my family for all their support during this time, especially to my children, Erin and Jenson (who at such a young age had to sacrifice time with me in order for this research to be completed), my gratitude can never be properly expressed in words.

Dedication

I dedicate this thesis to three people.

Firstly, to my mentor Professor Gareth Francis Bath who has supported me and encouraged me in the development of my career as a specialist and as an academic.

Secondly, to my children, Erin and Jenson, you mean the world to me.

Summary

Title: A meristemic approach to the design of small ruminant modules in veterinary education

Key words: Meristemic, small ruminants, education, curriculum development, assessment.

The word “meristem” is applied to plants as a region of growth. In this study, a veterinary curriculum in small stock is assessed from a meristemic approach, as a form of biomimicry applied to education. The word meristemic is a novel portmanteau (or blended word) derived from “meristematic” (a region of actively dividing cells) and “epistemic” (relating to knowledge). A curriculum needs to allow for areas of growth and acknowledge that students cannot carry all the necessary information with them throughout their studies and future career. This means that throughout their studies, students can learn only the necessary and relevant information and can build on such knowledge depending on what fields they chose. Thus, it is important to follow an approach based on meristems to curriculum design. This will allow students opportunities to increase knowledge and practical experience in the correct sequence during the degree and then also later in the workplace. This thesis provides a method for including meristems in a curriculum and for this purpose focusses on the small ruminant modules of the BVSc degree at the University of Pretoria.

Meristemic is therefore defined as allowing areas of growth specifically related to knowledge or skills. A meristemic approach is defined as an approach using meristems as a basis for growth and is referred to in this thesis as the approach used for refining curriculum design. In this study, the method for applying a meristemic approach has been set out as a guide for use in refining curriculum design.

In conceptualising the meristemic approach, a number of existing curriculum design models were evaluated. The backward design was found to be the best fit for the veterinary science degree. Other models such as ADDIE are also useful in curriculum design. However, none of the models met the requirements of the researcher to be able to refine the curriculum once designed. As a curriculum is constantly reviewed to ensure that specific requirements are met, the researcher wanted to find an approach that could be used to refine a curriculum without having to completely redesign it. The meristemic approach begins with the development of the module using the backwards design of meeting day one competencies (DOCs) of a new graduate in veterinary science. Once the curriculum is in place, aspects of the ADDIE design model (Analysis, Design, Development, Implementation and Evaluation) are used to refine this curriculum. These aspects include “Analysis” of the current curriculum (Step 1), “Implementation” which is divided into two steps in the meristemic approach (Step 2 where

assessment is critically evaluated to determine whether the DOCs are being met, and Step 3 to determine whether practical content can be beneficial to the student within a particular module) and “Evaluation” where the mode of delivery of content is evaluated to determine whether face-to-face, online or a blended approach is best for specific modules (Step 4). Once these steps have been followed, nodes (meristems) can be identified within the modules. These modules are then pruned back to the nodes that were identified in order to allow for growth within the module. Once this has been done, the process may be repeated at any time without having to redesign the entire curriculum and each module within the curriculum can be refined at a time that is convenient for the staff members involved in that module and not at a predetermined time as would be the case in redesigning of an entire curriculum. With each use of the meristemic approach, new nodes will be identified as new information or techniques are presented within each discipline.

The first step of the meristemic approach is to critically reflect on the current curriculum. As the researcher is primarily involved in small ruminants, and a thorough critical reflection of the entire veterinary degree is outside of the scope of this thesis, the focus is specifically on two of the small ruminant modules, but can be applied to other modules within the degree. These two modules are evaluated in terms of a set of criteria that were discussed during a workshop on curriculum design.

The second step is to evaluate the assessment methods used. The assessment in the fifth year of the degree was used for this purpose and was assessed in terms of setting cut-scores, the level of knowledge required to complete the assessment and which of the day one competencies the assessment was able to cover. This study also revealed the relationships between cut scores, cognitive level and the number of day one competencies addressed. Expert judges set cut-scores using a modified Angoff method. This study revealed that the best criteria to use for choosing expert judges to set these cut-scores (when convening a large group of judges is not possible) is the proportion of time spent by the practitioner in the relevant discipline. The number of day one competencies covered by each question is directly correlated to the cognitive level of each question. Thus, cognitive level is an important consideration when setting cut scores and can be related to the number of day one competencies addressed. Judges were also used to determine the relevance of each of the assessment questions to allow the researcher to align the level of the module within the meristem as being foundational knowledge, core knowledge or specialist knowledge.

The third step of the meristemic approach is to determine the importance of practical training in the curriculum and how the practical training can benefit student learning even within theoretical modules. The content of the assessment (and thus the modules) is evaluated and

students' performance in a theoretical assessment is compared to practitioners' performance. The research was performed in this manner as the students had little practical experience compared to the practitioners who rely on practical experience to reinforce the theoretical training. This assists in determining whether more practical components of the degree can improve students' theoretical knowledge. The results showed that it is essential to include the practical components from an early stage in the curriculum as practical clinical experience assists in cementing the theoretical knowledge gained. Veterinarians with the greatest number of years' experience and who spent the majority of their time within the specific discipline outperformed the students with only theoretical knowledge and colleagues with fewer years' experience and time spent in the field.

The fourth and last step in the meristemic approach is to determine how the content of the various modules should be delivered. It is determined whether face-to-face contact time during a pre-clinical module is necessary, or whether a self-directed learning approach will provide an adequate learning opportunity to enable students to integrate the acquired knowledge. The method of teaching is evaluated considering other variables such as the lecturer, topics, cognitive levels and student attitude towards a self-directed learning approach. This study showed that the method of teaching did not affect student scores. However, the topic of the content, the cognitive level and student attitudes towards self-directed learning affected student scores. It is important to note though that as cognitive levels were not consistent across topics, this could have influenced the outcome of the model.

The scope of the meristemic approach is much wider than what can be addressed in a single thesis. As such, certain choices were made, and the thesis focused on those elements that were explained above. The meristemic approach is shown in a stepwise approach and this approach can be applied to any curriculum. Through this approach nodes or meristems are identified and these are used when developing specialist degrees. Thus, biomimicry can be successfully used in the form of a meristemic approach to assist academics in determining content and delivery within the design of a curriculum in order to distinguish foundational, core and specialist competencies. Further research is needed on the multitude of other curriculum design issues that this study could not address (such as the potential of using the meristemic approach on a macro level).

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Abbreviations and Acronyms

BCS Body Condition Score

BVSc Bachelor of Veterinary Science

CBE Computer-based Exam

CBT Computer-based Test

CWG Curriculum Working Group

DOC Day One Competency

HEQSF Higher Education Qualifications Sub-Framework

LMS Learning Management System

LWCC Livestock Welfare Coordinating Committee

MCQ Multiple Choice Question

MRQ Multiple Response Question

SABS South African Bureau of Standards

SDL Self-directed learning

WIL workplace integrated learning

List of Definitions

Active learning: active engagement of the students in the classroom (Deslauriers *et al.*, 2019).

Apical meristem: "the growth region in plants found within the root tips and the tips of the new shoots and leaves" (biologydictionary.net).

Biomimicry: mimicking nature's design and applying this to problem-solve and produce more efficient and practical materials, models or processes (Benyus, J.M., 1997; Esfand & Tomalia, 2001; Liu & Passino, 2002; Lin *et al.*, 2012).

Clinical: this refers to the final phase of the degree where students complete their practical training. In the University of Pretoria's Veterinary Science degree, this would include the second semester of the fifth year and the sixth year of study.

Competencies: this refers to both knowledge and skills that are acquired by the student.

Constructive alignment: derived from the constructivist learning theory where students take control of finding meaning in their own learning and aligning the objectives of a course with assessment (Biggs, 1996; Biggs, 1999).

Core knowledge: knowledge that a day one competent veterinarian would require (Irons, Holm, & Annandale, 2017).

Day one competency: knowledge and skills required of a veterinarian entering the workplace (Irons, Holm, & Annandale, 2017).

Epistemic: "relating to knowledge, denoting the branch of modal logic that deals with the formalization of certain epistemological concepts, such as knowledge, certainty, and ignorance" (collinsdictionary.com).

Foundational knowledge: formal or fundamental knowledge which provides the groundwork for other learning. This can also be interpreted as "Bloom's lower-order cognitive skills, which are typically thought of as the base of a learning pyramid, since these skills are the foundation for all higher-order cognitive skills" (https://ablconnect.harvard.edu/learn-foundational-knowledge viewed 13/11/2019).

Macro-alignment: alignment of content in the greater context.

Meristem: a region in plants where growth occurs (Starr & Taggart, 1992).

Meristemic: this is a term specific to this study and has not been previously defined. It is a portmanteau derived from the words “meristematic” and “epistemic”, and refers to allowing areas of growth specifically related to knowledge or skills.

Micro-alignment: alignment of module content between modules within the curriculum.

Node: another word for an area of growth or meristematic region.

Notional hours: the number of hours necessary for the average student to master the content of a module.

Passive learning: traditional lectures presented where students listen to the lecture but do not actively participate (Deslauriers *et al.*, 2019).

Pre-clinical: refers to the period just prior to the clinical portion of the training and would therefore include the modules that are taught before the commencement of the clinical training. For the small ruminant portion of the degree, this would be the first semester of the fifth year.

Purposive sampling: selective sampling with a specific purpose or goal (Palys, 2008; Palinkas *et al*., 2015).

Traditional knowledge: in the context of this study refers to knowledge that has not been scientifically reviewed but has been passed down through generations by word of mouth as tried and tested, and has been accepted by the communities who share this knowledge.

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Chapter 1

This study introduces a new concept in curriculum design. The concept and application thereof have not been researched previously and will be explained throughout the chapters that follow. This chapter will provide the background of the study, the problem statement and research questions. The nature of the study, the scope and ethical considerations will also be discussed.

1.1 ORIENTATION OF THE STUDY

This section introduces biomimicry, which is the thinking behind the meristem concept in education as it may be applied to curriculum design through the meristemic approach.

1.1.1 INTRODUCTION AND RATIONALE

There are many instructional design models in curriculum development including ADDIE, Bloom, Gagne, Merrill (May, 2018), Backward design (Wiggins & McTighe, 2000) and Miller (Witheridge, Ferns & Scott-Smith, 2019). Of these models, Bloom's taxonomy (Bloom *et al*., 1956) where cognitive levels are assigned to assessment questions on theoretical knowledge, and Miller's pyramid of competency (Miller, 1990; Witheridge *et al.,* 2019) where practical skills are assigned levels of competency, are used at the Faculty of Veterinary Science, University of Pretoria, with Bloom's taxonomy being the most popular model for theory assessments or computer-based assessments. The other models each have their own merit and from the veterinary science perspective, the backward design of Wiggins and McTighe (2000) appears to be the most appropriate for use in curriculum design thus far. However, this design has not been implemented to its full potential and it too was considered to be an incomplete design of the curriculum by the researcher as there is some debate on whether this model teaches to the test which has negative connotations (May, 2018) and could imply that content that is considered necessary, may be left out or the converse, that unnecessary content be included. The Analysis, Design, Development, Implementation and Evaluation (ADDIE) design model is used at the Faculty for curriculum design of online modules with success and is useful for designing new curricula. However, this design model did not allow for refinement of an existing curriculum without having to redesign the curriculum. Thus, the researcher was of the opinion that there could be a better approach to refining the veterinary science curriculum at the Faculty, rather than having to continuously redesign the curriculum.

Designing a curriculum is challenging. Designing one that is relevant, current, flexible and can be expanded at different phases/stages, is even more so. The researcher considered plant growth as a suitable model for refining a curriculum and the idea evolved into using biomimicry to assist with the refining process. Biomimicry is the concept of using nature's design to

problem-solve to produce materials, models or processes that are practical and efficient (Benyus, J.M., 1997; Esfand & Tomalia, 2001; Liu & Passino, 2002; Lin *et al.*, 2012). Biomimicry now has many different areas of application from technical designs (Rossin, 2010; Gamage & Hyde, 2012) to the medical field (Ward, 2008; Ahadian *et al.,* 2013). It has become so popular that it is even discussed in lay-publications (Lewis, 2019). Therefore, it is appropriate that this concept be applied to education. One area where this is applicable, and can easily be implemented, is curriculum design.

It is essential to redesign any medical curriculum on a continuous basis in order to include the latest practices, medications and technology. The researcher believes that five years would be a good interval between redesigning the curriculum. However, this does not mean that one has to wait five years before implementing changes and the researcher is of the opinion that a critical review of the curriculum should be done on a yearly basis. Designing a curriculum is time consuming and valuable time could be saved by modifying existing curricula rather than redesigning them. This would allow for refining the curriculum without having to redesign the entire curriculum. Modules within the curriculum that are meeting current requirements can be left as is, where other modules that need to be updated can be refined. In designing or refining a curriculum, criteria for sequencing, pacing, and content must be considered. For this process the meristem of a plant may be used as the form of biomimicry.

The word “meristem” refers to a region in a plant where growth occurs (Starr & Taggart, 1992). In plants, the meristem has the potential for many different outcomes such as roots, branches, leaves or thorns, and flowers or fruit (Starr & Taggart, 1992). This principle can be used to design an efficient curriculum and assist academic staff in determining not only where modules belong within a degree, but also what content is necessary for individual modules. For example, modules in anatomy and physiology form the foundational knowledge for any veterinary qualification. These modules can be considered to be the roots of the plant and may be as superficial, or as deep as necessary, to support the rest of the degree. Building on the foundational knowledge (or roots) is the core knowledge that the students will require to be able to function in the workplace (Figure 1.1). This comprises of the stem or trunk of the plant and may be viewed as knowledge essential to all practicing veterinarians from the first day of practice. This is otherwise known as day one competencies (DOC) or competencies expected of a new graduate entering the workplace (Irons, Holm and Annandale, 2017; Addendum B). The DOCs are important tools in the backward design of the curriculum and as the design was the most appropriate at the time of this study, it was decided to maintain this approach with some modifications. Once a student has graduated, he or she may choose to specialise or “branch out” into different fields. These fields may be as specialised as the graduate wishes them to be, for example, gaining more general knowledge in a field (longer

wide branches), such as herd health, or more specific and focussed knowledge (leaves and flowers), such as a specific parasite within the parasitology portion of a degree. Using the meristemic approach to curriculum design, potential for further growth and differentiation should always be left for each meristem developed in the student during their journey through the curriculum. Therefore, the meristemic approach is not an approach to be used as a novel approach to curriculum design, but rather a modification whereby the curriculum that has been developed can be “pruned back” to nodes where growth may resume. It is important to note that for some students with farming backgrounds, the meristems left in the curriculum may not apply to the student personally as they may have already developed competencies that have been left out of the undergraduate curriculum. Therefore, a best fit is not possible for the individual student, but rather for the student cohort.

Meristemic (a blended word from the words meristematic and epistemic) is therefore defined as referring to areas of growth in knowledge as it can be applied to other areas (such as curriculum design). A meristemic approach would be to identify areas in the curriculum that may be left as areas of growth for further post-graduate study. It is important to note that with a meristemic approach, the foundational knowledge should be appropriate to the core knowledge, so that each root tip, at each phase of the degree, is also considered a meristemic region with potential for further growth. Thus, foundational knowledge should not be greater than the knowledge gained later on as this will result in excessive focus on foundational knowledge that may not be required in a specific specialist field. By keeping the foundational knowledge to a minimum required to build the core knowledge upon, one allows for meristems within the foundational knowledge that can be expanded at a later stage to support specialist training. For example, a general practitioner performing a rumenotomy on a sheep that suffers from acidosis will only require the foundational anatomy basis necessary to perform the anaesthesia/analgesia and surgical procedure, and the foundational medical knowledge to correct the acidosis and get the rumen to function again. Whereas a specialist surgeon would require more in-depth anatomy of the entire animal in order to interpret any other pathologies, so that appropriate herd health advice can be given to maintain the long-term production of the entire flock. Similarly, a medicine specialist or pathologist would require more in-depth physiology and pathophysiology, and a herd or flock health specialist will require a stronger foundation in animal husbandry, nutrition or genetics.

Figure 1.1 represents the meristemic approach to curriculum design and shows the levels of the foundation, core and specialist knowledge as well as what is expected of a DOC veterinarian or new graduate.

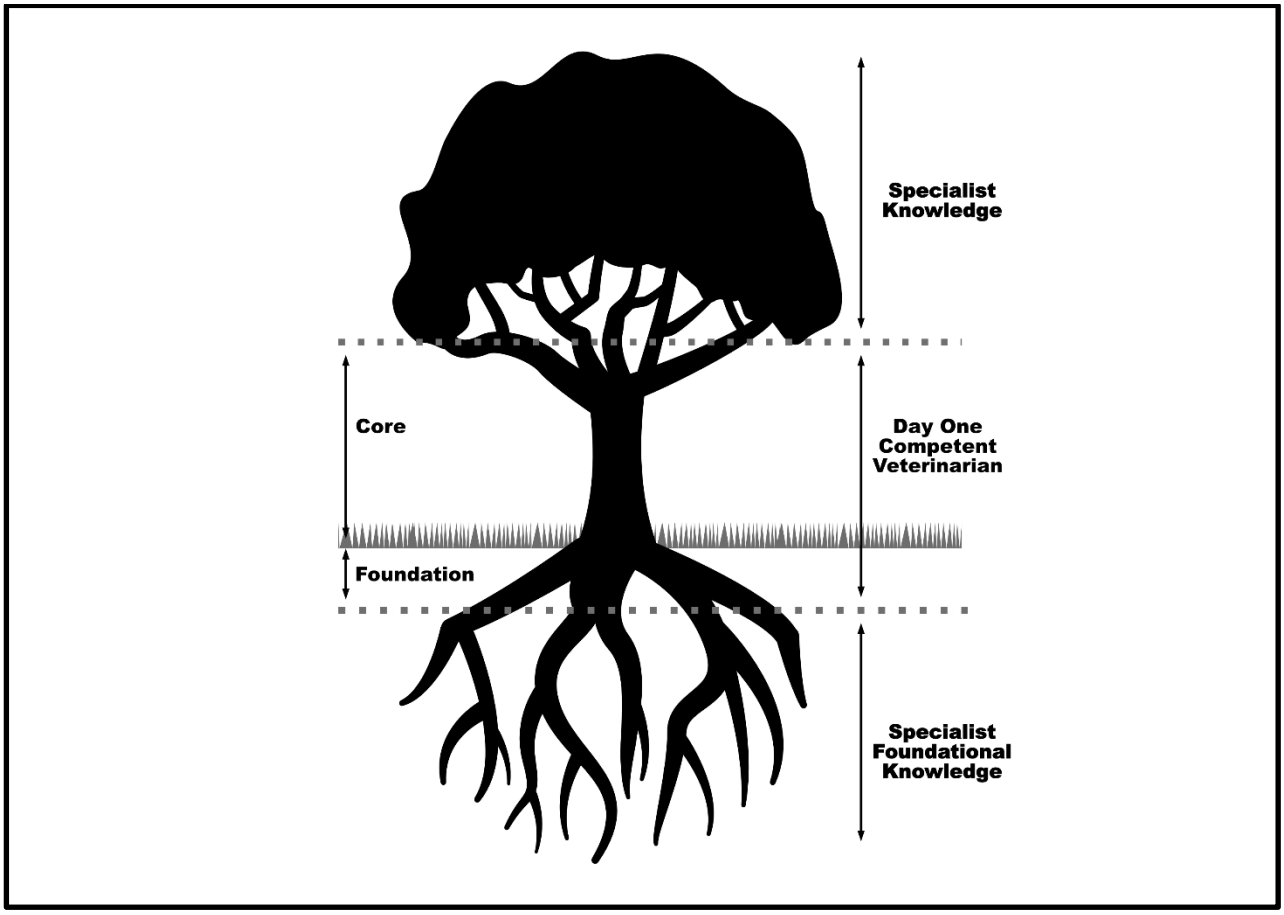

Figure 1.1: A meristemic approach to curriculum design in veterinary education determines the cut-off points for each of the foundational, core and specialist knowledge

A meristemic approach can therefore be explained as an approach that allows for growth during any phase – whether it be during the course of a diploma or degree, or furthering a career in the workplace. Veterinarians are consulted to treat patients that do not adhere to what is considered normal, be it disease or behavioural issues. They are also consulted for preventative measures and primary animal health. For the purpose of this study, a veterinarian who is required to determine what is considered to be abnormal, would consider the normal parameters as foundational knowledge. Thus, any normal parameters in form, function and behaviour are considered as foundational knowledge that the students would require to be able to continue further within the degree, and that other modules could build on as meristems. Core knowledge would therefore be the knowledge (and skills) required for a veterinarian to be able to function adequately on the first day after graduation. Thus, core knowledge would include the skills and competencies of a day one veterinarian. Foundational knowledge has been built on to provide these skills and knowledge, and therefore, core knowledge cannot truly be considered as stand alone, just as a tree would not be able to stand without the support of the roots (Figure 1.1). Specialist knowledge is considered to be the skills and competencies required of a veterinarian who practices in a specific field and may not be common to the general practitioners. This would include conditions and diseases that are not common to all

areas and situations and requires additional knowledge in order for the specialist to provide the best service and advice to the client. Most practitioners will refer such cases to specialists, or request an opinion from a specialist. A problem in the curriculum as it stood when the research was being conducted, is that the foundational knowledge was not aimed at DOC or core knowledge, but was provided to cover all potential areas of specialisation, both medically and surgically. There must be areas for growth in this foundation knowledge too. As the new graduates specialise in different areas, there will be a greater need acquire more theoretical and foundation knowledge in order to support such a specialisation.

An apical meristem is that part at the tip of a shoot, or root that will typically determine the height of a plant, or the depth or spread of the roots, and is usually at the centre of the developing parts of the plant (Steeves & Sussex, 1989; Bowman & Eshed, 2000). The apical meristem dictates the growth of the plant around it. By removing the apical meristem in plants, one allows more lateral growth to occur. Some veterinary schools have applied this principle in the form of “tracking” where students can pursue the career path of choice earlier on in the undergraduate degree. These students can then acquire a more specialised knowledge/skill set. However, where tracking is not implemented, a meristemic approach becomes crucial. A curriculum needs to allow for areas of growth, and acknowledge that students cannot carry all the necessary information with them throughout their studies and future career. Thus, it is important to explore a meristemic approach to curriculum design. This approach may allow students opportunities to increase knowledge and practical experience in the correct sequence during the degree and later in the workplace. For example, as sheep do not vocalise when in pain, yet goats vocalise for most handling, students should first learn about behaviour of certain species before performing farm procedures on these species (such as castrations), so that the student knows how animals respond to pain and how they can perform the procedures using animal welfare friendly approaches.

1.1.2 PROBLEM STATEMENT

The curriculum for the Veterinary Science degree at the University of Pretoria was in need of redesign in 2010. Over the years prior to 2010 new content had been added as notes and study guides were updated on a regular basis, yet redundant content was not removed and this led to an overload of content within the curriculum. This led to a disparity between the content volume and the notional hours proposed by the new Higher Education Qualifications Sub-Framework (HEQSF) as published in the Government Gazette (2012). The disparity between content and notional hours necessitated complying with the credit loads determined by the new legislation. In order to do this, a curriculum working group was appointed to critically evaluate each of the modules. As this process continued, there was a feeling of dissonance amongst the members as the modules were evaluated from the earliest years to the latter

years in order to be able to apply the new curriculum as soon as possible. The researcher felt uneasy about which content was considered specialist, core or foundational knowledge, as what was in the curriculum did not necessarily translate into what would be taught. This prompted the thoughts on a meristemic approach. The problem with designing a curriculum using clinicians to populate the content of a curriculum is that clinicians are often reluctant to use new approaches in fear that relevant content will be lost to the curriculum. This results in an overload of information, as described by May and Silva-Fletcher (2015). Using a meristemic approach at the onset of the redesign of the curriculum would be viewed as involving additional work from an already overloaded academic staff compliment and this could result in further reluctance to allow for growth in a curriculum. Intake number of students at the University of Pretoria were consistent from 1976 until 2000. However, increasing student numbers by 33% in 2001, 13% in 2006, 11% in 2011 and a further 27% in 2014, put additional pressure on the staff members to be able to deliver content of a curriculum.

However, by applying a meristemic approach, staff will be better equipped to determine where to include relevant content as well as how this should be delivered. Wiggins and McTighe (1998) recommend a backwards approach which suggests that one begin the design by determining the outcomes (or DOCs) at the end of the degree and then working backwards from the end to the beginning of the degree to ensure that those outcomes are covered by the redesign of the curriculum. This fits very well with the meristemic approach as it is necessary to know what the day one competencies are in order for the meristems to be left within the curriculum. Therefore, the meristemic approach towards the curriculum will be investigated as this will allow for excess content to be pruned from the modules in each of the years of the degree. However, evaluating every module within the degree would be outside of the scope of this study. Thus, the researcher used her own bias to determine areas that would be focussed on within the small ruminants scope of the degree.

1.1.3 RESEARCH QUESTIONS

The overarching question for the thesis is:

To what extent can biomimicry, in the form of a meristemic approach, be applied to curriculum design in veterinary education?

The researcher used her bias to determine how the meristemic approach would be applied. As the curriculum already existed, aspects of the ADDIE design model (May, 2018) were used. The ADDIE model is used to develop a curriculum from scratch and begins with analysis. It made sense that the first step in refining a curriculum would also be to analyse the current curriculum, however, an evaluation would be more in-depth and therefore more appropriate. Thus, the first step of the meristemic approach is to critically evaluate the curriculum as it has

been designed. This will allow for the pruning where necessary. This evaluation was based on a workshop that the researcher attended where certain modules were evaluated in such a manner. Another area in the ADDIE model is the implementation of the decisions made during the design process (May, 2018). This would become the next steps in the meristemic approach given that other aspects of ADDIE have already been covered when doing the backwards design of Wiggins and McTighe (2000) so are not necessary to repeat in the meristemic approach. The researcher also considered whether fewer people could be used when assigning cut-scores for assessments of the content of the current curriculum, and whether the judges used to determine these cut-scores would be able to assist in determining where the pruning could occur. An important aspect of the implementation is practical component of any module. Some modules were delivered on a theoretical basis with some case discussion and no real practical application of the information. To refine the practical application or content by having students “doing” (Miller, 1990) more instead of simply attending lectures, could result in students having a better theoretical knowledge reserve as applying the theoretical knowledge in a practical setting could cement such knowledge. Another area that was considered by the researcher was whether students needed to attend classes in order to achieve these DOCs, or whether the students could obtain knowledge through a self-directed approach. Other questions that this study will attempt to answer are specific to the next steps of the meristemic approach:

- *What are the best criteria to use when selecting expert judges to determine student performance? (Step 2 in the meristemic approach.)*
- *To what degree does practical experience improve theoretical knowledge? (Step 3 in the meristemic approach.)*
- *How does the method of teaching in small ruminant modules affect student performance? (Step 4 in the meristemic approach.)*

1.1.4 NATURE OF THE STUDY

This study is a mixed method study using both qualitative and quantitative methods. Qualitative portions of the study include the surveys completed by the students and practitioners. Quantitative portions include the observations listed under 1.1.6, as well as the statistical analyses of the data obtained in the study and the data that had been coded from qualitative data into quantitative data.

1.1.5 RESEARCH METHODOLOGY

This study was performed at the University of Pretoria’s Faculty of Veterinary Science as this is the only faculty in South Africa which offers degree studies in Veterinary Science. The relevant ethical approval was obtained for the study: V018-17 (Addendum A). The participants

in the study were informed of the aims and outcomes of the study and informed consent was obtained. The curriculum specific to small ruminants was evaluated and two of the modules were used for the studies in order to determine whether biomimicry could be applied to curriculum design. The first is the VET200 module, a BVSc II year module which introduces the student to the behaviour of the key domestic species such as cattle, pigs, sheep and goats, dogs and cats, and horses, to procedures performed on these species and to animal handling skills (*VET200 Veterinary Ethology and Genetics* 2015). The second module is the SSH510 module presented in the fifth (pre-clinical) year of the BVSc degree which covers diseases and conditions and management sections of herd/flock health in goats and sheep (*SSH510 Small Stock Health and Production* 2015). These two modules were used for the evaluation of the curriculum specific to small ruminants and are covered in more detail in chapter 2.

The SSH510 module was used for additional studies. For these studies, a mock exam paper was compiled from a pre-existing paper where each question was duplicated in terms of the topic covered, the question type (multiple choice or multiple response), the cognitive level according to Anderson and Krathwohl (2001), and the number of DOC covered per question. Two surveys were compiled for students and practitioners respectively.

The participants completed the mock exam and the practitioners were asked to also allocate cut-scores by means of an innovative individual modified Angoff method (described in detail in chapter 3). The practitioners were also required to allocate a relevance level to each of the questions as to their opinion of whether the question was irrelevant, foundational knowledge, core knowledge or specialist knowledge (further described in chapter 3). These studies included the standard for the main assessment, determining foundational, core and specialist content, determining whether DOCs are being adequately covered, and comparing the cut-scores and DOCs covered to Bloom's taxonomy, as revised by Anderson and Krathwahl (2001), and further described in chapter 3. The SSH510 module was further studied by investigating whether practical clinical experience assisted in cementing theoretical concepts as described in chapter 4. Practical clinical experience in terms of years of experience and proportion of time spent with small ruminants, were used to determine whether the practical clinical experience of the practitioners could account for the difference in performance between the students and the practitioners. It was then determined whether students perform better in assessments having received face-to-face contact with the lecturer compared to a self-directed learning approach. Students were given an assessment prior to commencement of the SSH510 module to determine their baseline knowledge and ability to source information from open resources. The students were allocated to attend either the lecture, or to do the self-directed learning by means of block randomisation. At the completion of the module, the students were again required to complete the assessment to determine what competencies

had been acquired during the module. Students were given assignments to complete on a specific topic and were responsible for sourcing information in order to complete the assignment. This is discussed in chapter 5 and assists academics in deciding on how to deliver content.

Methods to ensure validity and reliability of the data are as follows. There are numerous articles on the validity and reliability of the Angoff method and others (Nedelsky, 1954; Hambleton & Eignor, 1979; Harasym, 1981; Downing, Lieska & Raible, 2003; Hurtz & Auerbach, 2003) – this is discussed in the introduction to the study in chapter 3. The findings of these articles are sometimes contradictory, however, from the literature, the Angoff method has been shown to be the most preferred method of setting cut-scores (Berk, 1986; Cascio, Alexander & Barrett, 1988; Fehrmann *et al.,* 1991). Using Likert-type questions is an accepted way to measure responses in surveys (Allen & Seaman, 2007; Clason & Dormody, 1994; Garland, 1991; Gliem & Gliem, 2003). Likert's proposed scale has been used in Agricultural and Veterinary fields for assessing Body Condition (Russel, 1984) and Famacha scores (Bath, Malan & van Wyk, 1996) in small ruminants. When analysing Likert-type data, one should use the percentage responses for each item, rather than the means (Clason & Dormody, 1994).

The survey questions were set up using evidence-based methods as described in the chapters 3, 4 and 5 which follow for each of the studies. This ensured the validity of the questions. Questions were rephrased to ensure that the students did not just randomly allocate a score on the Likert scale, but actually read the question beforehand to ensure that they were giving the same answer to a rephrased question as they had to the original question. The survey questions and assessment questions were checked by three other parties to ensure that the questions were not ambiguous.

Transferability of the data was measured in the following way. The students completed the surveys at the end of the five-month long module (SSH510) after completing the assessment for a second time. The practitioners completed the assessments and surveys during the course of their working days. Some practitioners responded within two weeks while others took up to five months to respond depending on the workload of the practice. It was decided to allow practitioners to complete the assessment and surveys in their own time, rather than to set a cut-off, as this would ensure that they were able to respond. Emergency cases in practice would likely receive immediate attention and be prioritised above the completion of an assessment and survey. The students were allocated a time limit to complete the assessment and survey to ensure that they did not communicate with their peers. It is likely that some practitioners may have communicated with their peers when completing the assessment. However, the assessment was open resource for both students and

practitioners. Practitioners' scores for the assessment suggest that they did not spend additional time sourcing information (as was requested in the cover letter that instructed them to rather try to answer the questions without communicating with colleagues and with minimal research).

Credibility was measured by means of analyst triangulation (Patton, 1999) used in the data analysis. The researcher made use of the University's statistical analysts and discussed all results with the analyst to ensure that the data was analysed as accurately as possible. This occurred over a period of several months to ensure that the final results were reliable and credible. Other data that was obtained in the survey that could be coded was coded by the researcher and checked by the analyst. Member checking (Krefting, 1991) was also made use of as the participants were approached to check the researcher's understanding, and to provide additional information for the study in chapter 4 where practical experience was necessary. Here, the participants were required to add information on practical experience to the survey that they had already completed.

1.1.6 OBSERVATIONS

The following observations were recorded: input variables, confounding variables and output variables.

1.1.6.1 Input variables

The following input variables were used in the study to determine whether method of teaching has an effect on scores:

- Student's previous mean scores for the assessment prior to having a specific method of teaching for the topics
- Time in weeks between topics and the assessment at the end of the module (retention time)
- Facilitation method (face-to-face or self-directed learning) for each theme

1.1.6.2 Possible confounding variables

The following are confounding variables in the study:

- Background/prior learning – repeat students or students that have other graduate degrees.
- Practical experience – students who have previous practical experience in small ruminants

1.1.6.3 Output variables

The following variables are the output variables of the study:

- Computer Based Exam (CBE) scores

1.1.7 TARGET POPULATION AND SAMPLING

The student cohort registered in 2017 in the SSH510 module (n=163) was approached to participate in the study. Of the 116 students who volunteered to participate in the study, 89 fulfilled the requirements of the study (by completing the lectures, self-directed learning, assignments for all the topics and completing the final assessment), thereby providing useful data. Veterinary practitioners in mixed or production animal practice, were purposively sampled to participate in the study. Requests were sent via email to these participants and further participation was requested for targeted vets to pass on the information to other practices. Participants were required to be in mixed practice and have a minimum exposure to ruminants. A generalised request was posted on a veterinary platform where rural practitioners seek advice from colleagues in the field, namely “ruralvet”. Forty-two responded and 35 provided useable data without missing data that could not be dealt with in the statistical analysis. The study relied on voluntary participation and once there were sufficient respondents for a convenience sample as this was a new investigation, the analyses were performed. A power analysis was later performed to determine whether the numbers could provide statistically significant results. The following was used: G*Power 3.1.9.2, at an alpha level of 5%, and a large effect size (as was calculated using the current results). The power analysis showed that the sample sizes of both veterinarians and students were large enough to ensure a power of above 90%. It is recommended that the power analysis be done at the onset of future studies.

Permission to grant continuing professional development points to practitioner participants was obtained from the South African Veterinary Council. Both students and practitioners completed assessments and surveys. Assessments and surveys were collated, and data captured by the researcher.

1.1.8 DATA ANALYSIS

The University of Pretoria’s Department of Statistics assisted with the data analysis using SAS software, Version 9.4 of the SAS System for Windows (SAS Institute, Cary, North Carolina, USA).

The Shapiro-Wilk test was used to evaluate if the data was normally distributed or not. When the normality assumption of the parametric tests was not met, the non-parametric alternative test, the Mann-Whitney U test, was used (Shapiro & Wilk, 1965; Rani Das & Rahmatullah Imon, 2016). The Spearman rank correlation was used (which measures the monotonic association between variables) for variables that were ordinal in nature, rather than the normally distributed continuous data. When comparing correlations and determining whether they differ significantly, the Fisher’s Z transformation was used (Fisher, 1915).

A linear regression model was used to investigate the effect that congress attendance frequency, years' experience, time spent with sheep and goats and the revised Blooms' level had on the veterinarians' tests scores. An ordinal regression model was used for the teaching methods.

1.1.9 DELIMITATIONS OF THE STUDY

This study was aimed specifically at the curriculum development of the small ruminant modules within the veterinary curriculum at the University of Pretoria. Practical assessment of DOCs is not within the scope of this thesis.

1.1.10 LIMITATIONS OF THE STUDY

The researcher is involved in both modules that are critically evaluated, thus there may be a certain amount of bias. Purposive sampling was used to obtain information on number of years' experience with production animals, more specifically small ruminants. Thus, the generalizability of the findings to other fields is decreased. Information on student demographics in terms of gender, race and economics was not considered in this study and these variables may have confounded the results. It would be useful to include such information in future research. For the teaching method portion of the study, all students were exposed equally to direct contact learning, as well as self-directed learning. Ideally, students should have received one or the other throughout the module to exclude effects from both forms of teaching. However, it would be difficult to obtain student consent for this method and there would have been ethical implications if students in a particular grouping failed the module. Thus, the students were exposed to both methods in different topics within the module and the data of a student's performance under one topic was assigned to the teaching method. In the qualitative portion of this study, the findings could be interpreted differently by another researcher.

1.1.11 IMPLEMENTING A MERISTEMIC APPROACH – A CONCEPTUAL FRAMEWORK

In conceptualising the meristemic approach, it was determined that as this method has not been described previously, the researcher would need to develop a way in which a meristemic approach to curriculum design could be applied. A few steps were considered to decide where to cut content for the core curriculum in order to leave meristem regions for further growth in the veterinary curriculum. It is difficult to cut content from a core curriculum without first analysing the current curriculum and determining what the aims of the curriculum are. Having decided that biomimicry could offer the researcher a novel approach, namely the meristemic approach in evaluating the curriculum design and determining areas of growth within the curriculum, the next phase was to determine which steps to use in the meristemic approach. It was determined that there are several important aspects to curriculum design in the

Veterinary Science field and these included day one competencies, methods of assessment (which should be closely linked to the day one competencies), a critical reflection on the current curriculum content and presentation, the best approach to presenting content including practical aspects and self-directed learning or face-to-face contact. The order in which these should occur was further deliberated taking the ADDIE model (May, 2018) as a basis. It was determined that one cannot know where one should be heading with a curriculum unless there are clear day one competencies set and then comparing the current curriculum to the day one competencies one wishes to achieve. Thus, the first step is to critically reflect (Moon, 2004) on the current curriculum that one wishes to adapt and allowing areas for growth in the curriculum design. Reflecting on the curriculum can be done through analysing the macro-curriculum first and then moving on to individual modules by deconstructing the curriculum. Once the modules have been put into context and the aims of the modules are clearly defined, one can then move on to evaluate how the modules are assessed as assessment drives learning (Biggs, & Collis, 1982) and evaluating the assessments will give further insight into content that may be covered elsewhere which leads to step 2 of the process. To evaluate the entire curriculum was outside of the scope of this study and therefore it was decided to focus on the micro-curriculum of a specific area, namely small ruminants.

The second step is to evaluate the implementation of the learning process that students experience and, as such, assessment methods used in the modules to determine if they are adequate for the content within each module and in so doing, also to consider standard setting and how this is best achieved. These assessments should be aligned with the day one competencies that have been set out. This is also known as the backward design (Wiggins and McTighe, 1998). A criticism for this design is that the students are taught to the test. However, this does not mean teaching the actual assessment but rather teaching towards the day one competencies and that is a very good design for medical professions. Another helpful evaluation is to ask a panel of discipline experts whether questions covered foundational, core or specialist knowledge based on what information they use in practice. Once the content is decided, the presentation of such content should receive further attention. This involves determining what content to present in a practical manner and what content should be theoretical, so as to have both theoretical and practical content complementing each other (Biggs, 1993) and this leads to step 3 of the meristemic approach.

The third step is to determine whether practical content will improve the theoretical knowledge gained throughout the preclinical years, and where such practical content should be included. The fourth step is then to determine how best the content can be presented, either by practical means, face-to-face contact, a self-directed learning approach, or a blended approach to facilitate the learning.

Therefore, the meristemic approach can be conducted in these four basic steps.

1.1.11.1 Step 1: Critically reflect on the existing curriculum

Jennifer Clarence-Fincham, Lynn Quinn and Jo-Anne Vorster from Rhodes University presented a short course entitled Curriculum Development in Higher Education in 2015. The presenters identified areas that could be used to reflect on the existing curriculum. Some of their suggested areas were used to reflect on the curriculum in chapter 2 of this study. These areas included the purpose of the modules, the responsiveness to national and institutional policies, the critical cross-field outcomes and day one competencies (DOC). The constructive alignment (Biggs, 1996; 1999) of the modules with other modules, existing selection of content, resources for the module, existing sequencing and pacing, orientation to the curriculum, epistemic diversity, curriculum responsiveness and transformation, existing teaching and learning, and lastly existing assessment methods, was evaluated. Applying this process assisted academics in determining the objectives of the modules, which content should be included, and which content should be removed thereby allowing areas of growth.

1.1.11.2 Step 2: Critically evaluate the assessment methods and content assessed in these methods

All assessments within the modules were evaluated. However, for the purpose of this study, the summative assessment method of the fifth year, pre-clinical module (SSH510) were considered in more detail, and included the cognitive level at which the assessment is aimed. An evaluation of the summative assessment by private practitioners to determine whether the content is considered to be relevant to the undergraduate level, was also included. It was of utmost importance to include the cognitive level of the assessment questions in such evaluations and to ensure that an appropriate cognitive level was applied in specific years of the degree. This study is further described in chapter 3.

The hypotheses of the study were:

i) Hypothesis: A smaller group of expert judges can determine cut-scores and student performance as accurately as a larger group of mixed practitioners, when using a modified, individual Angoff method.

Null hypothesis: A smaller group of expert judges is not as accurate at determining cut-scores and student performance as a larger group when using a modified, individual Angoff method.

ii) Hypothesis: Cognitive level of the assessment affects student performance.

Null hypothesis: Cognitive level of the assessment has no effect on student performance.

1.1.11.3 Step 3: Determine the importance of practical content and decide on sequencing

For this step, theoretical knowledge of the students in the pre-clinical module was assessed, and compared to private practitioners who have varying amounts of clinical practical experience, in an attempt to determine to what extent practical experience affects theoretical knowledge. The results of this study also assisted in determining whether it is necessary to include practical experience in the pre-clinical years, in order to improve theoretical knowledge of the students, as well as when to start incorporating practical experience.

Hypothesis: Practical experience improves performance in theoretical assessment.

Null hypothesis: Practical experience has no effect on performance in theoretical assessment.

1.1.11.4 Step 4: Determine the mode of delivery of theoretical content

The existing teaching philosophy and methods, namely constructivism (Biggs, 1996), flipped classrooms (DeLozier & Rhodes, 2017), as well as workplace integrated learning (WIL) (Pienaar, 2014), were evaluated in order to determine the best mode of delivery of theoretical content. For the purpose of this document, the standard teaching methods used in the fifth year module, namely traditional lectures, active learning principles (Deslauriers *et al.,* 2019) and case studies, were compared to a self-directed learning approach in order to determine whether some content may be delivered in this manner. This module occurs in the first semester of the pre-clinical year of the BVSc degree (fifth year of the six-year degree). The final 18 months are where students do the clinical practical work in the degree. By adding self-directed learning, another dimension to learning could be approached.

Hypothesis: Face-to-face contact with a lecturer results in better student performance than a self-directed approach.

Null Hypothesis: There is no difference in student performance when comparing face-to-face contact and self-directed learning.

1.2 SUMMARY

This thesis provides a method for including meristems in curriculum design and, for this purpose, focusses on the small ruminant modules of the BVSc degree at the University of Pretoria. The method for applying a meristemic approach has been set out in this chapter. Step 1: The existing curriculum regarding small ruminants was critically evaluated. Step 2: The method of assessment was assessed. Expert judges determined cut-scores using a modified, individual Angoff method. Criteria for choosing these judges is discussed. Step 3: The students' performance in a theoretical assessment was compared to practitioners' performance to determine whether more practical components of the degree can improve students' theoretical knowledge. Step 4: It was determined whether face-to-face contact time during a pre-clinical module is necessary, or whether a self-directed learning approach would provide an adequate learning opportunity to enable students to integrate the acquired knowledge. The meristemic approach is then discussed in a way that can be applied to curriculum design.

In the next chapter, the first step in the meristemic approach is explored and the existing curriculum specific to small ruminants is evaluated, with special reference to the second year VET200 module which provides students with knowledge on behaviour of species and farm procedures, and the fifth year SSH510 module which provide knowledge on parasitic, infectious and nutritional conditions or diseases, reproduction and management aspects. The SSH510 module occurs in the preclinical year i.e. the year just before the students enter their practical or clinical training portion of the BVSc degree and as such, connects the previous modules that have introduced infectious diseases, parasitology, reproductions, nutritional conditions, and managemental and economic factors involved in small stock farming and is mostly presented to the students in the form of case studies.

Chapter 2

In this chapter the first step of the meristemic approach is explored as a critical reflection of the curriculum as it was presented to the students who participated in the study. It is important to note that since the commencement of the study, the curriculum has been revised and thus, this is cross-sectional review of the curriculum at that time. The reflection is grounded in a short course that was presented by Rhodes University on curriculum design when the University of Pretoria was considering redesigning the curriculum of the nursing diploma into a degree. As an exercise during this course, staff were asked to reflect on a module that they are involved in presenting or coordinating. The VET202 module was chosen for this purpose and subsequent to the course, the SSH510 module was reflected on in a similar manner. The point of the critical evaluation is to determine where to leave meristems or areas of growth to reduce the content that students are required to cover, thereby allowing for more in-depth understanding of the remaining content. This process specifically catered for the Day One Competent veterinarian.

2.1 INTRODUCTION

The word “curriculum” appears to have many different interpretations when it comes to academics. Fraser and Bosanquet (2006) describe four basic categories of academic’s understanding of what a curriculum is. The first two categories deal mainly with the product (including the structure and different components of a programme) and the second two with being more student-centred (involved with what the students achieve and how they interact with the programme). When drawing up a curriculum for higher education, those involved should consider all details of how an end result (or achievement of a degree in this case) is achieved, such as the modules and programme and how the day one competencies will be met and assessed.

This study focussed on the South African context. Elements influencing the curriculum may fall into three main categories of the macro-, meso- and micro-curriculum and have been adapted from work done by Kachelhoffer *et al.* (1991). Firstly, the macro-curriculum, which includes all of the input from stakeholders, government, university and faculty, decisions on DOCs or outcomes and what those should be, what the requirements are according to the Higher Education Qualifications Sub-Framework (HEQSF) (Government Gazette, 2012), and how those requirements are best met. Secondly, the meso-curriculum, which is a broad view and should give an indication of how one will achieve the goals set out to obtain the end result. Thirdly, the micro-curriculum, which would include the syllabus, the programme with all the finer details of the plan for achieving DOCs or outcomes. This includes the modules that would be required, the sequencing and pacing of those subjects and how much time should be spent

on each of the subjects, and, within each of those modules, the documentation that describes what is included in the module.

There are various stakeholders including government, professional bodies such as the South African Veterinary Council (SAVC), the South African Veterinary Association (SAVA) and private practitioners. Other countries that acknowledge the degree by allowing graduates from South Africa to practice without further examination, also influence how the curriculum is structured. For example, international accreditation authorities such as the Royal College of Veterinary Surgeons assess the standard of the degree. Aligning the standards of two or more accreditation authorities allows for reciprocity and thus the graduates are able to practice outside of South Africa. Therefore, the curriculum must have some international relevance.

Local demands from stakeholders on the curriculum in this study include more African content and transformation to see, among other, the numbers of graduates reflecting the demographics of the country, whereas global demands want a graduate that is able to deal with a wider variety of issues as opposed to only those applicable in an African context. However, there is some cross-over areas, for example, climate change and food security, where both national and international stakeholders have a similar interest. Where the South African veterinary curriculum has been strongly grounded in companion animal medicine and surgery in the past, there has been a slow shift towards production animals, One Health and food security over the past few years as is reflected by the curriculum (Irons *et al.,* 2017). Welfare is also receiving greater attention, especially the welfare of production (or food producing) animals. Here, welfare organisations also play a role in curriculum design.

For the purpose of this section, the focus will be on two specific modules. The first is the Veterinary Ethology and Genetics module (VET200) that deals with training veterinary students in behaviour, animal handling, welfare and procedures typically performed on farm animals during the second year of the BVSc programme. The second is the Small Stock Health (SSH510) module presented in the pre-clinical year that consolidates all small ruminant information acquired thus far. For the purpose of this study, although the word “curriculum” has a much larger meaning, it will be used when referring to individual modules (and in parts only the small ruminant section).

2.2 STEP 1: CRITICALLY REFLECT ON THE EXISTING CURRICULUM

This chapter is presented as a qualitative study on the BVSc curriculum preclinical small ruminant component. It includes a critical reflection on the curriculum from BVSc II and BVSc V (two modules that specifically aim to integrate knowledge applicable to small ruminants) that was presented to the students during the years 2014 and 2017 respectively. The VET200 and

SSH510 modules were reflected upon according to the following criteria as discussed during the workshop presented by the staff from Rhodes University:

1) The purpose of the modules
2) The responsiveness to national and institutional policies
3) Contextual factors affecting the curriculum design and implementation
4) Critical cross-field outcomes and day one competencies (DOC)
5) Constructive alignment of the modules with other modules
6) Selection of content
7) Resources for the module
8) Sequencing and pacing
9) Orientation to the curriculum
10) Epistemic diversity
11) Curriculum responsiveness and transformation
12) Teaching and learning
13) Assessment

The VET200 module introduces the students to animal ethology and procedures routinely done by farmers or animal owners on the key domestic species (dogs, horses, pigs, cattle, sheep and goats). The module does not include diseases or conditions that occur in the species and is considered to be foundational knowledge. At the onset of the SSH510 module, all relevant knowledge should have been acquired by the student and by completing the module, the student should be prepared to enter the clinical year where practical skills are acquired. The SSH510 assessment therefore assesses whether the student is able to consult on a number of small ruminant health issues in individual animal and flock/herd scenarios. The final exam provides the academic staff with an opportunity to assess all preclinical knowledge that has been acquired. As the transition from a mostly theoretical stage to a practically based part of the degree is a critical phase, it was vital to determine whether the assessment at the end of this module prepares the students appropriately. Therefore, the SSH510 summative assessment (formatted as a computer-based exam) was thoroughly evaluated. Each question was classified according to Bloom's Taxonomy as modified by Anderson and Krathwohl (2001). Each question was assigned the Day One Competencies that it covers (Addendum B). Each question had to cover at least one Day One Competency.

2.2.1 PURPOSE OF THE MODULES

Both modules are posted on clickUP which is a version of Blackboard® that was branded for the University of Pretoria. ClickUP is the Learning Management System (LMS) that the

University of Pretoria uses. Information relevant to a specific module is therefore posted on clickUP.

During a curriculum design review process, a working group was put together to determine what content should remain within each of the modules within the BVSc degree (Irons *et al.,* 2017). This content had to align with the list of DOCs (Addendum B). The list was provided to staff whose task was to first identify which of the DOCs were applicable to the module in which the staff taught, and then to set outcomes to meet these competencies. The curriculum document for each module was standardised so that all documents used the same language, style and format (Addenda B and C for VET200 and SSH510 respectively). The Curriculum Working Group (CWG) then met at regular intervals to review the documents. As a Senior Lecturer and small ruminant specialist, the researcher participated in both the VET200 and SSH510 modules' curriculum design that pertained to small ruminants. Once the CWG had edited the documents and agreed on the content, the BVSc programme committee finalised and approved the curriculum, and monitored its implementation through monthly meetings. There was a strong focus on content during these meetings. At no time was it discussed how the content should be conveyed to the students, or whether it should be covered in the classroom or in the field. This was one of the major downfalls of designing a curriculum in this manner. This ultimately led to many lecturers teaching an old course in a different context, instead of adapting it to suit the new curriculum, as has been found by May and Silva-Fletcher (2015). Thus, the goal of trying to make the course more practical for student learning as part of amending the curriculum, was not effectively achieved.

2.2.1.1 The VET200 module

"The VET200 module covers normal behaviour, development of breeds, applied genetics, animal welfare, general animal management and housing, the safe, effective and humane handling of animals, as well as common procedures that are routinely performed on the key domestic species (dogs, cats, horses, cattle, pigs, sheep and goats)", as found in the study guide (*VET200 Veterinary Ethology and Genetics* 2015) as posted on clickUP.

The following purpose statement is provided in the study guide and, informs the students why this module is included in the degree: "This module forms an important basis for the rest of your veterinary career. Without mastering basic handling skills and being able to interpret animal behaviour, veterinarians will not be able to examine and treat patients correctly or advise clients on the correct procedures. It is therefore important that enough time is spent practicing these skills during the practical sessions so that final year students are able to approach their clinical cases with confidence. It is important that all lectures and practical sessions are prepared for adequately to get the most out of this course in preparing you for

your future career. The information to prepare beforehand is provided in your notes, on clickUP and on DVDs."

The module is a year module and is housed under the Department of Production Animal Studies within the Faculty of Veterinary Science. There is also an element of genetics that is presented in this module during the course of the year. The researcher is the module co-ordinator and as such has been intimately involved in the curriculum design of the module throughout.

The VET200 document needed to incorporate three different modules from the previous curriculum into one module to be presented in the second year. The modules were evaluated by the CWG according to the year in which the modules would be presented to the students.

The module comprises of both theory and practical elements and is presented to the students by means of notes, demonstration videos, formal lectures and practical student training. Seven academic staff members present the module with the assistance of two support staff members (a veterinary nurse and a veterinary technician). Up to ten undergraduate student teaching assistants provide assistance during the practical training sessions, i.e. two per species group namely dogs and cats, small ruminants (sheep and goats), horses, cattle, and pigs.

2.2.1.2 The SSH510 module

This module had not been redesigned recently and had run in the same manner for some years. The module covers the following main topics concerning diseases and conditions, and herd/flock principles: sudden deaths, lameness, respiratory system, nutrition, vaccines/immunology, management, internal parasites, economics, pathology, zoonoses, mastitis, perinatal period/neonate, biosecurity, ecto-parasites, skin conditions, selection and culling, and reproduction.

The purpose statement of this module is as follows in the study guide: "This module will be presented in a way that will empower participating students to communicate with farmers and give advice regarding preventive medicine and production. Formal lectures will not be presented; instead, staff will facilitate case discussions, practical sessions and group / teamwork which will include peer instruction and assessment. Participation is essential. Knowledge required will be drawn from other courses presented within the faculty."

This module is also a year module, housed under the Department of Production Animal Studies within the Faculty of Veterinary Science, University of Pretoria. The module is presented by three staff members from the Small Stock Section that specialised in sheep and goats.

2.2.2 RESPONSIVENESS TO NATIONAL AND INSTITUTIONAL POLICIES

The VET200 module is presented in the second year of the BVSc degree and has been allocated 23 credits (230 notional hours). The SSH510 module has 25 credits (250 notional hours) and the students are required to have gained all the necessary theoretical knowledge from previous modules. These are in line with the revised Higher Education Qualifications Sub-Framework (2013).

2.2.3 CONTEXTUAL FACTORS AFFECTING THE CURRICULUM DESIGN AND IMPLEMENTATION

The international, national and institutional factors affecting decision-making in the redesign of a curriculum are discussed as was done in the workshop presented by the staff of Rhodes University.

2.2.3.1 International factors

Internationally, there is a greater focus required on food security (according to the sustainable development goals of the United Nations) as opposed to treating individual animals. In addition, there is the need to reduce the effects of climate change and so to provide food security with a minimal impact on the environment, while still being able to supply the demands of the growing population.

2.2.3.2 National factors

The following concepts were again discussed during the workshop presented by the staff from Rhodes University and it was concluded that in the South African context, national factors include how to improve GDP, how to improve the quality of life of the general population, improving small scale farming, creating employment, and here the need for transformation becomes more tangible. There is a need to include the majority population in the productivity of the country. It is the researcher's opinion that employing people from outside the country will not address the issues, however, the pool of qualified people in the country must first be built up before transformation can truly take place the way it should. Ways to do this would be to include more locally relevant content into the curriculum and to include information that has been passed down through the ages into the curriculum, to show that knowledge can be obtained from many different sources and can have an equal weighting in the curriculum.

2.2.3.3 Institutional factors

The institutional context for this paper is the University of Pretoria, Faculty of Veterinary Science. This is the only veterinary faculty in South Africa and as such, there is no other local faculty with which to compare the curriculum. For this reason, the curriculum is compared to

world-leading universities instead and therefore may be missing the local content that makes it uniquely South African, or even African. While most students attending the University of Pretoria's Veterinary Faculty for the purpose of obtaining a Bachelor of Veterinary Science degree are South African, a smaller proportion are from different nationalities.

Departmental considerations within the institutional factors would be how to divide time into appropriate sections to achieve the best results within the department and also to spread workload fairly without one section or discipline doing the majority of the work. One of the goals of all universities in South Africa is to include transformation into the future planning of the curriculum by making the degree more locally relevant.

2.2.3.4 The educational context in general

Clarence-Fincham and Naidoo (2013) concluded that one of the most important ways to enable educational contexts is to give staff the time to allow for critical reflection on a regular basis. It was possible during this research to allow for time to critically reflect on the process of introducing a meristemic approach to curriculum design.

2.2.3.5 Disciplinary factors

Most staff that have specialised in a specific discipline have carved out their domain and in doing so have put in a lot of time and effort and in some cases have made sacrifices in order to do so. When training post graduate students it is expected that the experts or specialists will be training them, but it is debatable whether this is necessary at the level of undergraduate training. It should not be of concern to staff members where in some instances the work load may be presented by less qualified staff to allow the specialists to give their time towards research and post graduate training so long as the correct information is covered. There is perhaps the concern that once workload has lightened, the post may not seem necessary by management and staff may be concerned about job security, but this is purely speculation. It is important to understand that the day one competent vet will not be at the level of a specialist and will require further training to get there. That being said, the researcher is of the opinion that the specialist could be the best person to contribute towards the content of the curriculum in that discipline as they have the knowledge of what the most important issues are in that specific field but should have input from general practitioners as well. They, together with input from other stakeholders such as private practitioners and other industry partners have the potential to shape the curriculum to achieve all the goals set out. This will be studied further in chapter 3.

2.2.4 CRITICAL CROSS-FIELD OUTCOMES AND DAY ONE COMPETENCIES

This section focuses on the desired outcomes and preparation of the graduate for future careers.

2.2.4.1 Critical cross-field outcomes

The following critical cross-field outcomes shared during the workshop presented by Rhodes University staff, are covered during the both the VET200 and SSH510 modules:

a) Identify and solve problems – part of the practical component is follow-up and risk assessment. For example, in VET200, if a wound gets infected the students have to recognise the signs of infection and know which appropriate course of action to take. They also need to be able to identify emergencies such as rumen bloat, as it requires life-saving intervention. As the student progresses to the SSH510 module they are required to identify diseases or conditions and recommend appropriate treatment or actions.

b) Work in a team – students are divided into practical groups and even within the group they are divided into smaller groups, which are then allocated animals on which to perform specific procedures for VET200. Within these groups, students must decide who will restrain the animal and who will perform which procedures. In SSH510 they present case discussions on problem solving in groups.

c) Organise and manage themselves – the students have a say in which group they prefer to be, and also which students will get to perform which procedures, as there are insufficient live animals for each student to perform all the procedures for VET200. For the SSH510 module the students need to allocate tasks to each member of the group, in order to be able to present their findings on their case studies.

d) Collect, analyse and evaluate information – this critical cross-field outcome is addressed to a limited extent in the VET200 module. For example, students are required to assess individual animals' body condition scores (BCS) and Famacha scores (Leask *et al*., 2013) and can then determine the general health status of the flock or herd. They are also required to inform the staff member what course of action to take to remedy the situation if the scores are undesirable. In the SSH510 module the students are expected to collect, analyse and evaluate information to handle their case studies.

e) Communicate effectively – this is accomplished by means of using practical assessments for the practical aspects of the VET200 module. The students are required to verbalise the procedures being performed and inform the examiner on the theory behind the procedure as it is being performed. The students in the SSH510

module use effective communication throughout the module when dealing with case studies.

f) Use science and technology – the students are tested by means of computer-based testing (CBT) as part of the assessment (to be discussed further later in this paper). They are also taught about the latest developments in the field, for example the identification of livestock that can be linked to their records by means of special ear tags.

g) Recognise problem solving contexts – here the students are expected to be able to identify when equipment is malfunctioning, and either be able to repair it or choose an alternative method to perform a specific procedure. The advantages and disadvantages of each method of performing specific procedures must be considered when performing such procedures. Later in the SSH510 module they are expected to apply problem solving to the case studies.

h) Reflect on and explore effective learning strategies – this is covered minimally during the formal lecture periods when the students are assigned tasks to present to the class.

i) Participate as a responsible citizen – the students are informed of animal welfare aspects and where to report poor welfare if necessary.

Of the critical cross-field outcomes discussed during the workshop, the following are not well covered in the VET200 module, but are covered in SSH510 to a limited extent and more extensively in other modules within the degree:

j) Be culturally and aesthetically sensitive

k) Explore education and career opportunities

l) Develop entrepreneurial opportunities.

2.2.4.2 Specific Intended Outcomes/Day One Competencies

The process of the redesign of the curriculum has been described by Irons, Holm and Annandale (2017). The Day One Competencies (Addendum B) document was used to draw up the micro-curricula for both modules and each of these documents specified which of the outcomes would be covered in each module.

2.2.4.3 Outcome-based Education

Outcome-based education means looking at what one would like the students to be able to know or do, or critically reflect on, and then selecting the content of the module or course based on these outcomes before deciding on how these goals are best achieved (Jansen, 1998). The VET200 module (and the rest of the BVSc degree) was designed with outcome-based education in mind. Stakeholders were asked what a day one competent veterinarian

should be required to do and the modules in the degree were designed with that list in mind. It was also sometimes difficult to decide how these day one competencies would be achieved in the foundation modules. For example, being able to spay a bitch requires anatomical knowledge, an understanding of physiology, and surgical techniques, to name but a few topics. Deciding just how much anatomy or physiology to include in those first years to cover work that would be done in the final year that had not even been discussed yet, proved difficult. For that reason, much detail was included that could have been left out. It would be far better to design a curriculum from the final year towards the first year. However, the curriculum design process would take longer to complete if done this way. In addition, the entire curriculum for the BVSc degree would have to be completed before students began the new curriculum instead of phasing it in as each year was completed. It has since been agreed that the redesign of a curriculum would be outcomes-based as discussed by Jansen (1998).

Recent graduates were not included in the redesign of the curriculum as discussed. However, the researcher is of the opinion that recent graduates should give their opinion on the content and how this is conveyed to the students and therefore should be included in the curriculum design process, but to a limited extent. For this reason, recent graduates were included as participants in this study (as described in subsequent chapters).

2.2.5 CONSTRUCTIVE ALIGNMENT OF THE MODULES WITH OTHER MODULES

Constructive alignment refers to how the modules align with broader aims or goals and also how they align with other modules within the degree (Biggs, 2003).

2.2.5.1 Macro-alignment

This covers how the modules align with the stakeholders' goals, for example the purpose of the modules, the mission and vision of the University of Pretoria, and the mandate for traditional universities as discussed during the workshop.

The purpose of higher education

It is the opinion of the researcher that the purpose of higher education should be to encourage students to become thinkers and problem solvers. These modules and specifically the sheep and goat section of the VET200 module aligns with the purpose in that students are encouraged to find the best solutions. They are also encouraged to find innovative ways to do things. This is supported by the 2025 strategic plan of the University of Pretoria.

The mission and vision of the University of Pretoria

The mission of the University is stated as follows on the University of Pretoria website (*Higher Education University of Pretoria* 2015): "We create a hub for the development, implementation,

management and governance of the business activities of the University of Pretoria. We respond to each opportunity with a bold joint enterprise, providing access to a multidisciplinary range of training and research skills."

The vision (*Higher Education University of Pretoria* 2015) is: "To be a training and research partner of choice by translating the quality, relevance and impact of the academic and research-intensive outputs of the University of Pretoria into all-inclusive solutions for our clients."

Both modules are aligned to the mission and vision of the University in that the students are exposed to the different training and research skills required to be a locally (and internationally) relevant veterinarian as the handling and procedure skills acquired are standardised world-wide with animal welfare in mind. The diseases and conditions covered in the SSH510 module also address this. With this mission in mind the students are equipped to provide a valuable service to clients in advising on the best methods of handling their animals and performing certain procedures and dealing with diseases and conditions.

Mandate for traditional universities

During the workshop presented by the Rhodes University staff, the mandate for traditional universities was discussed and curriculum transformation to include epistemological diversity was identified as part of the transformation. This is included in the teaching of these modules but is not stated as such in the curriculum documentation. It should clearly be written into the documents in order to make sure that the message is conveyed to all staff and students during the course.

Micro-alignment

Micro-alignment refers to how these modules fit in with other modules within the degree. The VET200 module aligns both vertically (to include modules that have occurred previously and will occur later in the degree) and horizontally (modules that occur within the same year of the degree) with other modules in the BVSc degree. How to catch a sheep to avoid injury to oneself and the animal requires knowledge of anatomy and physiology, as chasing the sheep for a prolonged period of time can cause the temperature, pulse and respiratory rates of the animal to increase. Catching a sheep in the correct manner then provides essential skills required in the later years, where examining a sheep and restraining it for surgical procedures applies. The later years are able to quite successfully build on to what has been gained through this module. However, during this module the students are required to do some background research for concepts that will only be covered in the later years. This not only gives them foundational knowledge, but already teaches them how to research concepts that have not

yet been taught. The sheep and goat section of this module brings in other species as well, by asking students to compare what behaviour a sheep with rabies would show, compared to a cow with rabies. In order to complete this assignment, the students need to know what normal behaviour is exhibited in both species and how this will change when infected with the virus (the details of the virus, and how or why it causes the behavioural changes is taught in later years). The genetics aspect of the course is closely linked to the species, for example sheep were bred for additional pleating in the skin in an attempt to increase wool yield. It has since been proven that breeding for additional pleating does not yield additional wool, therefore the genetics component will cover not selecting sheep that are heavily pleated, as this is a heritable trait that is passed on to offspring and attracts blowfly strike due to constant moisture in the folds. Blowfly strike is again linked to parasitology modules where students are taught how to identify the different blowflies and the lifecycles. Farm procedures causing necrotic wounds may cause tetanus in the livestock and this is aligned to microbiology – specifically bacteriology – where the students are taught about the organism causing tetanus. Students always ask for further information which is often given. However, it is emphasized that the details will be taught in later years, and they normally accept that, and sometimes even do their own research further. SSH510, as mentioned previously, encompasses all that has been learned thus far in the degree with regards to small ruminants. Therefore, the SSH510 module aligns vertically with previous modules as it brings together the theoretical information learned in previous modules and then discusses in a case-based manner how these diseases are addressed in the herd/flock health approach instead of treating individual animals. Horizontally the module aligns with modules that deal with cattle as there are conditions which are common to both cattle and sheep and have very similar methods of diagnosis and treatment. Thus, the SSH510 module lends support to these other modules by using a different approach to cement the knowledge.

Constructive alignment is illustrated in Figure 2.1 below which represents the core component of the curriculum. The same principles can be used for the foundation knowledge as well. Here it can be seen that the core (or trunk described in Chapter 1 previously) is made up of many modules. These modules may be very tightly aligned so that there is a single trunk, or can be more loosely aligned so that they are more easily separated from each other in the curriculum design.

Figure 2.1: Visual representation of the core component of the curriculum as individual modules within the degree

The horizontal alignment of modules can be more easily visualised in Figure 2.2 where it can be seen how the branches of the one module supports the other module within the core knowledge and this is referred to as horizontal alignment.

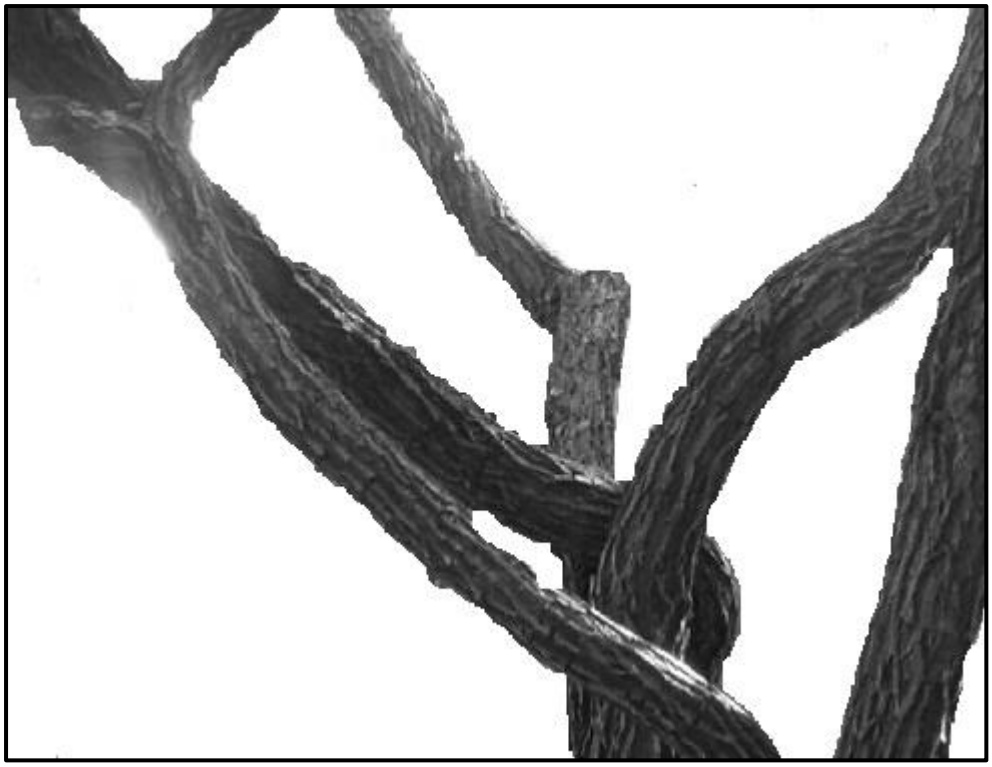

Figure 2.2: Graphic representation of horizontal alignment of modules with support from vertically aligned modules

2.2.6 SELECTION OF CONTENT

This section covers how content should be selected for inclusion in the curriculum. This is an important aspect in this study and will be dealt with again in chapter 4, where the notion that theoretical knowledge is improved by practical experience, will be explored.

2.2.6.1 General content

For the VET200 and SSH510 modules, the process for choosing course content was based on what had been taught previously. Staff used the DOC document as a guide, continuously referring to what content would be necessary to the new graduate to determine what content should remain in the new curriculum. Content that did not contribute to these competencies was excluded. However, the problem was that staff were uncertain as to whether or not the content that was regarded as important day one competencies for students to know, but was cut from this module, would indeed be taught in later modules. Therefore, some content that may not be necessary in the module was kept for fear that it would be lost or forgotten.

The staff involved in lecturing the VET200 module agreed that, for this module, the students would be required to be able to approach and handle any key domestic species as a day one competency. These species included dogs, cats, horses, pigs, cattle, sheep and goats. Students should also perform basic procedures that laymen and farmers could perform, in order for them to be able to train laymen, farmers and farm workers on the best method of carrying out these procedures. It was agreed that in order for this to be accomplished the

students would be required to know the basic animal behaviour, in order to interpret whether they were handling the animals safely and humanely. It was further agreed that a basic knowledge of selection of breeding animals would be a good foundation-type knowledge in order to advise the public and to meet some of the day one competencies.

2.2.6.2 Specific course/module content

Contact sessions for VET200 were considered to be time when students would have face-to-face contact with the lecturer. For the theoretical component of the module, these face-to-face lecture sessions were allocated to the following components: genetics (20% of the lecture time), general welfare & behaviour (10%), horses (20%), small companion animals (dogs and cats) (20%), cattle (10%), small ruminants (sheep and goats) (10%) and pigs (10%) as the theoretical knowledge covered was more for the genetics, horses and small companion animals. In addition to the theoretical contact time, practical training was included. The practical training for the production animal species (small ruminants, pigs and cattle) comprised of double the number of practical training sessions compared to the companion animals (horses and small companion animals) as there was more content to cover during these practical training sessions as compared to the theoretical sessions. Thus, each component received equal attention for all the species.

For each of the 5 species, the content included behaviour, husbandry and handling, routinely performed procedures, genetics for breeding and production purposes (where applicable). Nutrition was only included for the companion animals as other modules focused in more detail on the nutritional needs for cattle, small ruminants and pigs.

The SSH510 module consolidated the knowledge and skills gained in previous years in the form of case studies and discussions specific to sheep and goats. These can broadly be categorised into sudden deaths, lameness, respiratory system, nutrition, vaccines/immunology, management, internal parasites, economics, pathology, zoonoses, mastitis, perinatal period/neonate, biosecurity, ectoparasites, skin, selection and culling, and reproduction.

2.2.7 RESOURCES FOR THE MODULE

The students were provided with printed notes for the lecture component for both VET200 and SSH510 modules, as well as practical manuals to be referred to while handling the animals and performing the various procedures for VET200. The notes were provided in an electronic version on clickUP as well. For VET200 the students also received a DVD on horse handling and a memory stick with video recordings for demonstrations on the cattle, sheep and goat, and pig sections.

Other references were listed in the study guides and students were expected to make use of the library and various sources available on the internet when completing assignments. The sources used were discussed during the feedback sessions after their assignments had been presented.

Students were able to contribute towards the content of the course and towards the resources through finding resources on the internet and in so doing contribute towards the transformation of the curriculum towards a more student-centred approach.

2.2.8 SEQUENCING AND PACING

It is important to ensure that modules occur in the correct time within the degree and that the content follows a logical sequence (Posner and Strike, 1976). There should also be sufficient time within the modules (notional hours) for students to master the content in an order that makes sense to the student.

2.2.8.1 Sequencing

The focus for this research is on the sheep and goat section of the VET200 module. It was decided that the best approach is to begin with an introduction to the flock/herd, different breeds that may be identified, the purpose of different breeds and the products that can be obtained. This information was included so as not to take up much time but to put all students on the same level as some have not had any contact with farm animals prior to arriving at the Faculty of Veterinary Science. Students were also shown basic facilities and how they work and were then instructed on how to catch and handle the animals followed by the simplest to most risky farm procedures in order. The staff presenting this module found that in doing it in this way desensitised the students to the painful and bloody procedures in that they were more confident in their handling skills by the time they are required to castrate or tail dock lambs or dehorn kids.

The VET200 module leads well into the SSH510 module later where the diseases and conditions and management practices are discussed further.

2.2.8.2 Pacing

How much time is needed? Are there times when the students will require more time to process information? These questions are important and provided that the module is not overloaded with content, the pacing can occur in a well thought out and structured manner.

An indication of the pacing is to look at credits or notional hours and then determine if there is enough time to cover all the content. While there was a problem with the VET200 module (too much content and not enough hours), the SSH510 module seemed to be properly addressed.

Thus, the content of the VET200 module needed to be evaluated and meristems allowed to address the pacing issue as content was being delivered at too fast a pace which did not allow students time to sufficiently practice skills and process information. For the latest curriculum, the Genetics and Nutrition portions have subsequently been removed from the VET200 module and are addressed elsewhere in the curriculum.

2.2.9 ORIENTATION TO CURRICULUM

McKenna (2011) and others (Luckett, 1995; Toohey, 1999) have set benchmarks or paradigms against which a curriculum can be measured to assess whether the desired level of learning is being achieved. It is important to compare a curriculum to these types of concepts so that one can evaluate how subject matter is being taught to achieve the outcomes for a Day One Competent vet. Firstly, the positivist paradigm focuses on “a set of skills that needs to be transferred from the lecturer to the student” (McKenna, 2011). This is applicable to the VET200 module. Secondly, the interpretivist paradigm is more interactive between the student and the lecturer and involves understanding of the subject matter (McKenna, 2011) as applies to the SSH510 module. Thirdly, the critical paradigm calls for the person doing the tasks to critically reflect on how they as a person are affecting the outcome and what society’s views may be (McKenna, 2011). Lastly, the post-structural paradigm the students are required to act out a task and can be compare to workplace integrated learning. These last two are more applicable to the clinical portion of the degree.

While some traditional learning in the form of formal lectures is required to form the basis of knowledge required for this module, the main focus in the VET200 module is practical. The VET200 module falls under a performance and systems-based approach (Toohey, 1999). There are many paradigms in curriculum design (McKenna, 2011). The teaching and learning for both modules is in the process category or Hermeneutic paradigm (where knowledge is discipline-based and has a hierarchical structure but is based on individual action by the student which is influenced by their background) according to Luckett (1995). In other words, the students are required to learn the content provided to them and the way they learn depends on their background experience. Many of the students do not have practical experience with ruminants for example (refer to chapter 4 for details on prior experience). However, the module does include some critical thought (which traditionally would fall into the critical paradigm) where students are asked to choose the best option based on the information for a given set of circumstances. The curriculum for VET200 should include more of a critical paradigm and this will have to be worked on by all staff members as it is difficult to write into the curriculum and would be better suited to be addressed in the teaching of the module. This could include roll play where students are required to critically evaluate a scenario or a procedure that is performed in terms of economics and welfare for example. This may be considered a downfall

of drawing up a curriculum in that one can always include what should be taught in the curriculum documents, but it may not always express clearly enough on how this knowledge is learned. This is difficult to write into a curriculum document and therefore it is important that lecturing or teaching staff are trained properly in effective ways of getting students to acquire the relevant skills and competencies.

2.2.10 EPISTEMIC DIVERSITY

Epistemic diversity includes the assessing of teaching and learning. Luckett (2001) proposes four different quadrants as a framework for assessing teaching and learning, namely theory, practice, experiential knowledge (knowledge gained through experience that is not necessarily through accredited learning, in other words background practical experience acquired from living in a rural environment compared to urban life) and epistemic knowledge. According to her framework, the VET200 module includes both quadrants one and two (theory and practice) with very little from quadrants three and four (experiential knowledge and epistemic knowledge). This approach is suitable for the subject matter and the level in which the module is taught (second year of a six-year degree) and presents quite a lot of new information that the students are required to remember for future modules in terms of animal behaviour. However, although this module is a foundation module i.e. it forms the building blocks for later modules that are more workplace orientated, it is not impossible to include more work place learning within this module and therefore some elements should be taught in a way that will bring in some of quadrant three and four. The VET200 module falls mainly into the second quadrant as it is a practically orientated module. Seventy five percent of the coursework done in the module is practical in nature and 25% theoretical. Within each of these two sections there minimal opportunities for critical reflection. The theory component follows the more traditional approach and therefore falls into quadrant one (theory) with some critical thought during the assessments. Of the theoretical component only 5% would be considered to fall into quadrant 4. Thus, this is not sufficient to align with the epistemic knowledge quadrant). A performance and systems-based approach is used particularly for the practical component. The practicals do however again have some quadrant four in the teaching and learning where students would for example critically reflect on the welfare implications of using certain equipment for farm procedures but again, less than 10% of the practical training would fall into this quadrant. Students are required to make the important epistemic translation from “knowing that” to “knowing how”, for example how some of the contextual/responsiveness issues are addressed depends on the environment in which this occurs: workplace or simulated or in this case, it is the practical setting on live animals or in the skills lab on models.

The SSH510 module addresses epistemic translations as the majority of the module is case-based learning where students are required to provide a list of differential diagnoses and management or treatment options.

2.2.11 CURRICULUM RESPONSIVENESS AND TRANSFORMATION

Responsiveness and transformation are relatively recent concepts in curriculum design. Moll (2004) states that universities need to respond to pressures and expectations that are placed on them. These expectations can be global, national or even student expectations. He states that “curriculum responsiveness” implies some benchmarks against which the curriculum can be judged whilst being put into context (Moll, 2004). There is currently emphasis being placed (worldwide) on food security (United Nations Sustainable Development Goal 2, 2015). Food security includes farming of animals and more emphasis should be placed on production animals than on companion animals in order to transform the curriculum in that companion animals are often viewed as a luxury and not a necessity. The VET200 and SSH510 addresses this issue to ensure that farming with animals can be both productive and profitable.

2.2.11.1 The role of important stakeholders in the curriculum design process

There are various stakeholders previously mentioned (see Introduction 2.1) that influence the curriculum design. These stakeholders are both local and international. There is some overlap in interest when considering climate change and food security. These stakeholders contribute towards the decisions regarding content and transformation of the curriculum. Animal welfare is now more relevant than previously and is being considered essential in food production.

Universities worldwide have the responsibility to not only provide an education for a student, but also to educate the students in their greater responsibility towards society.

2.2.11.2 Responsiveness

Responsiveness can be to the economy, culture and the discipline itself. These were discussed in the workshop presented by the Rhodes University staff.

Economic responsiveness occurs in the curriculum in the form of what is affordable as well as what is profitable and often a compromise has to be made. Students are taught to think through economic decisions and assist farmers in making decisions based on sound economic principles. For example, an ewe has dystocia and the farmer decides that as the ewe is of little value in terms of genetic potential, it is more profitable for him to send the ewe for emergency slaughter than to call a vet out to perform a caesarean section. That same farmer may make the opposite decision if the ewe is of superior genetic make-up, such as a stud ewe where her offspring (if bred to a valuable stud ram) warrant the extra expenditure as the lambs are valuable and will get the farmer a better price on sale. Students are then able to assist farmers

in making important economic decisions, thereby improving the profitability of the farming enterprise, and therefore, contributing towards the country's economic development as well.

Cultural responsiveness refers to the difference in cultures between the lecturer and the diverse student population and how the curriculum can be used to bridge the gap. What also needs to be considered here is the student's previous exposure to the key domestic species. For example, in certain cultures dogs are used for hunting whereas in other cultures they are included as companion animals into the family structure. This is an important concept for the students to understand that not all of their future clients would come from the same cultural background.

An advantage of these modules it that there is a strong animal welfare component. While some might argue that it is difficult to consider animal welfare when humans are suffering, animal welfare can assist in bringing the two cultures together, in that regardless of the background or culture, the correct way to handle animals and perform procedures is in the most humane way. It is important the students are taught to respect these cultures and to take all possible viewpoints into consideration. Including the above examples into the curriculum could assist in bridging the gap between the different cultures of the students and the staff members and allowing all to see the information from a different perspective.

Responsiveness to the discipline implies that lecturers are required to keep up to date with the new research and information in their respective disciplines. This is not a problem for Veterinarians as the South African Veterinary Council (SAVC) requires that veterinarians participate in continued professional development (CPD) in order to remain registered. Veterinarians are required to be registered with the SAVC in order to practice in South Africa.

2.2.11.3 Transformation

Transformation of the curriculum is not so much about *who* is doing the teaching and *whom* is being taught, but rather *what* is being taught and *how* it is being taught and *why* it is being taught in a manner so that no student is left behind or disadvantaged (Clarence-Fincham, & Naidoo, 2013). Transformation is closely linked to responsiveness. Transformation includes incorporating information into the curriculum that is more locally relevant for example teaching procedures that are practiced with success in Africa but in the past have been frowned upon, for example phytomedicine. Not all emerging farmers or small-scale farmers have the capital to buy expensive transport vehicles and rely on other, very effective, methods of restraining an animal to allow for safe transport in alternative vehicles. Fractures of long bones can be set using pvc piping and some wool or cotton wool as padding. Different methods of castration and tail docking are taught, and the students are encouraged to evaluate the different methods in terms of accuracy, effectiveness, costs and welfare implications and to choose the best

option given different sets of circumstances. Methods of evaluating anaemia in sheep and goats to assess worm burden have been developed at the Faculty of Veterinary Science in South Africa that are now used worldwide such as Famacha (Malan *et al*. 2001; Leask *et al*. 2013) and the Five Point Check (Bath & van Wyk, 2009). This is a good example of transformation of the curriculum to include more locally relevant content.

2.2.12 TEACHING AND LEARNING

The staff in the small ruminant discipline have taken an innovative approach to teaching for a number of years. The small ruminant staff consists of a number of innovators that were key in implementing computer-based assessments, video recordings of procedures and alternative methods of student teaching, learning and assessment (Pettey, 2014). Peer instruction has been successfully incorporated into the teaching of the small ruminant discipline as has been described by Crouch and Mazur (2001) and Fagan *et al.* (2002). The main approach is to give the class assignments that requires of them to gather information and to present their findings to the class, rather than to give the traditional lectures.

The students are provided with notes but are expected to supplement the notes with their own research which is discussed during class presentations. Staff have been making use of innovative ways of performing case studies with model sheep (Pettey, 2014) and using the models to act out different scenarios where students were then required to “triage” the patients and “administer” the necessary treatment to the flock and individual animals based on “real time” experiences. This was mainly used in the later years such as SSH510 in the fifth year and with final year students (sixth year). However, there are probably aspects of the VET200 module that could be taught in this manner.

2.2.12.1 Evaluation of the modules

Each year students put comments into a box (anonymously). The comments were assessed and forwarded to the relevant staff for feedback. Time was scheduled with the students for formal feedback. Staff were also evaluated formally, by the students, on their teaching approach and this information was given back to staff in the form of graphs to show what the students thought were good, bad or average. This is an institutional student lecturer feedback system managed centrally by the Department for Education Innovation, with feedback provided to the individual lecturer and line manager. The class elected a course/module student representative that communicated with staff on behalf of the students for a specific module or course. At the end of the year the students completed the summative assessments. During these assessments either internal moderators (academic staff within the Faculty who are not directly involved with the teaching of the module) or external examiners were appointed as part of the quality assurance process. These people were appointed for two reasons.

Firstly, they were there to ensure that the students were on par with their knowledge of the course content. Secondly, to give feedback to the academic staff involved with the teaching of the module as to where improvements could be made to the curriculum. The internal moderators or external examiners would review the modules content and observe the summative assessment. They completed forms on their evaluations of the assessment and these, together with the student evaluations were fed back to the staff so that changes could be made to the curriculum. How the content is conveyed is much easier to change and this is discussed further in chapter 5 which explores different methods of facilitating learning.

2.2.13 ASSESSMENT

Assessments for both the VET200 and SSH510 modules were evaluated in terms of the assessment methods to validate content.

2.2.13.1 Assessment methods

During the modules the students were assessed in a number of ways:

a) Computer based testing (CBT) for both VET200 and SSH510 modules and is convenient as it cuts down the time required to mark papers (Cantor *et al.*, 2015). It is essential that staff consider cognitive levels when setting CBT questions in order for students to use higher reasoning and thinking to answer the questions (Bloom *et al.*, 1956). True or false questions were avoided as the students have a 50% chance of selecting the correct answer when merely guessing and not knowing. Other questions such as identifying parts of a diagram were also used in the CBT.
b) Quizzes or mini-assessments on much smaller volumes of content or on key aspects which carried less weight towards the final mark (VET200) were also done on computers. They contribute more towards formative assessment.
c) Practical oral examinations (where students perform practical skills which include theoretical questions about the skills) to evaluate practical skills (VET200). Although oral exams are viewed as being subjective, this form of evaluation of students' skills is vital in the module as the students need to be able to demonstrate techniques that have been learned during practical sessions with the animals as well as explain why they are done in a specific manner. The practical oral assessments were assessed using rubrics. There are newer methods of assessment that have been developed and since this evaluation of the curriculum, have been considered with the possibility of inclusion in the module such as Direct Observation of Procedural Skill (DOPS) (May & Head, 2010) and Objective Structured Clinical Examination (OSCE) (Davis *et al.*, 2006; Hecker *et al*., 2010; May & Head, 2010).

d) Case-based group work (SSH510). The students were divided into smaller groups and given a case study to solve. The group was given 45 minutes to find solutions and was then required to present their findings to the class (Pettey, 2014).
e) Peer assessment was included in (d) above as the students that were observing the presentations were to assess the presentations and these scores were compared to the scores given by the academic staff. Students were then scored according to how accurate their assessments of their peers were compared to the staff evaluations.

2.2.13.2 Using the assessment to validate content

The assessments used in the modules can be further evaluated to determine what content is relevant for each meristem. This will be studied further in Chapters 3, 4 and 5. Part of evaluating an assessment is to include cognitive levels when setting questions. When deciding on which level of (revised) Bloom's taxonomy (Anderson & Krathwohl, 2001) the question is categorised, it is important to consider the answer options and not the question in isolation when setting multiple choice type questions. This is important because the options (both answers and distractors) offered can increase the cognitive level (E. Mostert, Education Innovation Faculty of Veterinary Science, personal communication 2016). Depending on the distractors, the student is required to not only remember the correct answer from the "learned" options, but is also required to "understand" the concepts, "analyse" the available options and then "apply" all the information into choosing an option that best fits. Thus, a "remember" type question can be upgraded to an "analyse" question.

2.3 CONCLUSION

In this chapter, a critical reflection was performed on the two modules (namely VET200 and SSH510) that focus on small ruminant teaching and learning. Thirteen criteria were considered in the critical reflection. Ultimately, while there is some area where improvement may occur, the modules delivered what was to be expected at their relevant levels. It is concluded that in order to provide the best teaching and learning opportunities, there should be more critical reflection in the VET200 module from the students as this will prepare them for future modules and will allow for meristemic areas to be left for growth of knowledge in latter modules.

One way of ensuring that the curriculum is designed to include all relevant content and exclude unnecessary content is to design the curriculum from the product towards the beginning (backwards design). This way the clear goal of what the product (being the day one competent veterinarian) needed to know would be in sight when designing the curriculum for each year and forms the basis of the meristemic approach.

Chapter 3

This chapter deals with the evaluation of the assessment method that is used as a summative assessment at the end of the SSH510 pre-clinical (fifth year) module.

3.1 STEP 2: CRITICALLY EVALUATE THE ASSESSMENT METHOD AND CONTENT ASSESSED IN THE METHOD

This SSH510 module has a strong macro-alignment with the theoretical modules that have been presented in the “foundation” phase of the degree and applies it in a case-based manner to round off the theoretical phase of the small ruminant modules. The assessment was evaluated in three ways. Firstly, the assessment method and standards predicted by the practitioners. Secondly, the content is evaluated by the level at which the practitioners determined the assessment to be aimed. Thirdly, whether the assessment covered the day one competencies as previously described.

3.1.1 ASSESSMENT METHOD AND STANDARD

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Comparing student performance to cut-scores determined by a modified individual Angoff method featuring Bloom's taxonomy

3.1.1.1 Abstract

Background

There are challenges around the practicality of conventional standard setting methods for student assessment. Furthermore, accuracy of absolute methods of standard setting is difficult to achieve.

The aim was to determine which group of judges is most accurate at establishing the minimum level required to pass questions in order to ensure an appropriate standard (cut scores), and how the Bloom’s level of each question affected the correlation of cut-scores to student performance.

Methods

The modifications to the classical Angoff method where a group of judges convene and discuss cut-scores was that, in this study, the judges set cut-scores independently and did not receive the answers to the questions that they were assessing. Computer-based multiple choice and multiple response type questions were compiled, and allocated Bloom’s levels.

Judges answered the questions, determined cut-scores and completed a questionnaire. Simple linear regression was used to determine whether number of years' experience, proportion of time spent in small ruminant practice or specialisation in the field resulted in the most accurate comparison to student performance.

Results

Individuals spending the greatest proportion of time in small ruminant practice demonstrated greater accuracy in determining cut-scores. The Bloom's level assigned to each question was reflected on student performance.

Conclusion

This study supports that the time spent in a particular discipline must be taken into consideration when selecting judges for establishing cut-scores, and that the cognitive level of each exam question be considered to improve accuracy.

Keywords**:** *veterinary education, small ruminants, veterinary graduates, modified Angoff, predicting student performance, Bloom's cognitive levels.*

Declaration of Interest

There is no conflict of interest to declare.

3.1.1.2 Introduction

There are many described, reliable and validated standard-setting methods, that can be broadly classified as absolute methods such as the Angoff (Angoff, 1971) and Ebel (Ebel, 1979; Cizek & Bunch, 2011) methods, and relative methods such as norm-referencing using the Cohen or Hofstee (Nedelsky, 1954; Hambleton & Eignor, 1979; Harasym, 1981; Downing, Lieska & Raible, 2003; Hurtz & Auerbach, 2003) methods. The Angoff method of standard setting is a criterion referenced method (Glass, 1978) where student performance is measured against certain criteria such as cut-scores, as opposed to norm-referencing where the student performance is compared to other students (Brown, 1998; Gronlund, 2006). Of these methods, the Angoff method appears to be the most preferred method as it is the easiest to apply (Berk, 1986; Cascio, Alexander & Barrett, 1988; Fehrmann, Woehr & Winfred Arthur,1991). However, in the medical professions the Ebel method is more widely used for multiple choice type questions, and takes the degree of difficulty into account (Downing et al., 2003; Cizek & Bunch, 2011; Frey, 2018). This is probably owing to the larger group sizes required by the Angoff method (Shulruf *et al*., 2016). Group sizes have been studied for the Angoff method (Shulruf et al., 2016) and results have shown that a larger group (15 judges) with mixed expertise produced more accurate results as opposed to a panel of either experts or non-

experts only. However, the authors conceded that further research was needed because their study was performed as simulated exercises, and the number of items was relatively small.

The Angoff method involves convening a panel of judges in the same location who then set cut-scores individually which are later compared to other judges in the panel. The cut-scores are then discussed and revised according to consensus (Angoff, 1971). The practical challenge of this method of convening judges has resulted in modifications of this method such as the modified Angoff method (Livingston & Zieky, 1982) and individual Angoff method (Senthong *et al*., 2013). Generally, convening a large group of judges who are also familiar with test-takers (Verhoeven *et al.*, 1999) in order to set cut-scores is often difficult, costly and impractical (Mubuuke, Mwesigwa & Kiguli, 2017) and this would apply particularly to the veterinary profession where most of the judges would potentially be recruited from private practices. Even 15 judges as researched by Shulruf et al. (2016) is considered a large group in terms of practicality in the veterinary field. While the modified Angoff method (Angoff, 1971; Livingston & Zieky, 1982) has been established to be reliable (George, Haque & Oyebode, 2006), other Angoff methods such as the modified individual method could prove to be effective at determining success rates for a computer-based, multiple choice/multiple response type assessment (Senthong *et al.*, 2013). Convening judges (in this case practicing veterinarians) for a day to judge assessment in terms of setting cut-scores is impractical and not cost-effective for several reasons including loss of income for the veterinarian's practice for an extended period, as well as incurred additional expenses surrounding travel and accommodation as needed.

Norcini and others (1987, 1988, 1991, 1992a, 1992b) have studied the effects of variations on standard setting methods and numbers of experts and items. They described allowing some judgement to be made outside of the standardised environment of convening the panel in a set location, as did Senthong and others (2013). One of the disadvantages of having the judges discuss the cut-scores in order to reach consensus is that some judges may be more easily swayed into agreeing with another, more persuasive judge's score (Hurtz & Auerbach, 2003). Fitzpatrick (1989) and Myers and Lamm (1976) found that by not allowing judges to discuss cut-scores group polarisation was eliminated. Senthong and others (2013) studied the effect of group, versus modified individual standard-setting (where judges work independently and average scores are used), on multiple choice questions in fourth year medical students. They concluded that the modified individual method of allocating Angoff cut-scores was a feasible way to set a standardised pass score.

Hurtz and Auerbach (2003) stated that if there is consensus among experts on what the cut-score should be, it is more likely to resemble the "true" performance standard. Thus, the Angoff

cut-scores assigned by the judges can be good predictors of student performance (difficulty scores). Even if the group method of assigning Angoff cut-scores provides a more accurate predictor of determining student success, if there is little difference between group and individual methods, it would be beneficial from financial and time points of view to use the latter method.

While group and individual standard-setting methods of applying Angoff's method have already been described (Senthong *et al*., 2013), this study aims to determine whether a smaller, "specialist" or "small ruminant practitioner" cohort of judges is better at predicting student performance than a larger, more generalised cohort when using a modified individual standard-setting method of Angoff. It is considered by the researchers to be a more practical way to involve veterinary practitioners in setting standards and ultimately predicting student performance.

3.1.1.3 Methods

The purpose of this study was to compare the use of a small group of expert practitioners to determine cut-scores, to that of a larger group in order to provide a more practical option, and to compare cut-scores to actual student performance. Additionally, to determine how Bloom's revised levels affected both cut-scores and student performance.

Material studied

For the purpose of this study, a computer-based, summative assessment was compiled for the small ruminant module (Pettey, 2014) which was based on a pre-existing summative assessment given to undergraduate students. The small ruminant module is delivered through case-based discussions, and the assessment consisted of 90 multiple choice and multiple response question (MCQ and MRQ respectively) items based on sheep and goat clinical cases, presenting signs, diagnoses and treatment options. As this assessment was duplicated from a previous assessment which only formed part of the examination. Thus, the total score was 101 marks for the 90 questions. The questions were assigned by the researcher and an educational curriculum specialist according to Bloom's Taxonomy (Bloom et al., 1956) as revised by Anderson and Krathwohl (2001). Bloom's levels include remembering (level 1), understanding (level 2), applying (level 3), analysing (level 4), creating (level 5) and evaluating (level 6) and were revised by Anderson and Krathwohl (2001) so that evaluating (now level 5) was considered to be at a lower cognitive level than creating (now level 6). The allocation of the 90 questions into the revised Bloom's levels were as follows: remember (n=18), understand (n=22), apply (n=23), analyse (n=22) and evaluate (n=5). The researcher was unable to construct a computer-based, multiple choice/response type question that fulfilled the requirements for the revised Bloom's level 6 of "create" and thus this level was excluded from

the study. For this assessment it was determined that higher order thinking type questions fell into the remaining three latter levels (3 to 5) of revised Bloom. Therefore, 80% of the assessment involved higher order thinking type questions with only 20% falling into the remember/understand levels (1 and 2). The revised Bloom's level (1 to 5) values in the assessment were classified as ordinal data (Allen & Seaman, 2007).

The questions in the assessment were also categorised into topics and question types and the mark allocation was recorded. Topics included sudden deaths, lameness, respiratory system, nutrition, vaccines/immunology, management, internal parasites, economics, pathology, zoonoses, mastitis, perinatal period/neonate, biosecurity, ectoparasites, skin, selection and culling, and reproduction.

The assessment was given to two academic members within the Department of Production Animal Studies and one member of the Department for Education Innovation of the University of Pretoria to evaluate in terms of correctness and degree of difficulty for quality control. Questions were amended according to their recommendations and again checked to ensure that all the criteria were met in terms of the assigned topic, Bloom's revised level, as well as whether the question was a MCQ or MRQ and mark allocation so that it corresponded with the previous assessment in all of these criteria.

Following each question, the judges were asked: "What percentage of borderline students do you think will answer this question correctly?" A borderline student was described as a student that would typically achieve 50% in an assessment as 50% is the pass mark for this assessment. These assigned percentages are hereafter referred to as the "Angoff cut-scores".

Questionnaires were set for the practitioners based on evidence-based principles that previously described (1) the types of questions to include in research by Bailey (1978), Berdie, Anderson and Niebuhr (1986), and Perkin (1995), (2) the order in which questions should be presented (Sheatsley, 1983; McClendon & O'Brien, 1988), (3) the length of the questionnaire (Berdie, 1973), and (4) open-ended questions (Montgomery & Crittenden, 1977; Geer, 1988) in research. These questionnaires were compiled to accompany the assessment.

The questionnaire for the practitioners gathered information surrounding personal details, contact details and registration numbers, highest qualification, years of experience, frequency in attending conferences for continuing education, proportion of time each veterinarian spent with ruminants, proportion of time spent on small ruminants, average herd or flock size. Lastly, the questionnaire included an open-ended question that elicited their opinions on whether recent graduates met the Day One competencies (Irons, Holm & Annandale, 2017) of a veterinarian. The rest of the questions were classified as ordinal data, interval data and ratio

data (Allen & Seaman, 2007). The practitioners received their questionnaires together with the assessment.

Area descriptions

The study involving the students took place at the University of Pretoria's Faculty of Veterinary Science in South Africa as part of the pre-clinical module on small ruminants.[29] However, participating judges were able to complete the assessments and questionnaires from home. These judges were from areas across the country.

Participants

Those willing to participate (both students and judges) agreed to participate by signing that they had read the letter of informed consent. Participants were able to exit the study at any given time.

Judges

A general request for volunteers was distributed on "ruralvet" (ruralvet@yahoo.com), a platform where rural practitioners can share cases they encounter and ask for advice from other members. Rural practitioners practicing in mixed practice, with at least 50% of their time spent on ruminants were purposively targeted (Tongco, 2007; Palys, 2008; Palinkas *et al*., 2015) and 70 practitioners were personally approached by the researcher and were invited to participate in the study. Academic staff from the Department of Production Animal Studies and Pathology Section of the Paraclinical Studies Department of the Faculty of Veterinary Science, University of Pretoria, were also invited to participate, though staff and private practitioners whose focus was on companion animals were excluded. Only practitioners who practiced or had previously practiced in Southern Africa were eligible to participate as they are familiar with the local diseases and conditions. The first of those approached were six practitioners (group 1) who are considered by their peers to be specialists in the field, based on the following criteria:

Held a specialist qualification in small ruminant health - registration of such specialist qualification with either the South African Veterinary Council (SAVC) or the European College of Small Ruminant Health Management (ECSRHM).

Have been involved in student examinations as either an internal examiner, external examiner, or a SAVC monitor for the preclinical small ruminant module (SSH510).

Have a minimum of 15 years postgraduate experience in either mixed or production animal practice with specific experience in small ruminants.

It must be noted that here are only five registered small ruminant specialists in South Africa, including the researcher and a colleague that was excluded from the study as he was involved in quality control of the assessment as well as teaching of the module in which the study was being performed. Therefore, only three specialists met the criteria and were selected in group 1.

Thereafter, the general practitioners were approached (group 2). These practitioners comprised the rest of the participants as they were not registered as specialists or recognised as such. Some of these practitioners included young veterinarians who were focussed on small ruminants but did not have 15 years of clinical experience. Additional volunteers were recruited by the respondents themselves who also shared the assessment and questionnaire with colleagues who had not been personally approached, nor were members of ruralvet, but had experience with ruminants.

A total of 43 practitioners responded and 35 provided useable data. Eight were excluded due to several incomplete responses that could not be dealt with as missing data (Dohoo, Martin & Stryhn, 2003). Respondents included academics (n = 5) private veterinarians (n = 25), state veterinarians (n = 2) and practicing veterinarians in industry (n = 3). Some of the respondents (n=3) did not answer a small proportion of the questions owing to the fact that they were undecided on responses, or did not know the answer to the question (as was indicated on their responses). In these cases, the data was dealt with as missing data according to Dohoo, and others (2003) by simply excluding the data from the calculations of the medians or means as this would not affect the results.

Students

The student cohort of the small ruminant fifth year module (2017), were offered the opportunity to participate in the study. The fifth year of the degree is split into two semesters with the first semester comprising of theoretical-based modules and the second semester being the start of the clinical training programme. Therefore, the students who were registered in the module, were considered to be pre-clinical as the clinical component only began in the second semester. An incentive was that they would be able to experience a summative assessment similar to the summative assessment for the small ruminant module and in so doing have a better idea of the type of questions asked in a summative assessment at this level.

The student cohort consisted of 163 students, and 116 students signed the informed consent and agreed to participate. However, only 89 students complied with the requirements for participation in the study regarding lecture attendance, which was verified by the students completing an assignment in the topic of each lecture, and completion of the assessment at the end of the module, thus providing usable data.

Procedures

A letter of informed consent was compiled to ensure that respondents understood their rights when participating in the study. The study was approved by the University of Pretoria's Ethics Committee (V018-17).

The assessment was sent to the judges via email with instructions on how to complete and then provide cut-scores for each of the questions. The assessment was regarded as open resource and the judges were asked not to take longer than two hours to complete. As the judges were required to give additional information in the form of cut-scores and not just complete the assessment, the time each judge took to complete the assessment was not recorded. Judges indicated on their assessments where they had preferred not or were uncertain to answer questions that they did not have any theoretical knowledge on the subject resulting in some missing data.

Norcini and others (1987, 1992) and Shulruf and others (2016) have described best practice where groups of judges convene, with larger groups being more accurate, and judges are able to see the answers to each of the questions, allocate a cut-score and then discuss and reallocate cut-scores. However, Senthong and others (2013) showed that individual judges may also provide suitable cut scores. Mubuuke and others (2017) found that judges were biased in allocating scores where answers for the questions were provided and judges able to discuss cut-scores, and advised that the answers be withheld in order to avoid bias. Thus, the judges were requested to give their own opinions and were not given the answers to the questions in the assessment so that they could give an unbiased cut-score for each question.

At the end of the small ruminant module students completed the assessment in a computer-based format with a time limit of one minute per mark, as is the expected practice at the Faculty of Veterinary Science, University of Pretoria. The students were permitted to use any "open resources" which included textbooks and other printed material, notes, as well as internet resources, except were prohibited from communicating with their peers or practitioners.

Data were analysed comparing the specialists' (group 1) Angoff cut-scores to the generalists' (group 2) Angoff cut-scores to determine which of the groups was more accurate at determining cut-scores using the students' performance as a reference value for an appropriate standard.

The question was raised as to whether there were better criteria (than specialist registration or recognition as previously described in the criteria for the specialist group) that could be used to choose a similar smaller group of judges to provide accurate results in determining cut-scores. The following information was used from the questionnaire:

1) Number of years' experience.

2) Proportion of time spent with small ruminants.

3) Congress attendance frequency.

Number of years' experience and proportion of time spent with small ruminants were classified as ratio data (Allen & Seaman, 2007).

Congress attendance was categorised for data analysis purposes: judges attending congresses less frequently than once every four years were given a score of 0, judges attending congresses once every four years, once every three years, once every two years, once a year and more than once a year were scored as 1,2,3,4 and 5 respectively. This was classified as ordinal data (Allen & Seaman, 2007).

A further investigation was performed to determine if one of these independent variables, namely proportion of time spent in practice on small ruminants, number of years' experience or congress attendance frequency, could provide a better criterion for use in selection of the smaller judges' panel, rather than specialist registration. A simple linear regression was used to determine which of these variables as described above were the most accurate at determining cut scores. A final simple regression model showed that the small group of small ruminant practitioners are better able to determine cut scores. Thus, a group of practitioners declaring that they spent more than 70% of their time in small ruminant practice (sheep and goats) were chosen (group 3) and compared to mixed practitioners (group 4). In determining the cut-off of 70% of time with small ruminants, the decision was firstly based on the fact that 20% of the respondents fitted this category (the other 80% being designated to the generalist group). Secondly, because the next judge on the list (when ranked according to the percentage of time spent with small ruminants) only spent 50% of his/her time with small ruminants and could, therefore, not be considered as spending the majority of his/her time in small ruminant practice. This categorisation resulted in two of the original specialists being excluded from the small ruminant practitioner group (as even though they were registered specialists, they spent a large proportion of their time in practice on other species), with three new practitioners being added based on time spent with sheep and goats. These three additional small ruminant practitioners had not been in practice for more than 15 years and did not fit the criteria to be part of the specialist group (group 1), however, they did spend the majority of their time in small ruminant practice. As Senthong and others (2013) used only 3 judges per group and Shulruf and others (2016) proposed 15 judges, the resultant number of judges in the small ruminant practitioners group (n=7) was considered to be sufficient, and was comparable to the number of judges in the specialist group (n=6).

The Angoff cut-scores were calculated as the mean cut-scores, using the cut-scores supplied by the veterinarians per question for each group of judges.

The data were tested for normality using the Shapiro-Wilk test (Shapiro & Wilk, 1965; Rani Das & Rahmatullah Imon, 2016). While the judges scores were normally distributed within each of the four groups (specialists = 0.245, generalists = 0.576, small ruminant practitioners = 0.529 and general practitioners = 0.505), the students' results within the revised Blooms levels were not normally distributed (0.043), and considering that the group sizes differed greatly, the non-parametric Mann Whitney U test was used to compare the test scores of the students to the Angoff cut-scores of the practitioners in order to be consistent within the methodology. The Pearson's correlation between the Angoff cut-scores and the actual student scores were calculated and the significance of the correlations were evaluated (the null hypothesis states that the correlation is not significantly different from zero). To determine whether correlations differed significantly, the Fishers' Z transformation (Fisher, 1915) was used.

It was further investigated whether cognitive level (revised Bloom) may have had an effect on both student performance and Angoff cut-scores. It was again determined which group was better at predicting student performance, within each of the revised Bloom's categories. As the revised Bloom's levels is ordinal in nature, the Spearman's rank correlation was calculated to evaluate if there is a relationship between the students' test scores and the two Angoff categories of judges cut-scores when the scores were evaluated per Blooms level.

3.1.1.4 Results

Assessment scores as obtained by the judges prior to assigning cut-scores were recorded and are summarised in Table 3.1.

Table 3.1: Average assessment scores for the different groups of judges

	Smaller group of expert judges		General practitioners	
Investigation	**n**	**Median (IQR)**	**n**	**Median (IQR)**
Comparing specialists and generalist (groups 1 and 2)	6	73.27 [a] (70.30; 85.15)	29	59.41 [b] (54.46; 63.37)
Comparing small ruminant practitioners and general practitioners (groups 3 and 4)	7	73.27 [a] (63.37; 84.15)	28	58.91 [b] (53.96; 64.85)

[a,b]Medians with different superscripts in rows, differ significantly ($p < 0.05$)

Comparison of specialists (group 1) and generalists (group 2)

A comparison of the specialists' (group 1) Angoff cut-scores and the generalists' (group 2) Angoff cut-scores against student scores can be seen in Figure 3.1.

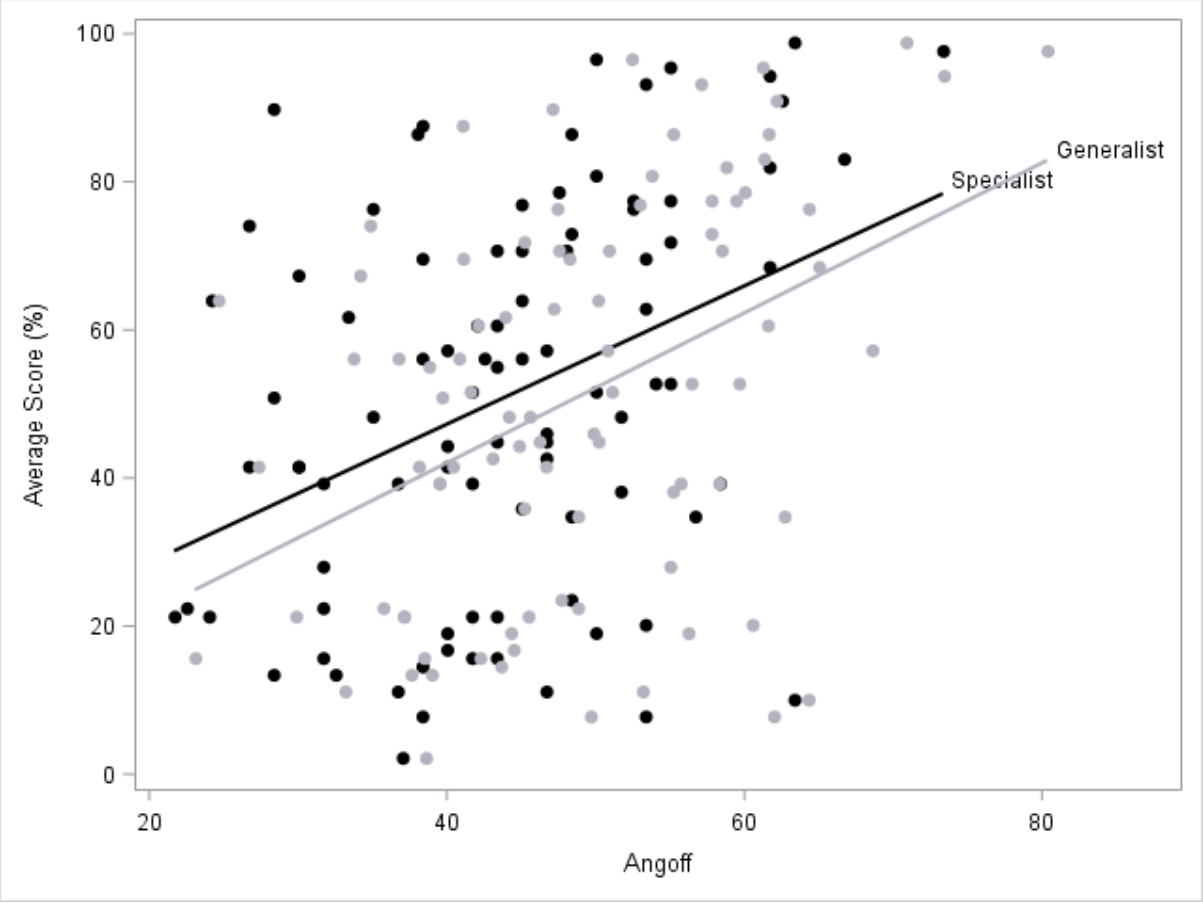

Figure 3.1: Comparison of Angoff cut-scores of the specialists (group 1) and generalists (group 2) to the students' test scores

The correlations between the student scores and the Angoff cut-scores of the specialists (p=0.0002) generalists (p<0.0001) and were significantly different from zero. The results of the Fisher's Z transformation indicated that the two sets of correlations are not significantly different from each other (p=0.76).

The difference between the two regression lines was evaluated and found to be similar with intercepts (p=0.6002) and slopes (p=0.8142), hence illustrating that the characteristics of the regression lines are not significantly different.

Comparison of small ruminant practitioners (group 3) and general practitioners (group 4)

A comparison of the small ruminant practitioners' (group 3) Angoff cut-scores and the general practitioners' (group 4) Angoff cut-scores against student scores can be seen in Figure 3.2.

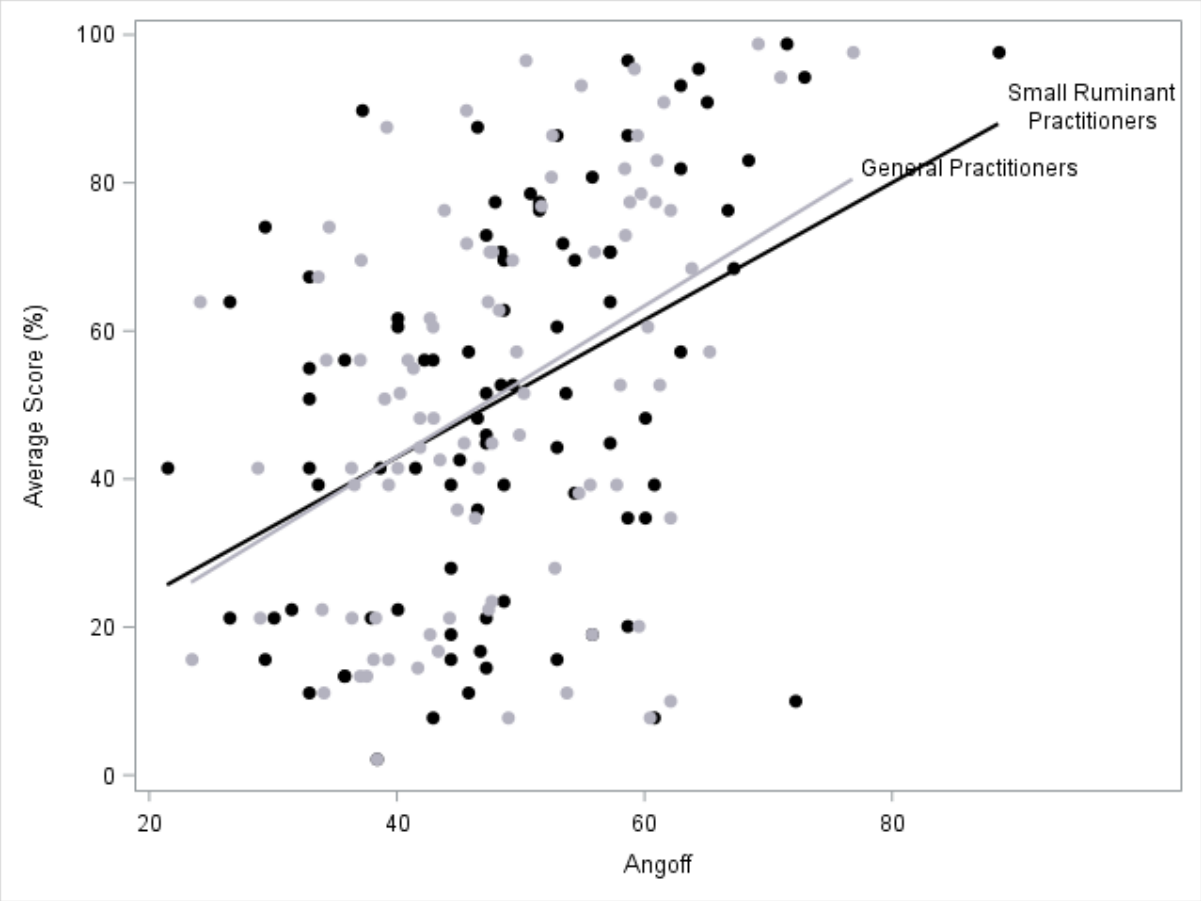

Figure 3.2: Comparison of Angoff cut-scores of the small ruminant practitioners (group 3) and general practitioners (group 4) to the students' assessment scores

The correlations between the student scores and the Angoff cut-scores of the small ruminant practitioners (p <0.0001) and general practitioners (p<0.0001) and were significantly different

from zero. The correlation between Angoff cut-scores of the small ruminant practitioners and the general practitioners was not significantly different (p=0.94) (Fisher, 1915).

The difference between the two regression lines was also evaluated and found to be similar with the intercepts (p=0.8199) and slopes (p=0.7739) hence illustrating that the characteristics of the regression lines are not significantly different.

Relationship between student scores and Angoff cut-scores per revised Bloom's level

It was investigated whether there was a relationship between the students' test scores and the Angoff cut-scores per revised Bloom's level for generalists vs specialists and general practitioners vs small ruminant practitioners (Figures 3.3 & 3.4 respectively).

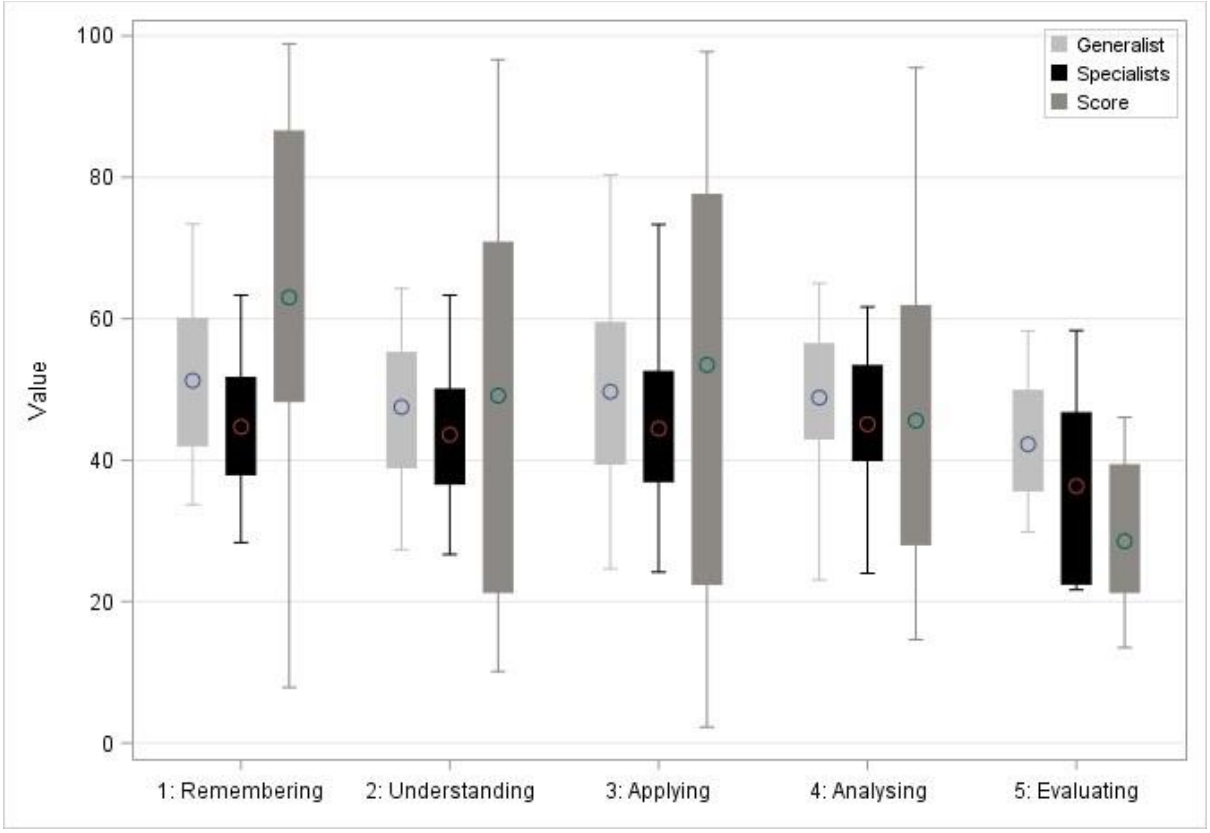

Figure 3.3: Comparison of Angoff cut-scores of the generalists (group 2) and specialists (group 1) with student performance (score) according to revised Bloom's levels

The results show that no significant relationship exists between the student scores and the Angoff cut-scores of the specialists (group 1) (r = 0.4, p=0.51) but a significant relationship exists between the student scores and the Angoff cut-scores of the generalists (r = 0.9,

p=0.04) when analysed according to the revised Bloom's levels (Figure 3.3).

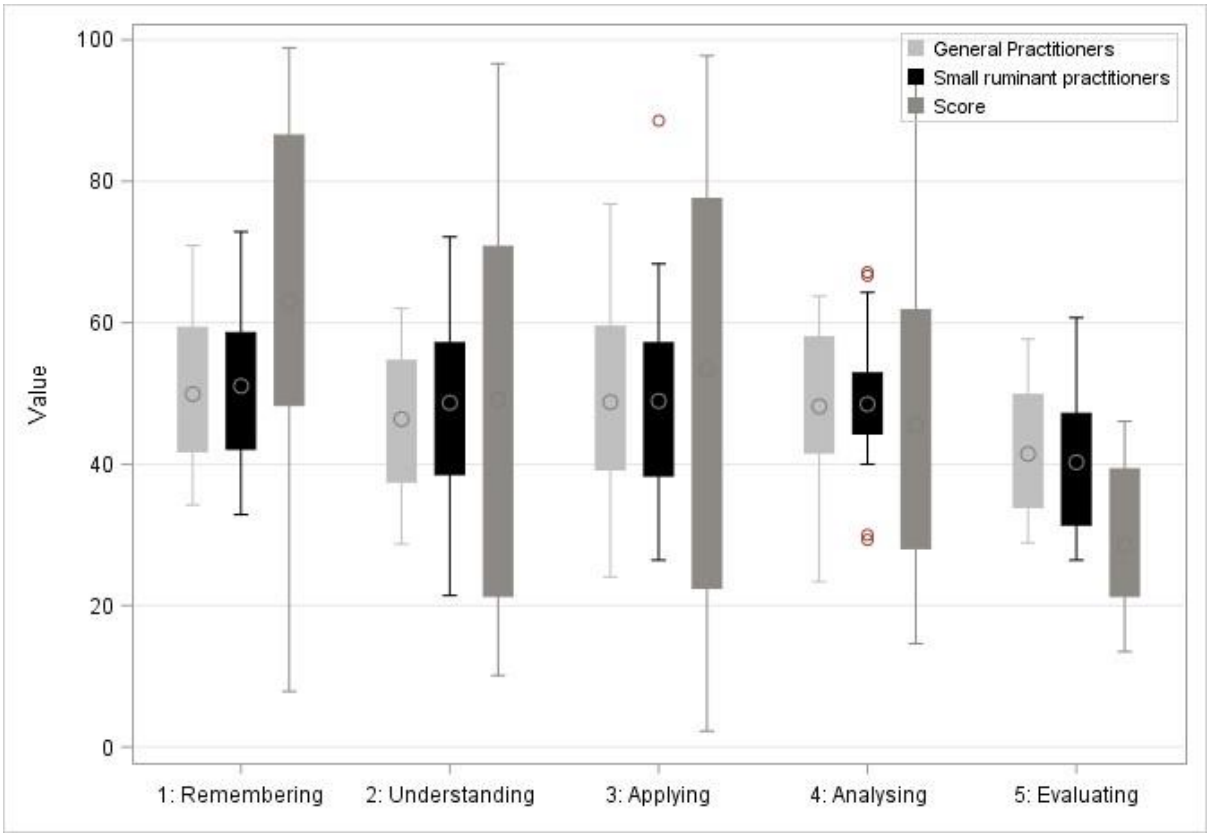

Figure 3.4: Comparison of Angoff cut-scores of general practitioners (group 4) and small ruminant practitioners (group 3) to student performance (score) according to revised Bloom's levels

The results show that a significant relationship exists between the test scores and the Angoff cut-scores for both the general practitioners ($r = 0.9$, $p = 0.0374$) and small ruminant practitioners ($r = 1.0$, $p<0.0001$) respectively (Figure 3.4).

The results in Table 3.2 compare the Angoff cut-scores and student scores to the ordinal Bloom's level and show that only the student scores and the small ruminant practitioners (group 3) had a significant relationship with the revised Bloom's levels.

Table 3.2: Spearman's correlations of all four Angoff cut-scores groups and student's scores with revised Bloom's level

Scores	Spearman's Correlation (r)	p-value
Student scores	-0.9	0.0379*
Angoff cut-scores specialist (group 1)	-0.3	0.6238
Angoff cut-scores generalist (group 2)	-0.7	0.1881
Angoff cut-scores small ruminant practitioners (group 3)	-0.9	0.0374*
Angoff cut-scores general practitioners (group 4)	-0.7	0.1881

For these four different Angoff cut-score groups, simple linear regression models were analysed in order to determine which group could best predict the student performance. The different models were compared using the coefficient of determination (R^2) in order to determine which Angoff cut-score resulted in the best predictions as can be seen in Table 3.3.

Each regression model consisted of the student score (per question) as the dependent variable with the Angoff cut-scores as the independent variable.

Table 3.3: Summary of regression R^2 results for the four different Angoff cut-score groups

Angoff cut-score group	R^2
Specialists (group 1)	0.1465
Generalists (group 2)	0.1780
Small ruminant practitioners (group 3)	0.1795
General practitioners (group 4)	0.1712

Table 3.4 summarises the correlations between the student scores and the Angoff cut-scores of the four different groups. All correlations are significantly different from zero.

Table 3.4: Summary of correlations between student scores and Angoff cut-scores for the different groups

Angoff cut-scores group	Pearson's correlation (r)
Specialists (group 1)	0.3827
Generalists (group 2)	0.4219
Small ruminant practitioners (group 3)	0.4237
General practitioners (group 4)	0.4138

3.1.1.5 Discussion

The p-values in Table 3.1 tested whether there was a significant difference between the assessment scores obtained by the smaller groups (groups 1 and 3) when comparing the results to the larger groups (groups 2 and 4). The non-parametric Mann-Whitney U test was used and since both groups had a p-value less than 0.05, it can be stated that the smaller groups (groups 1 and 3) had significantly higher test results than the larger groups (groups 2 and 4). This validated choosing these specific practitioners as the expert judges.

After analysing the data comparing specialists (group 1) to generalists (group 2) Angoff cut-scores, it was found that the larger group of generalists (group 2) were better at predicting the student performance than the specialists so it would seem that this would confirm what previous studies have found in that the larger groups are more accurate (Shulruf *et al*., 2016). This group tended to have a higher association between Angoff cut-scores allocated and students' scores (Figure 3.1). However, the specialist and small ruminant practitioner groups (groups 1 and 3 respectively) performed better in the assessment than the generalist and general practitioner groups (groups 2 and 4 respectively) as can be seen in Table 3.1. When taking revised Bloom's levels into account, the small ruminant practitioners were the better fit. Although the R^2 values are low (Table 3.3), the aim of this study was not to predict student performance as such, but rather to determine which group of judges would be the best to use as a smaller group of experts. However, students were not afforded the opportunity to study prior to the assessment and despite having access to resources, they were expected to complete the assessment within the usual exam time limit. Therefore, the average scores obtained by the students more closely reflected the scores that would be obtained by the borderline student who typically achieves 50% for an assessment. Thus, the cut-scores allocated by the judges correlated with the students' scores and so they could be used in this instance to predict student performance. Student scores can in this case be used to validate the accuracy of the judges cut-scores. Of the four groups that were compared in this study,

the small ruminant practitioners (group 3) provided the best solution when selecting a small group of expert judges. Although this group achieved higher assessment scores (Table 3.1), their Angoff cut-scores were more strongly associated with revised Bloom's levels, as were the students (Table 3.2). Thus, this group considered the cognitive level or degree of difficulty of a question when allocating an Angoff cut-score that was more closely aligned to the students' performance. This is an important consideration when selecting a panel of expert judges.

It is important to include revised Bloom's levels in both assessments and when determining student performance. The effect of revised Bloom's and the association between Angoff cut-scores and student performance respectively can be seen in Figure 3.5. In this study the judges were not made aware of the revised Bloom's levels in order to avoid bias. Further research could show different results if these cognitive levels are known by the judges and may thus influence Angoff cut-scores.

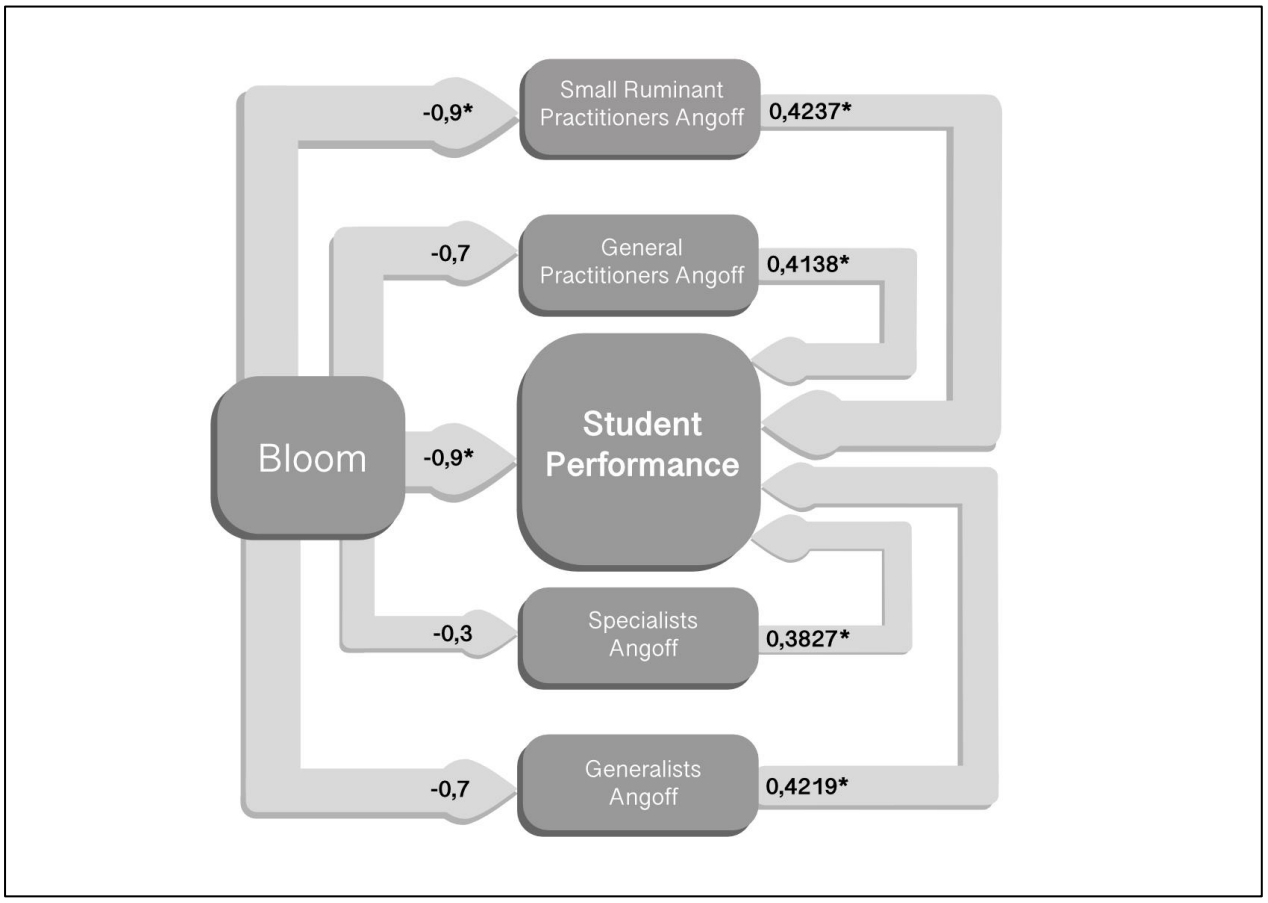

*Figure 3.5: Associations between revised Bloom levels, Angoff cut-scores and student performance. *Indicates values where there are significant differences (refer to Tables 3.2 and 3.4)*

The focus of this study is on small ruminant veterinary practitioners in South Africa. There were certain limitations when conducting this study. Firstly, the researcher was involved in the setting and evaluating of assessments in this module and thus a certain amount of bias

can be expected when allocating Bloom's levels. This was the reason for including the education specialist in this area. Secondly, purposive sampling was used for selecting judges to participate in the study and thus the generalizability of the findings to other fields is decreased. Lastly, additional information on the students and judges such as gender, race, background (of the students as all judges were from ruminant practices) and economics were not included in the analysis of the data and these variables may have confounded the results. However, the principles can be applied internationally and similar studies in other countries and disciplines can broaden the scope of such a study.

3.1.1.6 Conclusion

It is concluded that the most reliable criteria for selecting a smaller group of judges to set Angoff cut-scores, when the judges cannot be convened in one place, is the proportion of time spent on the specific discipline. In this study it was the group of small ruminant practitioners (group 3) that were better able to predict student performance. Other studies comparing groups of expert judges with regards to sizes of different groups have not considered the cognitive levels of the questions asked when assigning cut-scores; yet such must be taken into consideration in future studies to improve the accuracy of criterion-referenced methods of standard setting.

Acknowledgement

The authors would like to thank the University of Pretoria for Funding received from the University of Pretoria's Vice Chancellor's Grant, Ms Sandra Wilkinson for assistance in formatting the document and Mr Akhil Rampersadh for assisting with the graphic design of Figure 3.5.

References have been moved to the relevant section of the thesis.

3.1.2 EVALUATING THE CONTENT AND LEVEL OF THE ASSESSMENT

In addition to giving the Angoff values in the above article, the veterinarians who participated were asked to categorise each question to determine where in the meristem the content belonged. This is purely opinion-based, but the aim was to determine whether the content covered in the assessment belonged in the module or not.

3.1.2.1 Method

The categories provided for the veterinarians to allocate a level for each of the questions, in the previously described assessment, were as follows:

0 = Irrelevant to the module

1 = Foundational knowledge

2 = Core knowledge

3 = Specialist knowledge

Questions where more than 40% of the respondents indicated the question to be at level 0 or 3, were flagged as potentially problematic. Initially the level allocations of the entire veterinary group were evaluated as a whole. In order to determine why these had been allocated into either the specialist or irrelevant categories, the questions were then re-evaluated in two groups: specialists and general practitioners. Further, the levels assigned by the veterinarians was compared to scores that they obtained for the questions to determine if there was a correlation between scores obtained and the level allocated.

In order to determine if there is a relationship between the veterinarians' test scores and the chosen levels, the Spearman's Correlation Coefficient was calculated. A positive value indicated a positive relationship, a negative value indicated a negative relationship. The closer to 1 (or -1) the correlation coefficient, the stronger the relationship. Value between -0.5 and 0.5 were considered weak relationships. Additionally, the significance of the relationships was tested at a 5% level of significance. The null hypothesis states there is no correlation while the alternative hypothesis states that there is a correlation between the two variables.

3.1.2.2 Results

The results are presented in the figures below. Questions in which the veterinarians selected the options of foundation knowledge or core knowledge were considered to be appropriate, whereas questions with high numbers of irrelevant or specialist options (total of more than 40% combined) were flagged as potentially problematic.

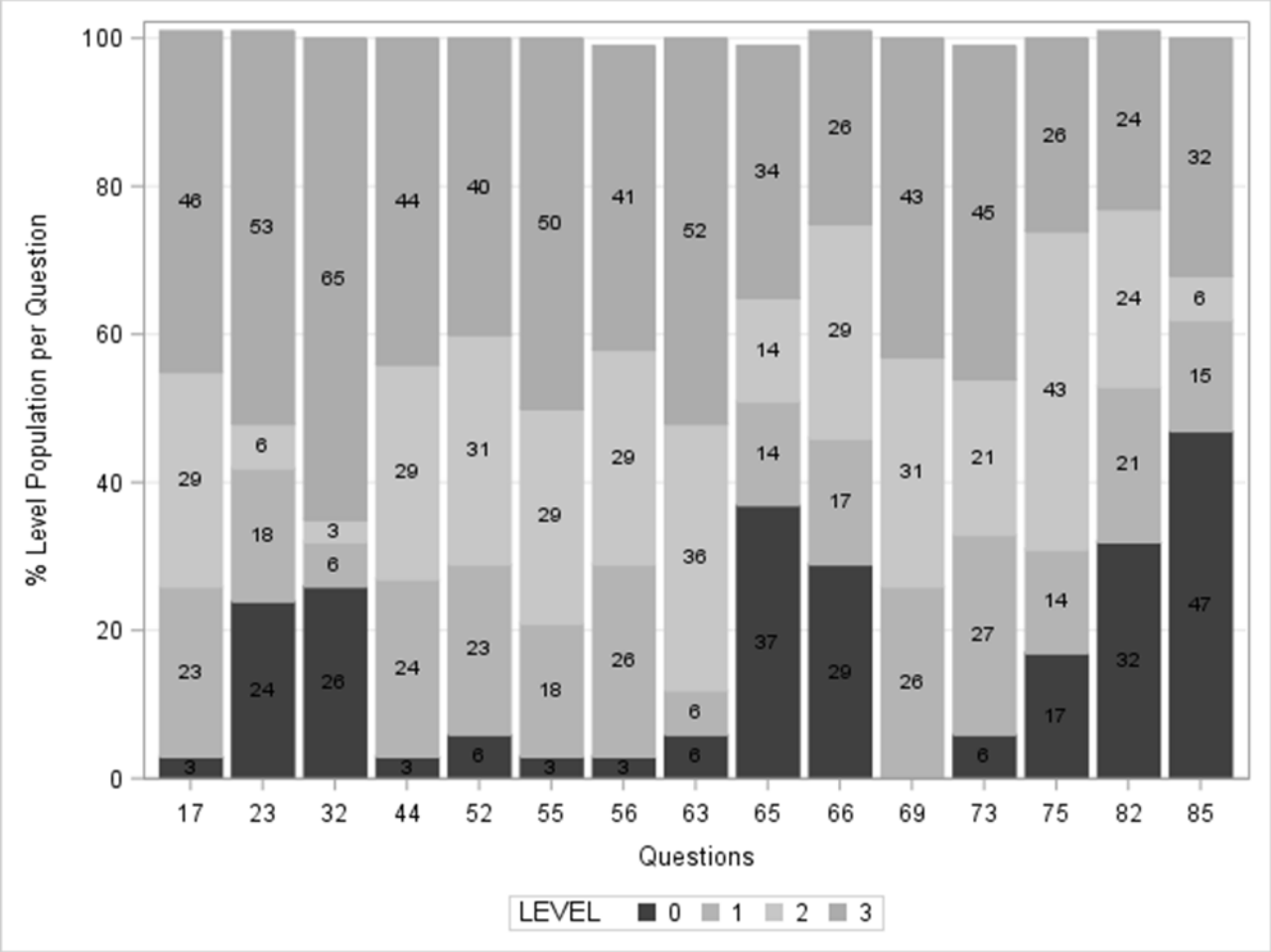

Figure 3.6: Question numbers that were flagged as having too many veterinarians (greater or equal to 40%) classify the question as irrelevant or at a specialist level (0 = irrelevant; 1 = foundational knowledge; 2 = core knowledge; 3 = specialist knowledge)

Figure 3.6 shows which questions were flagged. Flagged questions from nutrition (17), economics (23), reproduction (32, 44, and 56), perinatal (52), internal parasites (55), lameness (69), selection and culling (73) topics were considered by most respondents to be aimed at the specialist level. Further questions from economics (63 and 85), vaccines (65), pathology (66) and biosecurity (75 and 82) had mixed numbers of respondents considering them to be either irrelevant or at the specialist level. From the histogram it can be seen that the topics with the most flagged questions were from economics and reproduction with three flagged questions each and biosecurity with 2 flagged questions.

General practitioners' opinions compared to specialists' opinions on the level of the questions

As category 4 referred to specialist level questions, the specialist group of practitioners as described in 3.1 above was used and the rest of the practitioners were included in the general practitioner group.

The general practitioner group's responses are captured in 3.7 below.

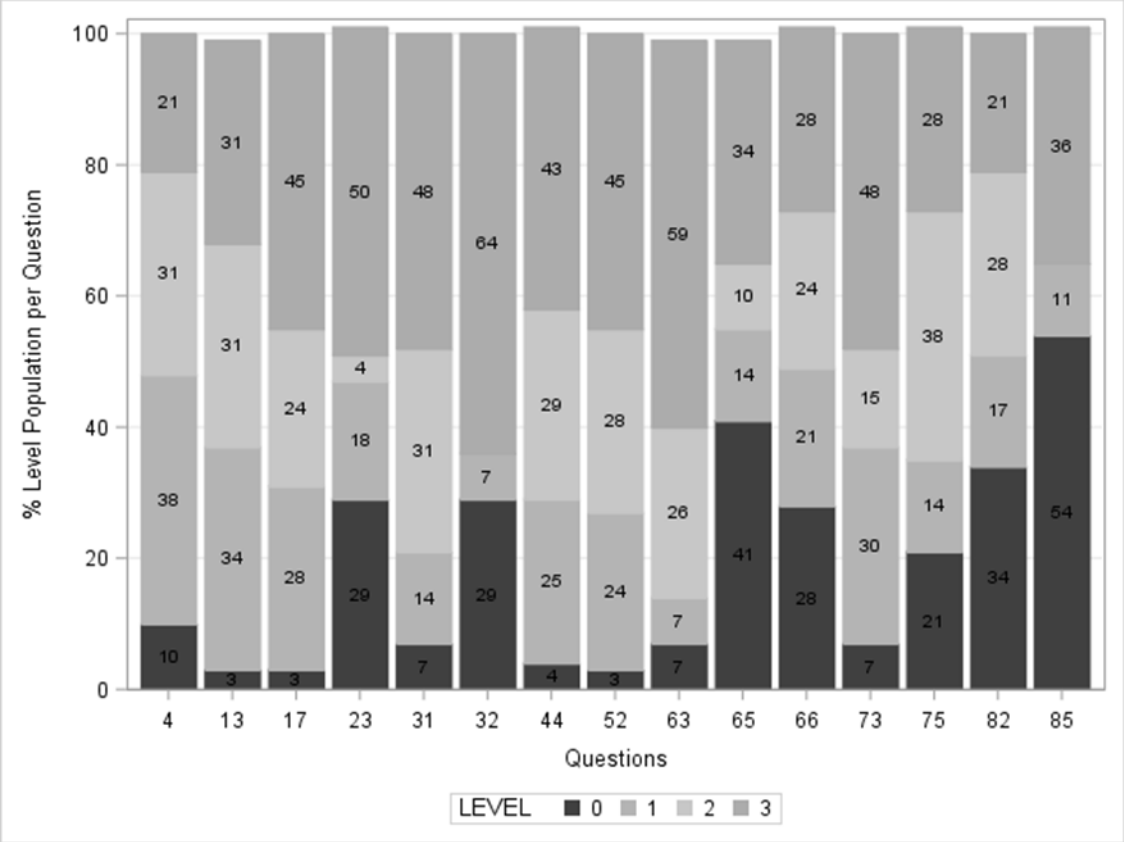

Figure 3.7: General practitioners' allocations to level of knowledge per question showing only flagged questions.

The specialist practitioner group's responses are captured in 3.8 below.

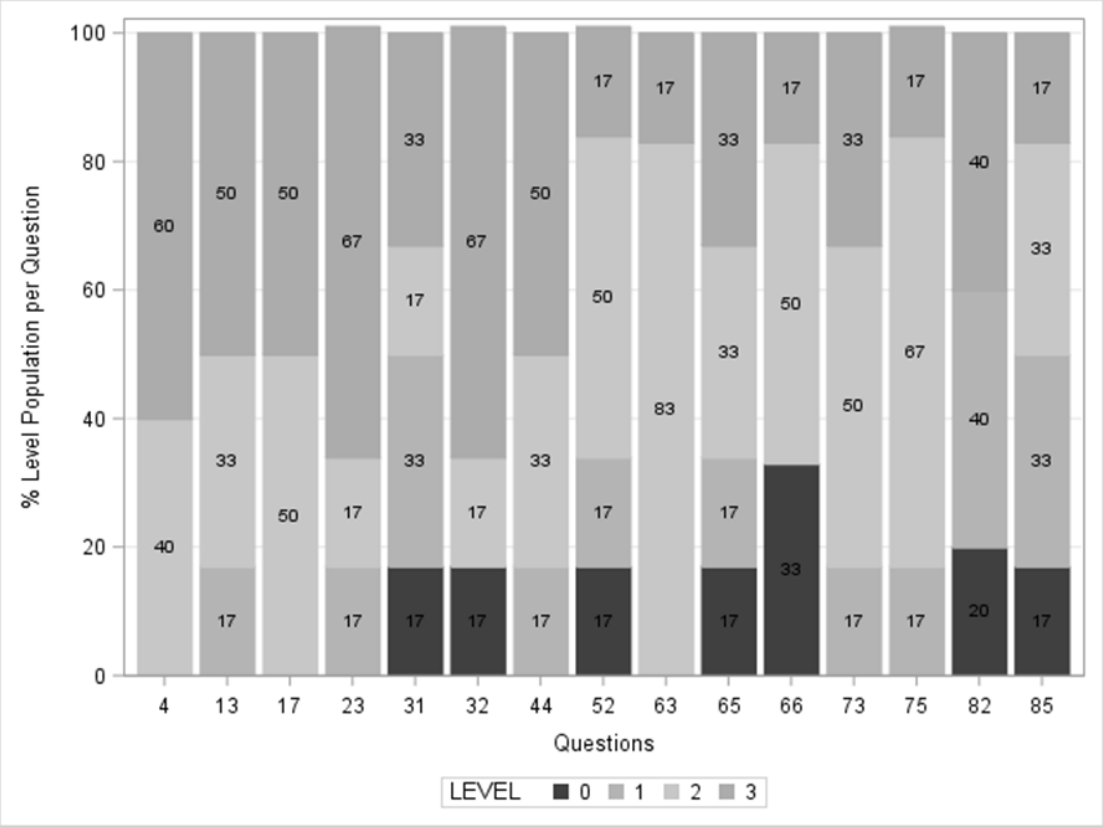

Figure 3.8: Specialists' allocations of level of knowledge per question showing only flagged questions.

From Figures 3.7 and 3.8, the following observations are made:

It can be seen that the specialists were of the opinion that question 4, dealing with nutrition, was aimed at specialist level. However, general practitioners did not tend to agree which is why it was not flagged when dealing with the group of veterinarians as a whole. The specialists indicated that questions 13 (economics) and 17 (nutrition) were at a specialist level. However, only question 17 was considered to be at specialist level by both groups of veterinarians. This question concerned prussic acid poisoning, and is a problem frequently encountered by practitioners. It is unclear why both groups considered it to be at a specialist level.

Both specialists and generalists agreed that question 23 (economics) was at a specialist level. However, the specialists did not categorise it as irrelevant as did some of the general practitioners.

Questions 31 (reproduction) and 32 (management) were categorised as either irrelevant, core or specialist by the specialist practitioners, and as irrelevant, foundation or specialist by the general practitioners. This question involved a specific breeding system. Question 44 (reproduction) was shown as being considered more strongly by the specialists than the general practitioners to be at specialist level. Some general practitioners categorised it as

irrelevant, yet the specialists did not express that same opinion. Question 52 (perinatal mortalities) was considered to be at specialist level when evaluated by all the practitioners. However, the specialists did not contribute to this perception and it is clear that only the generalists perceived it to be at specialist level. This question dealt with abortions and the perinatal period.

Question 63 (vaccinations) was mostly only considered to be at the specialist level by the general practitioners. Question 65 (economics) was a potential problem question (more so for the generalists, but was still flagged by the specialists). Question 66 (pathology) was not flagged by the specialists, but was by the generalists as either irrelevant or specialist and was a question concerning rabies which is an important zoonosis.

Question 73 (selection and culling) was mostly considered to be aimed at the specialist level by the general practitioners. Question 75 (biosecurity) again saw the generalists viewing the question as either irrelevant or at a specialist level. This question was based on biosecurity involved with ovine Johnes' disease, an important production disease confined to certain parts of the country.

Question 82 (biosecurity), although receiving some core allocations was evaluated as mostly foundation by the specialists and irrelevant by the general practitioners. This question concerned biosecurity in terms of diseases currently in South Africa that affects sheep in other countries, but not in South Africa. Question 85 (economics) was again viewed as either specialist or irrelevant by the majority of the general practitioners, yet not by the specialists.

The following view (Figure 3.9) represents the percentage of each level's representation per topic.

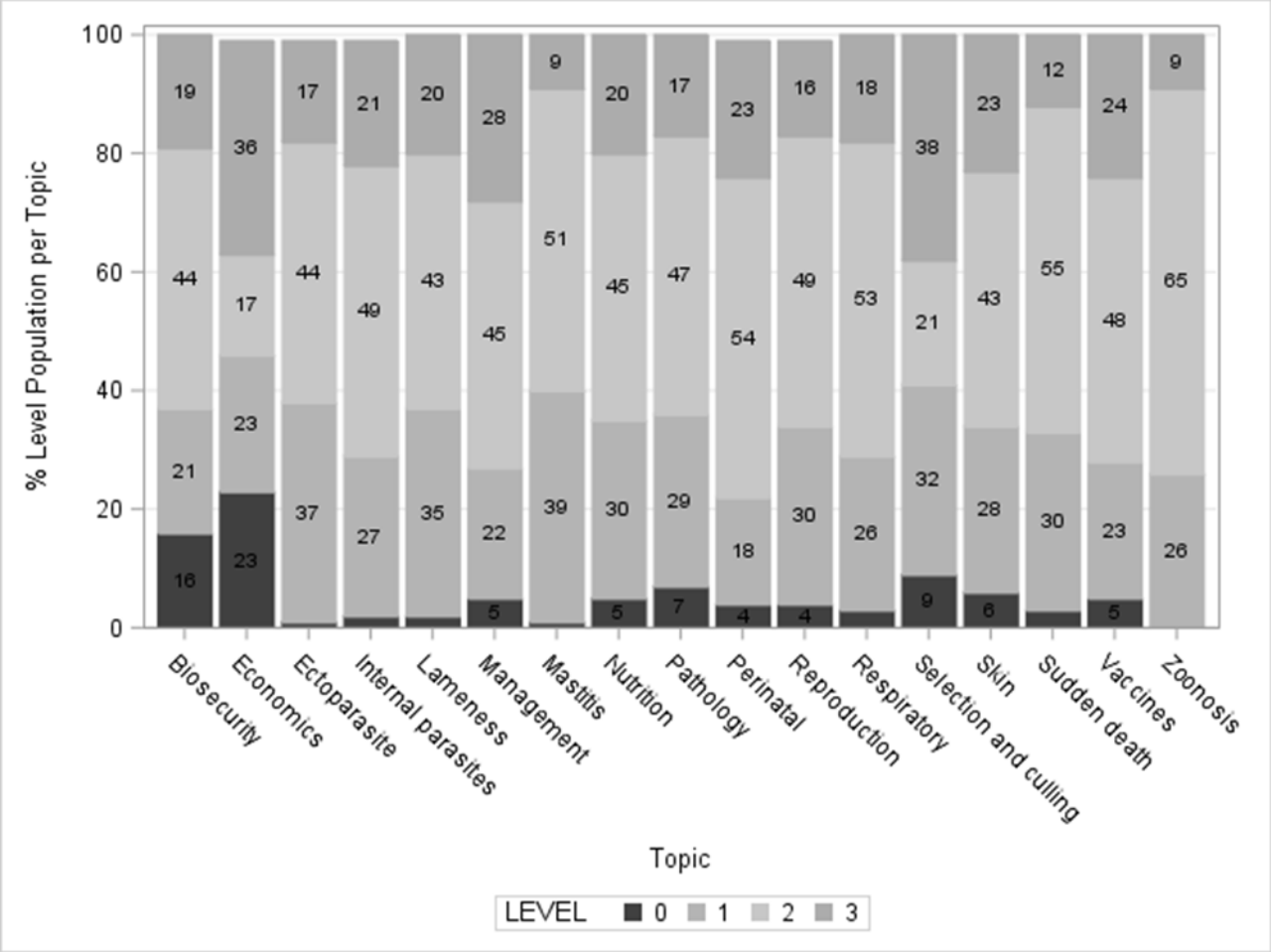

Figure 3.9: Summary of the percentage of levels allocated per topic for the combined veterinary practitioner group

It can be seen that economics and selection and culling are flagged as potentially problematic topics (Figure 3.9). Selection and culling should be investigated further as the core component of the level population is also considered too small.

Once again, dividing the group up into generalists and specialists is seen in the following figures. Figure 3.10 and 3.11 display the percentage of the level population per topic.

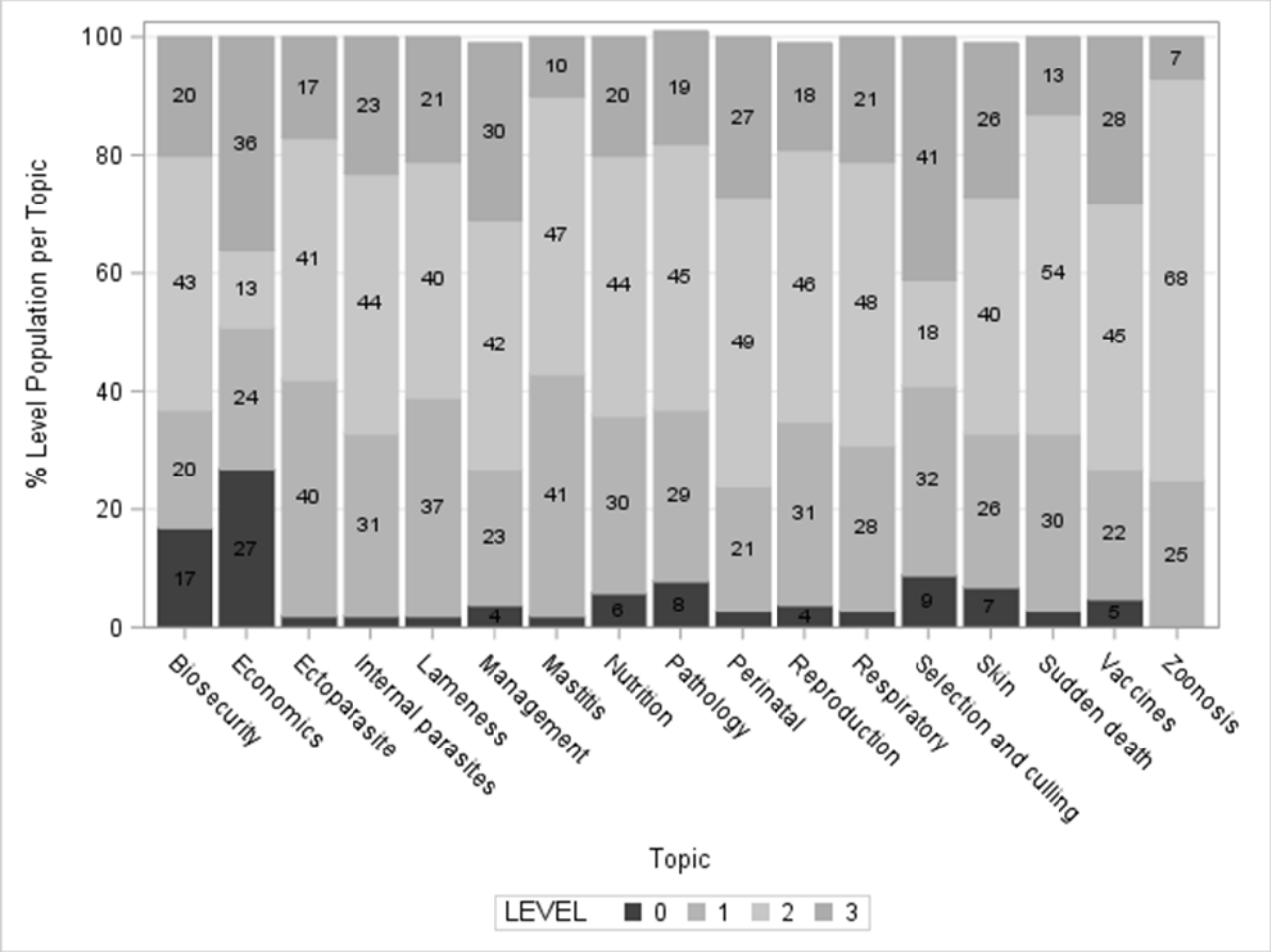

Figure 3.10: Summary of the percentage of levels allocated per topic for the general practitioner group

Economics and selection and culling are flagged by the general practitioners (Figure 3.10) but not by the specialists (Figure 3.11).

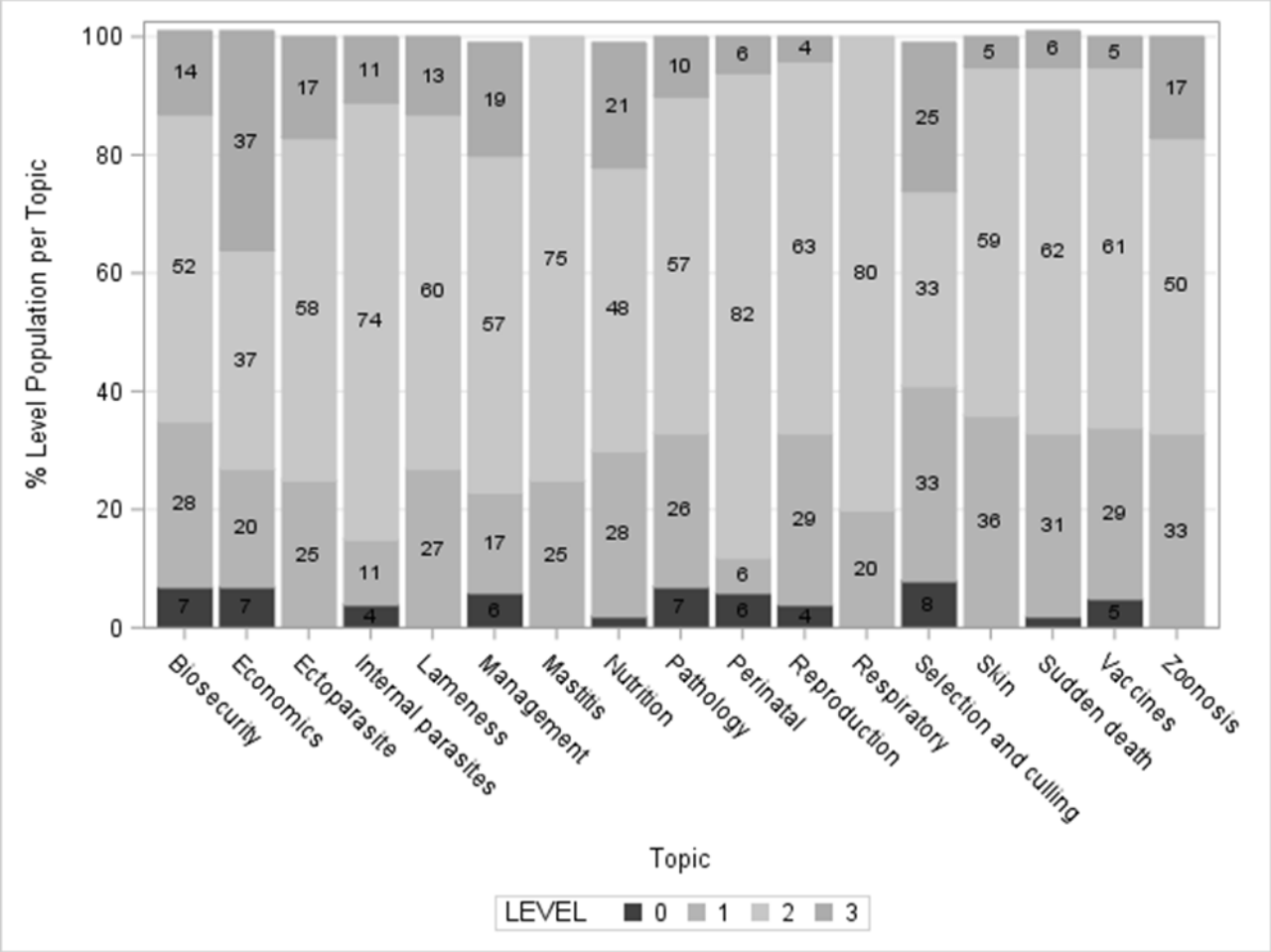

Figure 3.11: Summary of the percentage of levels allocated per topic for the specialist group

The following figures (Figures 3.12 & 3.13) display the number of times the veterinarians chose the certain levels per topic.

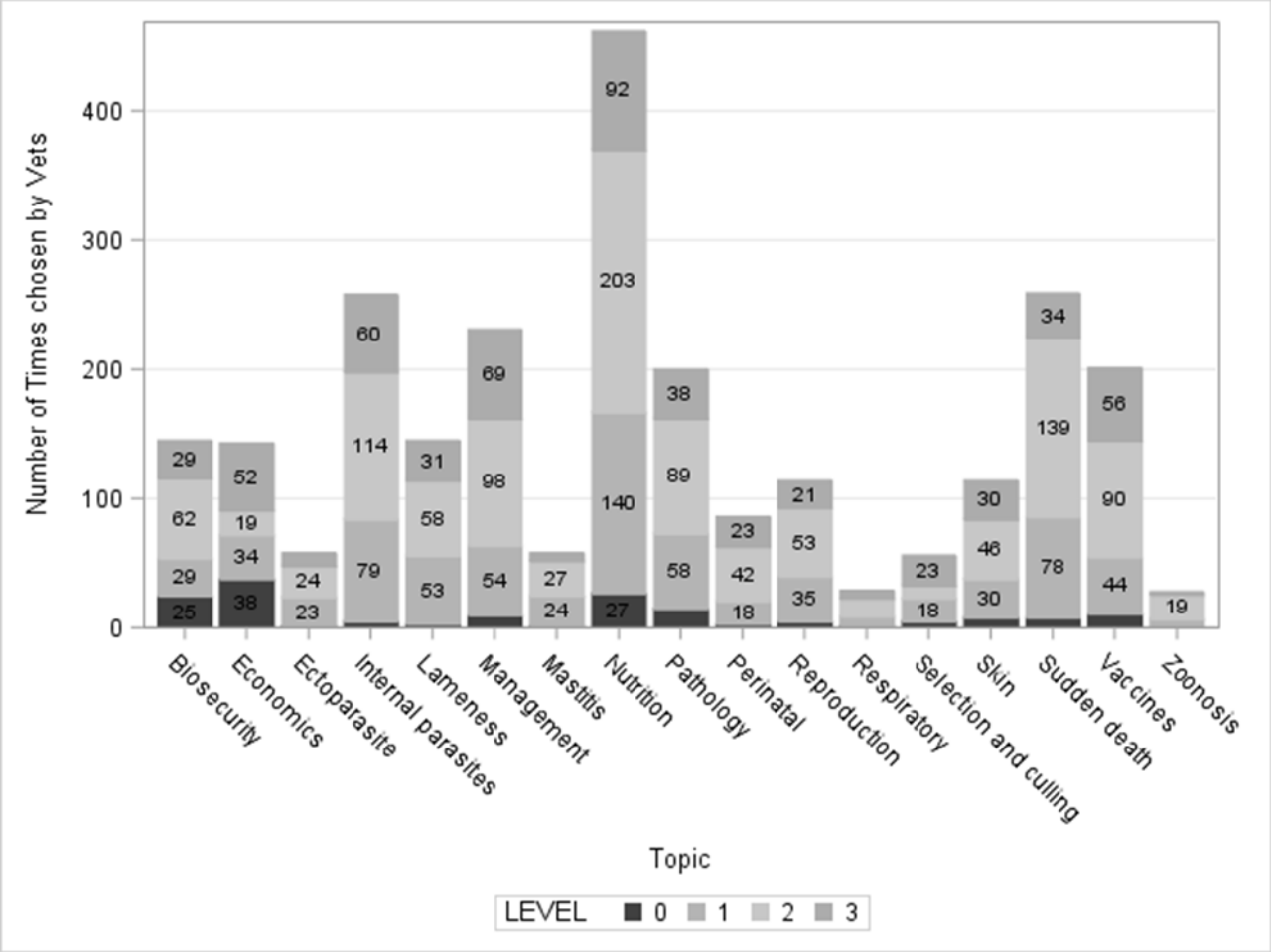

Figure 3.12: Summary of the number of times levels were allocated per topic by the general practitioners

Figure 3.12 shows the number of times practitioners chose certain levels compared to figure 3.13 showing the number of times levels were chosen by specialists.

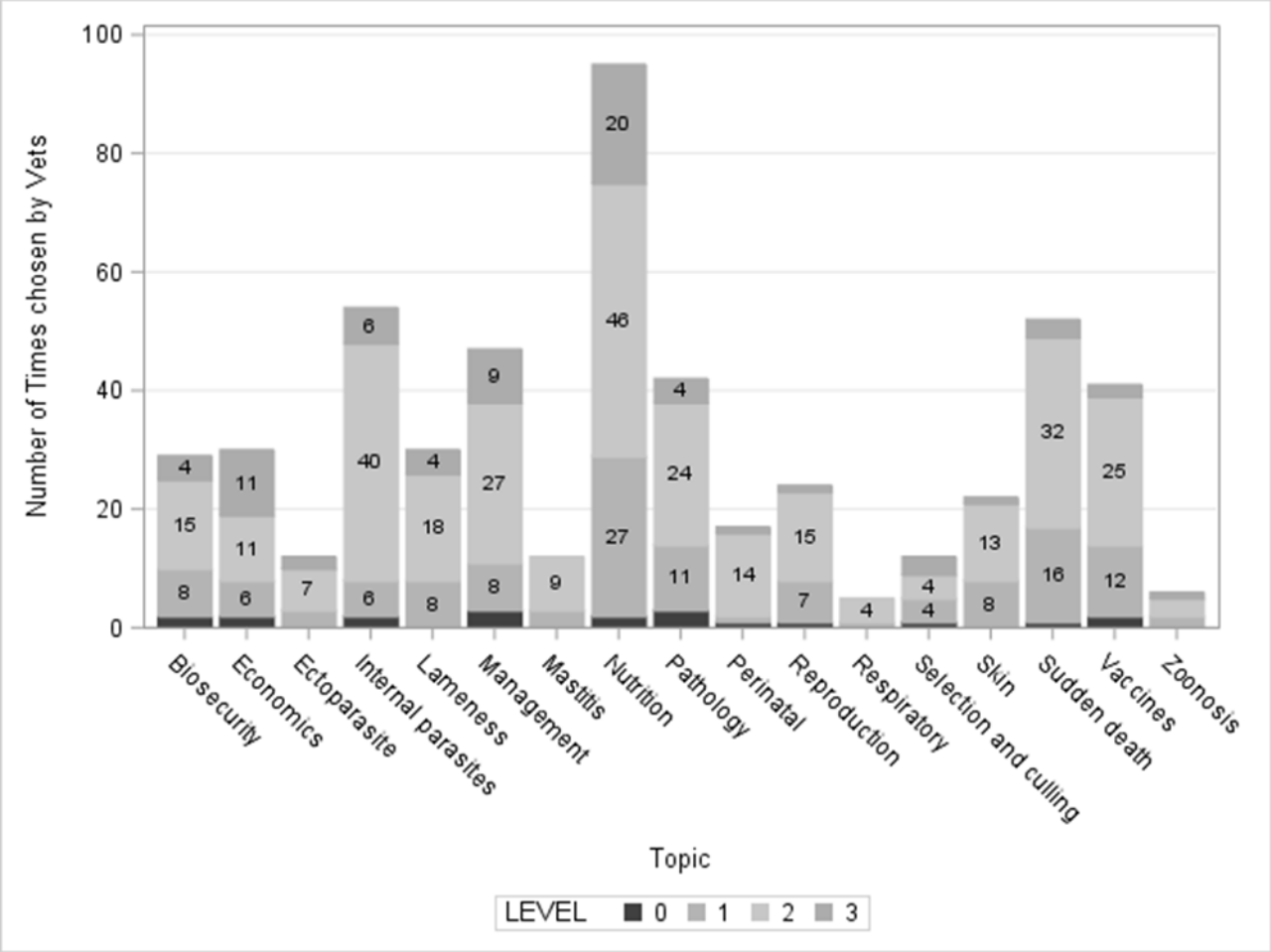

Figure 3.13: Summary of the number of times levels were allocated per topic for the specialists

Figures 3.12 and 3.13 show that each topic did not have an equal number of questions, but also show that the general practitioners were more likely to select a topic as irrelevant or specialist than the specialist group. The main topic of concern was economics.

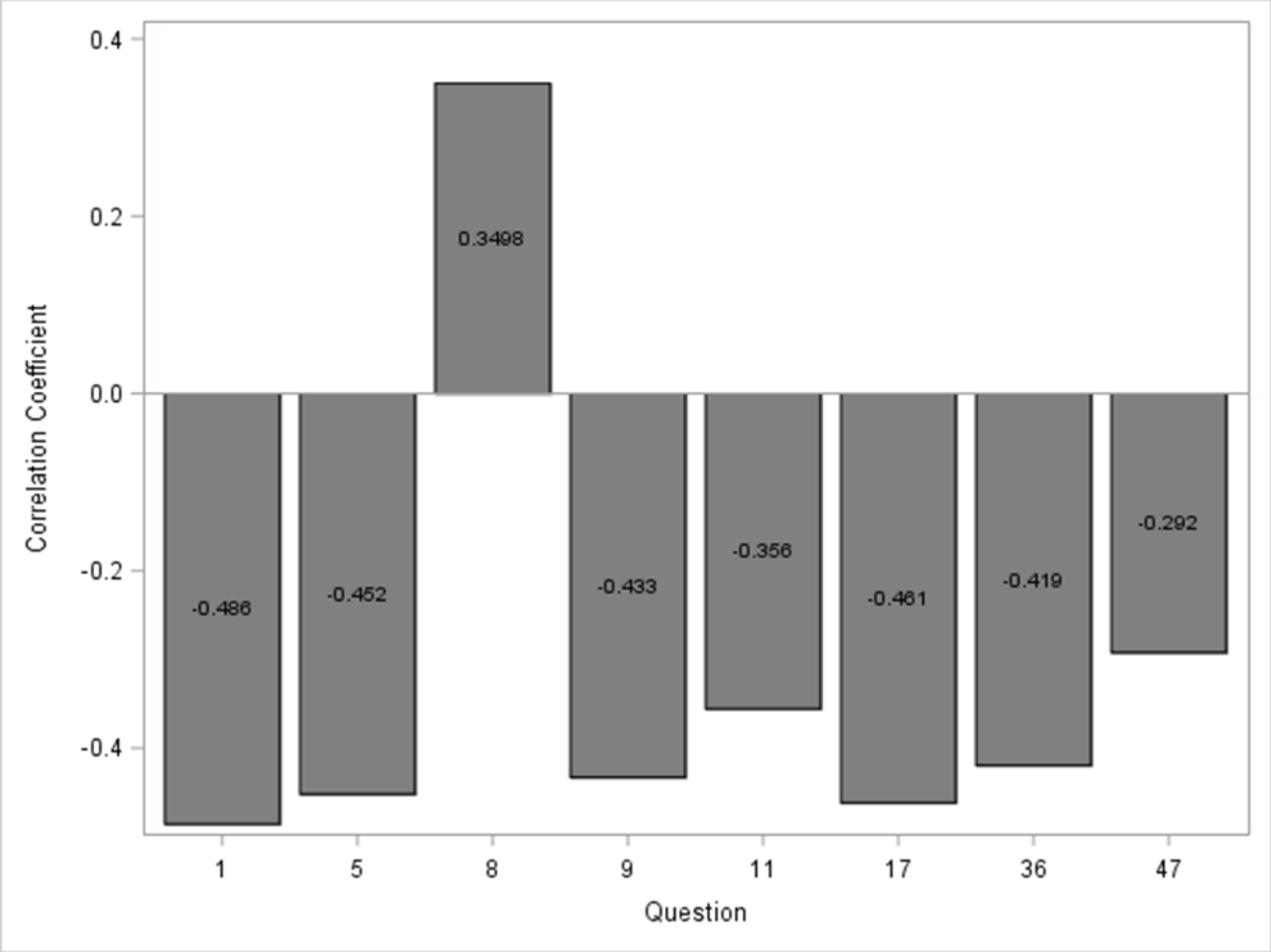

Figure 3.14: Correlation results for veterinarians' scores and levels allocated for questions. Only significant correlations are shown

Only eight of the 90 questions had significant correlations between the scores obtained by the veterinarians and the level allocated by the veterinarians as can be seen in Figure 3.14 above.

These questions were from the lameness, reproduction, internal parasites, nutrition, pathology and skin conditions sections of the work. All these questions fell into the lower cognitive level categories with questions 9, 11 and 47 as the highest in the group being "applying" questions.

3.1.2.3 Discussion

It is unclear why some topics (for example question 17 on prussic acid poisoning) are considered by practitioners to be at a specialist level even though it is frequently encountered in practice. Considering the effect of revised Bloom's levels seen from the study in 3.1 above, it can be deduced that it may be the cognitive level at which the question was set, rather than the topic of the question that prompted the practitioners to consider the question to be at a specialist level. This is investigated further in Chapter 4 where clinical experience and revised Bloom's levels are investigated for the different categories of experience for veterinarians.

In general, the specialists considered far fewer questions to be irrelevant than the general practitioners. This could be because the specialists can see how these questions fit in at a higher cognitive level. An example was question 66 where generalists felt the question to be either irrelevant or specialist. The question was on rabies and considering the recent rabies epidemic, one would think it should definitely be core material for a day one competent veterinarian.

The specialists allocated cut-scores independently of their personal scores for the assessment, indicating that they considered revised Bloom's levels, whereas the general practitioners did not. Therefore, the specialists' opinions on whether or not a question was at the specialist level should hold more weight than the general practitioners' opinions (as the specialist know what is actually required of a specialist).

Questions such as question 32, that have so few indicating it as a core component of a specific topic (management involving breeding systems), should be excluded from the assessment and the content should be considered for removal from the core curriculum and possibly be covered at a more refined meristemic area.

Economics is widely considered to be at the specialist level. Some general practitioners appear to be of the opinion that economics is irrelevant. However, it should be considered with every flock or herd visit and perceptions of the practitioners need to be changed in this regard. Biosecurity topic questions received similar views from general practitioners as the economics topic. Likewise, biosecurity is an integral part of farming and disease prevention that must receive more emphasis to produce a day one competent veterinarian.

Practitioners appeared to consider their knowledge as core in their area of practice for example those in the Eastern Cape are knowledgeable on diseases affecting Angora goats and considered these to be core, whereas those that do not see Angora goats regularly considered the knowledge to be either irrelevant or at Specialist level. This could motivate for area-specific CPD courses as these are rare in South Africa, and the same practitioners or academics normally facilitate most CPD courses. It is essential for local practitioners to participate and share their knowledge in specific areas and to also attend congresses where there is a broader audience. Such local CPD courses could offer new graduates the opportunity to familiarise themselves with the challenges faced in specific areas. Alternatively, post graduate short courses can be offered at the University in order to allow students to gather this knowledge before settling in the area.

None of the questions had a strong correlation between the scores obtained by the veterinarians and the levels allocated. Thus, it can be deducted that the veterinarians allocated

the questions to a level based on content, and not on what they considered to be the difficulty (or cognitive level) of the question.

3.1.2.4 Conclusion

Considering the meristemic approach, the results from this study indicate that economics and biosecurity could be considered as meristemic areas and further investigation would be required. The levels allocated by the judges can also assist in determining where in the meristemic model (Figure 1.1) the content belongs.

3.1.3 DAY ONE COMPETENCIES ADDRESSED

The aim for this section was to determine whether the SSH510 module adequately covers the day one competencies considered relevant to the small ruminant modules. Refer to Addendum B for the list of DOCs.

3.1.3.1 Method

Each question was allocated the relevant DOCs as were relevant to the module from the DOC document developed by the Faculty with input from various stakeholders (Irons *et al.,* 2017). Some questions covered more DOCs than others. The mean scores obtained for each of the DOCs by the veterinarians was then evaluated. The number of DOCs per question was then compared to the cognitive level of the questions. Spearman's Correlation Coefficient was calculated as for section 3.1.1.3 above. The DOCs were then plotted against revised Bloom's taxonomy.

3.1.3.2 Results

All the relevant DOCs were covered in the assessments. The DOC did not affect the scores obtained by the veterinarians. However, there was a correlation between the number of DOCs addressed by the question and the degree of difficulty of the questions (as per the revised Bloom's Taxonomy), as can be seen in Figure 3.15 below.

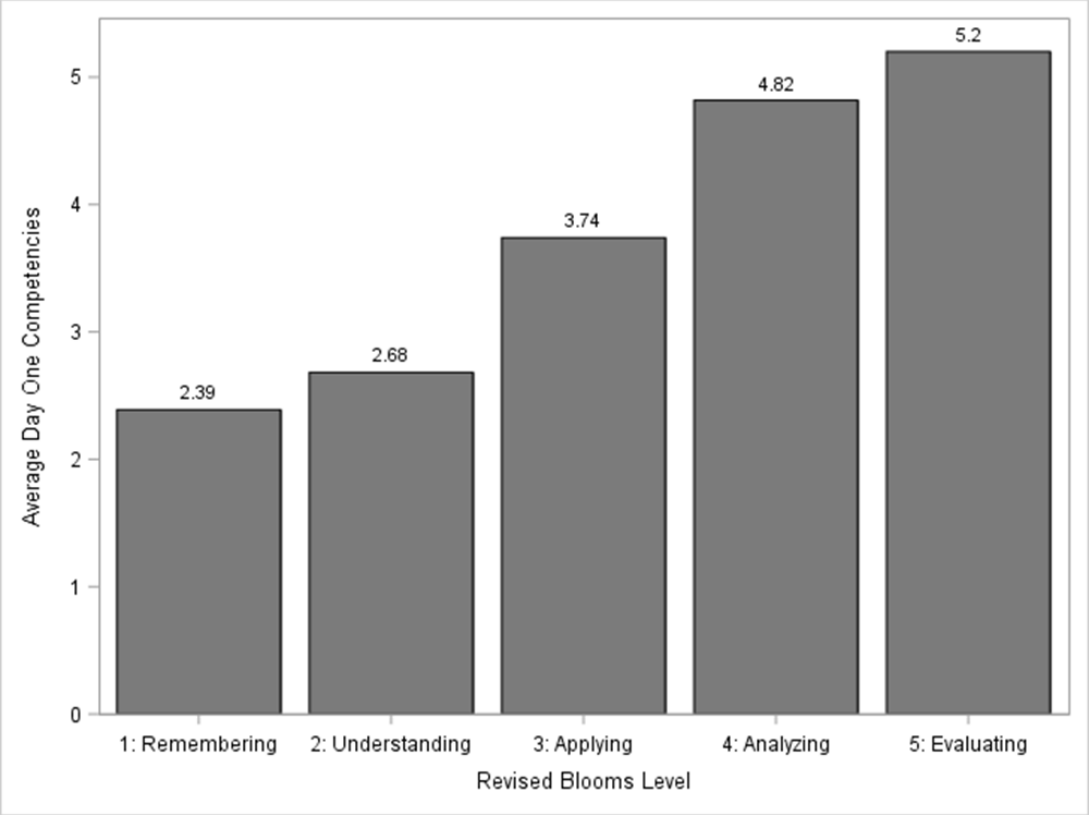

Figure 3.15: Mean number of day one competencies addressed for each of the cognitive levels.

3.1.3.3 Discussion

All veterinarians indicated that all DOCs were mostly classifiable as core knowledge, except for A1.5 (see Adendum B) where the generalists listed it as specialist knowledge. In the assessment, some DOCs were addressed more often than others were, as some DOCs are considered by the staff setting the assessment for the module, to be more important for preclinical students to have obtained.

Figure 3.15 validates the allocations of cognitive level and it is interesting to note the correlation between the cognitive level, and the number of DOCs covered at each of these levels. It can be seen that there is a strong positive correlation between the cognitive level of the question and the number of DOCs allocated to the question (Figure 3.15). This was not done in the original composition of the assessment, but was rather a finding after analysis of the paper using the revised Bloom's categories.

Figure 3.15 shows an important relationship between cognitive levels and DOCs. It is important to ensure that the DOCs are addressed by the assessment and the number of DOCs addressed can determine the strength of the assessment. However, it is not possible to assess most of the practical DOCs in a theoretical assessment. Such DOCs require practical assessments which is not within the scope of this thesis.

3.1.3.4 Conclusion

It is important to ensure that all the relevant DOCs are addressed in the assessment of the modules and such assessment should include a variety of assessment methods. By incorporating high cognitive levels in the questions in the theoretical assessment, academic staff indirectly select question that will cover more of the DOCs thus cementing these competencies in new graduates. It is therefore recommended that academic staff use this method to evaluate their own assessments and focus on using higher cognitive level questions to cover more DOCs.

3.2 DISCUSSION OF CHAPTER 3 WITHIN THE MERISTEMIC APPROACH

The critical review of the assessment and determining the level at which it is aimed, forms part of step 2 of the meristemic approach. It is critical to evaluate the assessment method to ensure that the standards are acceptable, the content is appropriate, and the day one competencies are met. This step allowed the researcher to show the importance of selecting the correct group of judges to determine cut scores and the value that these judges have in developing a curriculum. In this study it was found that judges with the most time spent in the discipline were the best candidates to determine cut scores and in so doing, fewer judges were used to set the standard. Having completed the analysis of the assessment, the levels allocated according to Bloom's revised taxonomy, and the DOCs addressed, the academic staff members may proceed to determine whether some of the content needs to be addressed later in the degree, or at the specialist level. At the conclusion of the theoretical portion of the degree (in the pre-clinical years), all relevant theoretical knowledge should have been adequately covered. Areas identified as specialist should be moved to the post-graduate degrees and the education of undergraduate students will then be focussed on them becoming a day one competent veterinarian in a wide field (wide trunk), that can support the branches of the areas where such a student wishes to further their career through elective practice (Figure 1.1).

Chapter 4

This chapter aims to determine whether practical experience contributes towards theoretical learning and when to include the practical experience in the degree. The hypothesis states that practical experience improves theoretical knowledge. It is important to note that for the above journal article in Chapter 3, the critical evaluation was only conducted on the fifth year SSH510 module. In this chapter, the marks for the second-year module (VET202) evaluated in Chapter 2 were correlated to the marks obtained for the summative assessment in the fifth-year module. It was found that there was no significant correlation. The study was performed in this manner as the second-year module is 75% practical for animal behaviour and farm procedures. Thus, the experience gained from previous modules did not affect the outcome of the assessments scores as this practical experience was not clinical in nature but rather consisted of procedures commonly performed on farms. Therefore, the experience gained from previous modules was not considered further in the study and only clinical practical experience was further investigated. This chapter deals with practical experience and its effect on theoretical knowledge in order to determine the importance of practical training and where best this practical training should be implemented. This outcome of no significant difference in the correlations is to be expected as the second year module is presented practically and involved the foundation knowledge of animal husbandry, management and farm procedures, whereas the fifth year module includes theoretical knowledge gained from other foundation modules on diseases and conditions that the students were not previously exposed to.

4.1 STEP 3: DETERMINE THE IMPORTANCE OF PRACTICAL CONTENT AND DECIDE ON SEQUENCING.

Determining the importance of practical content can be achieved by using a qualitative and quantitative study of the preclinical students' performance after presentation of the SSH510 module, and compare theoretical knowledge gained during the course of the degree to practitioners who have differing numbers of years' worth of practical experience.

4.1.1 THE IMPACT OF PRACTICAL EXPERIENCE ON THEORETICAL KNOWLEDGE AT DIFFERENT COGNITIVE LEVELS

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4.1.1.1 Abstract

Although theoretical training of veterinary students is uncomplicated even for larger groups, practical training remains a challenge. Much has been said about the value of practical training

in curriculum design. Yet the impact of practical training on theoretical knowledge needs further research.

A cohort of 89 students with very limited clinical practical experience completed an assessment at the end of their theoretical training in small ruminants. The scores obtained by the students were compared to scores obtained by a group of 35 veterinarians who volunteered to participate in the study. In addition to comparing the scores between students and practitioners, the cognitive level of each of the questions was considered.

Overall, veterinarians achieved higher test scores than the students. The veterinarians outperformed the students in all cognitive levels except for “applying” type questions where there was no difference. Different levels of experience, namely, young veterinarians (n=11), established veterinarians (n=13) and veterinarians approaching retirement (n=11) were evaluated against the revised Bloom’s cognitive levels. When modelling congress attendance frequency, years’ experience, proportion of time spent with ruminants and revised Blooms’ levels, congress attendance was not a significant variable and thus, only the other three variables remained.

This investigation found that practical experience has a positive effect on theoretical knowledge. The type of practical experience and where such practical experience is included in a curriculum needs further research. Working for a number of years in a specific discipline will provide the best support for theoretical knowledge.

Keywords**:** *assessment, curriculum design, education, practical experience, small ruminants, theoretical education, veterinary graduates*.

Declaration of Interest

There is no conflict of interest to declare.

4.1.1.2 Introduction

An increase in the use of technology has prompted an increase in undergraduate veterinary student numbers. At the University of Pretoria’s Faculty of Veterinary Science, intake figures remained the same from 1976 until 2001 when there was an increase of 33%, followed by further increases of 13%, 11% and 27% in 2006, 2011 and 2014 respectively. Collins and Taylor (2002), Allworth (2014), believed that undergraduate training would continue to focus on generalised knowledge. As a result, there would be an increase in demand on post-graduate training to develop practical skills, particularly in ruminants. This in turn has resulted in the development of postgraduate training centres such as the recent development of the European College of Small Ruminant Health Management (Bath, et al., 2006; Fthenakis,

2008). Katajavouri, Lindblom-Ylänne and Hirvonan (2006) stated that today's experts have to be able to refresh their expertise on a continual basis. This is already a requirement in the veterinary profession in order to maintain registration and is referred to as continuing professional development (CPD). This needs to be done in order to apply the knowledge acquired into practical work and to be updated with current knowledge and practice, and is particularly important when considering the technological advances in today's society.

Formal theoretical learning is essential for expert knowledge (Katajavouri et al., 2006). While Katavouri et al. (2006) believed that informal practical knowledge (or skills development) are learned in the workplace, others see the importance of integrating it into the curriculum as part of the final year programme (Kiggundu & Nayimuli, 2009; Walley & Albadri, 2015; Irons, Holm and Annandale, 2017). Irons et al. (2017) emphasize that this is important in producing a Day One Competent veterinarian and all the competencies expected in the curriculum are included as they are considered Day One Competencies thereby allowing a new graduate to practice effectively on the first day. There are, however, those who doubt the value of practical experience (Woolnough & Allsop, 1985; Hodson, 1990; Osbourne, 1993) and it is true that the type of practical experience, and not just any practical experience for the sake of inclusion in a curriculum, is important (Pienaar, 2014). An effective way of integrating practical experience as part of an undergraduate degree is workplace integrated learning (WIL) Pienaar (2014) also referred to as real world learning as discussed by Wrenn and Wrenn (2009). It is important to allow students to do the practical work involved in WIL with as little interference by the professional as possible to gain the maximum benefit of practical training (Wrenn & Wrenn, 2009). However, this is often difficult in the medical fields where lives as well as the professional's practice reputation is at stake.

Eraut (1994) stated that theoretical knowledge alone could not prepare students for the challenges faced in working life. While Benner, Tanner and Chesla (1995) suggested that practical and theoretical knowledge support the application and use of one another. Whereas Millar (2004) mentions that practical work includes interpretation of data and that learning involved in practical activity mostly occurs through discussing observations and measurements and interpreting them.

Katajavouri et al. (2006) further stated that metacognitive skills are acquired through practical experience and are important for lifelong learning. Lifelong learning is an integral part of the veterinary profession. It has been confirmed that practical knowledge is contextual and it is important for students to understand the link between theory and practice in order to apply theoretical knowledge in the workplace (Katajavouri et al., 2006).

Walley and Albadri (2015) reported that in a survey, final year dental students in the UK with more practical experience felt more comfortable discussing inhalation sedation with patients and parents, and were more satisfied with the quality of teaching. Increased student satisfaction with training was interpreted by Walley and Albadri (2015) as owing to more practical training being included in the curriculum. Students in the pre-clinical years at the Faculty of Veterinary Science of the University of Pretoria experience limited and basic practical training. The majority of the practical training occurs in the final year and a half of the current curriculum (Irons et al., 2017). Kiggundu and Nayimuli (2009) found that student teachers viewed teaching practice as an important component of their training. They reported that it assisted in contextualising the theoretical knowledge. However, the study on the dentistry students was perception-based. There are a number of ways that questionnaires may be compiled (Berdie, 1973; Montgomery & Crittenden, 1977; Bailey, 1978; Sheatsley, 1983; Berdie, Anderson & Niebuhr, 1986) and interpreted (Clason & Dormody, 1994; Allen & Seaman, 2007). The order of the questions is important (McClendon & O'Brien, 1988), and such questionnaires can include open-ended questions (Geer, 1988; Perkin, 1995) and Likert scales (Likert, 1932; Gliem & Gliem, 2003). While questionnaires (when set out correctly) and their use may provide valuable information, quantitative data on a subject can provide alternative perspectives. Thus, the authors hypothesised that it would be relevant to test the impact of practical training in a quantitative way as done in the current study.

The study by Katajavouri et al. (2006) confirmed that practical knowledge is contextual. It is therefore important to understand the link between theory and practice in order to apply theoretical knowledge in the workplace. Their study concluded that it is important to include practical training at an undergraduate level to ensure that students can recognise the need for certain theoretical components of a degree and demonstrate how these theoretical components can be applied practically.

If practitioners perform better at an assessment based on theoretical knowledge taught prior to the clinical year, than the students (who have recently completed the formal theoretical training with the knowledge fresh in their minds), then there is a strong motivation to incorporate more practical training into earlier years of the curriculum. In so doing, a more capable Day One Competent (Irons et al., 2017) veterinarian can be produced.

This study aims to determine what effect practical training has on theoretical knowledge and the ability of students or veterinarians to apply such practical training in order to answer theoretical questions in a computer-based assessment as currently used to assess pre-clinical (fifth year) veterinary students. In other words, to determine whether the converse of what all

these studies have concluded can be applied, by proving that practical experience can reinforce theoretical knowledge and allow it to be better applied.

4.1.1.3 Materials and Methods

Material studied

An assessment consisting of 90 questions totalling 101 marks was compiled as a standard computer-based assessment used for formative assessment in the preclinical (fifth) year of the BVSc degree at the University of Pretoria. Quality control by the education innovation and academic staff was implemented to categorise the questions according to Bloom's Taxonomy (Bloom et al., 1956) as revised by Anderson and Krathwohl (2001) with the following outcome: Remember (n=18), Understand (n=22), Apply (n=23), Analyse (n=22) and Evaluate (n=5). The data were classified as ordinal data as described by Allen and Seaman (2007). The allocation of the Bloom's categories was thus 80% in the higher order thinking range and 20% consisting of lower order thinking questions. Nine of the 90 questions (10%) were multiple response questions and the rest were multiple choice. Two academic staff members then reviewed the paper and memorandum for correctness. The questions were also categorised into topics to determine whether students had experience with a specific topic. Topics included biosecurity, economics, ectoparasites, internal parasites, lameness, management, nutrition, pathology, the perinatal period, reproduction, respiratory conditions, selection and culling, skin conditions, sudden deaths, vaccines and zoonoses.

Questionnaires were set for the participants (both veterinarians and students) to determine their level of practical experience. Papers by Berdie (1973), Montgomery and Crittenden (1977), Bailey (1978), Sheatsley (1983), and Berdie, Anderson and Niebuhr (1986) were used to draw up the questionnaire according to evidence-based methods. Open-ended questions were also included as suggested by Geer (1988) and Perkin (1995) and the order of questions considered in accordance with suggestions by McClendon and O'Brien (1988). Most questions were classified as ordinal data, interval data and ratio data (Allen & Seaman, 2007) with some open-ended questions that were coded and analysed separately.

Participants

Those willing to participate (students and veterinarians) signed a letter of informed consent in order to participate in the study. This letter informed them of their rights during the study and of the expected outcomes of the study. The researchers worked with a convenience sample of willing participants. For future studies, it would be recommended that power analysis be done before the study commences. However, a power analysis was performed on the

assessment that compared the scores between the veterinarians and the students. Using G*Power 3.1.9.2, at an alpha level of 5%, and a large effect size. The power analysis showed that the sample sizes of both groups were large enough to ensure a power of above 90%.

Veterinarians

Rural practitioners and faculty members were approached. Some were approached personally in addition to a call for participation on a local information platform "ruralvet" (ruralvet@yahoo.com). Some practitioners passed the assessment to colleagues as well.

Thirty five of the 42 respondents provided useable data. Those excluded had incomplete responses as entire sections were omitted from the survey and the assessment. However, of the 35, some had failed to answer one or two questions that could be dealt with as missing data that will not affect the outcome of calculations as described by Dohoo, Martin, & Stryhn (2003) where data is excluded from the calculations. Respondents included private veterinarians, state veterinarians and practicing veterinarians in industry.

Students

The student cohort that were registered for a small ruminant pre-clinical (fifth year) module described by Pettey (2014), were included in the study. There were 163 registered for the module and 89 of the 116 students who agreed to participate, provided useable data as they attended the necessary classes and completed the assessment without too many missing values.

Procedure

The study was approved by the University of Pretoria's Ethics Committee (V018-17).

In order to reduce resistance to participation by busy rural practitioners, the assessment was sent to the veterinarians with a "self-imposed" time limit of two hours to complete the assessment and questionnaire. There was no time restriction, as it is understood that practicing veterinarians may not have two consecutive hours to set aside for completing the task and some would have to leave the assessment mid-way to attend to cases before returning to complete the task. The students were required to sit the assessment as per the University of Pretoria rules and regulations. Students were given two hours to complete the assessment and the order of the questions for the students were randomised. Having completed the assessment, students were given additional time to complete the questionnaire. The veterinarians were asked not to spend too much time looking up answers, but to base most of their answers mainly on what knowledge they had acquired through their studies and experience. However, since it was difficult to monitor whether they spent much time

referencing answers, the assessment was regarded as ‘open resource’, thus allowing for both the students and the veterinarians to look up answers on the internet, textbooks or class notes.

The veterinarians received the questions in the same order during the assessment as it was emailed as a document where they could indicate their selection. The students completed the assessment in the Faculty’s computer laboratory and hence received the questions in a randomised order as is commonly done at the Faculty to prevent group polarisation where one person may influence the answers of those around him/her as found by Myers and Lamm (1976).

The following information was used from the questionnaires to determine the amount of practical experience:

1) Number of years’ experience (veterinarians).

2) Time spent with ruminants (veterinarians).

3) Congress attendance frequency (veterinarians).

4) Practical experience with any of the topics (students).

Number of years’ experience was classified as interval data, while time spent with ruminants was classified as ratio data (Allen & Seaman, 2007). Congress attendance frequency and practical experience for the students were classified as ordinal data. The congress attendance categories for the veterinarians were assigned as follows: missing data (0), less than once every four years (1), once every four years (2), once every three years (3), once every two years (4) and once a year (5). The student practical experience was assigned according to the number of topics that the students had experienced in a practical way – mostly through observation of cases. Only eight students had this type of experience, mostly through observation. This was not considered to be clinical experience. It was further investigated whether any practical experience obtained in earlier years of the degree would have had an effect on marks obtained for the current assessment. To do this, student marks obtained for the small ruminant section of a second-year module, which included practical handling of sheep and goats and farm procedures, were compared to the marks obtained for the current assessment. There was no significant correlation in the marks ($p=0.85$) using Fisher’s Z transformation (Fisher, 1915) and, therefore, all students were allocated zero years’ clinical experience.

It was then determined whether cognitive level of questions had an effect on students’ and veterinarians’ test scores. Finally, in order to determine whether there was a difference according to the number of years’ experience, the veterinarians were then categorised into

three groups. They were categorised as follows: qualified veterinarians with less than 6 years' experience (young veterinarians (n = 11)), veterinarians with 6 to 31 years' experience (established veterinarians (n = 13)) and veterinarians with more than 31 years' experience (approaching retirement veterinarians (n = 11)).

Data analyses

The Shapiro-Wilk test is one of the most popular tests for normality assumption diagnostics and was used to evaluate if the data within the groups being compared was normally distributed or not. It was found that only half of the groups' data was normally distributed. Since the normality assumption of the parametric tests was not met, the non-parametric alternative test, the Mann-Whitney U test, was used to compare the tests scores between the veterinarians and students (hence also reporting the median and IQR), for each of the cognitive levels (Shapiro & Wilk, 1965; Rani Das & Rahmatullah Imon, 2016). The Spearman rank correlation was used (which measures the monotonic association between variables) since one of the variables was ordinal in nature rather than the normally distributed continuous data. When comparing correlations and determining whether they differ significantly, the Fisher's Z transformation was used (Fisher, 1915).

A linear regression model was used to investigate the effect that congress attendance frequency, number of years' experience, time spent with sheep and goats and the revised Blooms' level had on the veterinarians' tests scores. As the students did not contribute to all the variables in the model, their data were excluded from the model and only the veterinarians' data were used.

4.1.1.4 Results

Overall, the students achieved lower scores than the veterinarians (Median, IQR: 51.5, 47.5 – 51.5 vs 62.4, 55.5 – 62.4, $p < 0.01$). This was the case for all cognitive levels except for applying.

When comparing each subgroup of veterinarians to the student scores, young veterinarians' scores did not differ from student scores for higher cognitive level questions, whereas this was not the case for more experienced veterinarians (Table 4.1).

Table 4.1: Comparison of students' scores to three categories of experienced veterinarians' scores for the different revised Bloom's levels

	Students (n = 89)	**Young vets (n = 11)**		**Established vets (n = 13)**		**Approaching retirement vets (n = 11)**	
Cognitive level	**median (IQR)**	**median (IQR)**	**p-value**	**median (IQR)**	**p-value**	**median (IQR)**	**p-value**
Remembering	62,5 (54,2; 70,8)	76,9 (57,4; 84,3)	0,04*	71,3 (58,3; 80,6)	0,08	82,4 (79,6; 88,0)	<0,01*
Understanding	50,0 (45,5; 59,1)	61,4 (52,3; 68,2)	0,01*	65,9 (56,8; 73,8)	<0,01*	65,9 (61,4; 75,0)	<0,01*
Applying	56,5 (47,8; 65,2)	54,4 (43,5; 63,0)	0,55	47,8 (41,3; 63,0)	0,21	63,0 (54,4; 73,9)	0,09
Analysing	47,8 (39,1; 56,5)	59,1 (47,7; 63,6)	0,07	52,3 (45,5; 63,6)	0,20	70,5 (59,1; 73,8)	<0,01*
Evaluating	20,0 (20,0; 40,0)	40,0 (0; 60,0)	0,46	40,0 (40,0; 60,0)	<0,01*	60,0 (40,0; 80,0)	<0,01*

* Indicates significance.

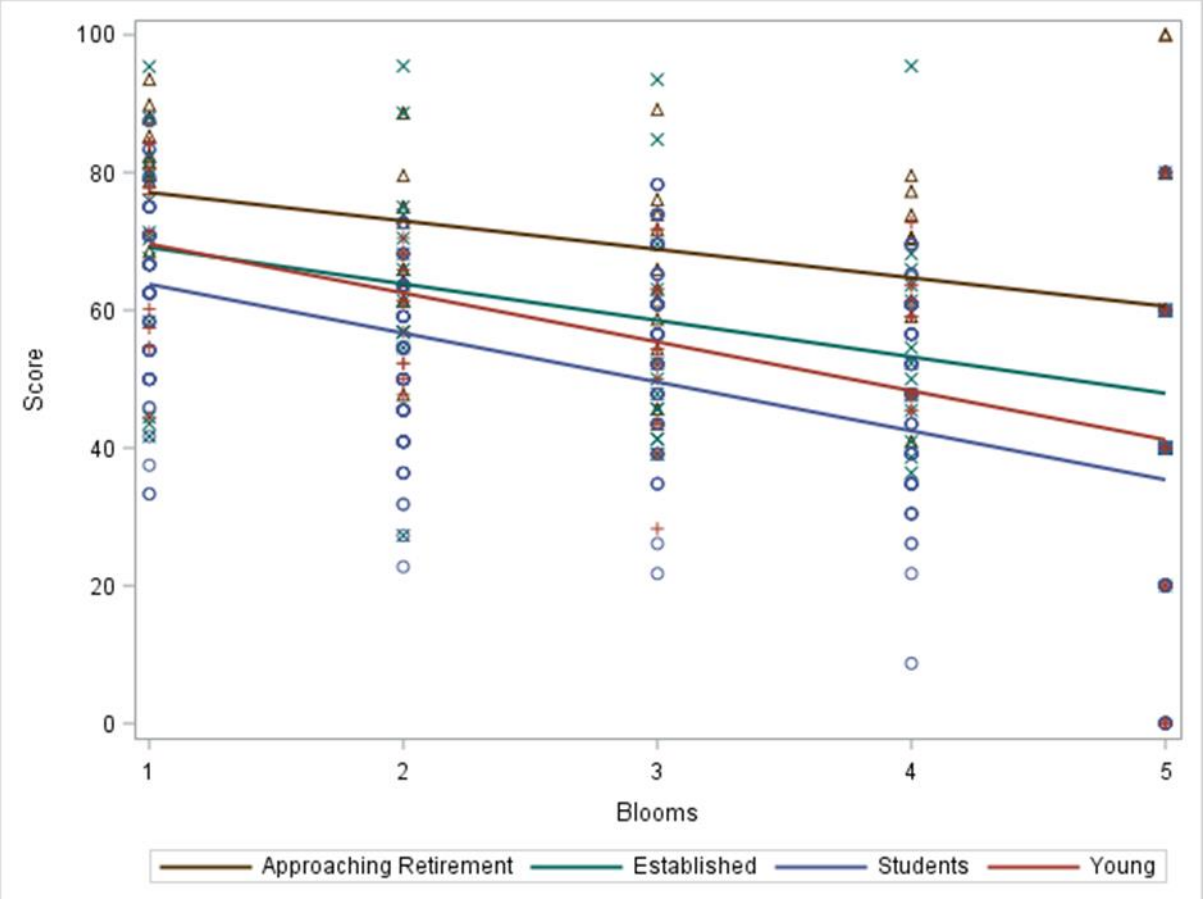

Figure 4.1: Assessment scores obtained for students, young veterinarians, established veterinarians and veterinarians approaching retirement according to cognitive level

The correlations between cognitive level of questions and score achieved were -0.55, -0.44, 0.44 and -0.37 for students, young veterinarians, established veterinarians and veterinarians

approaching retirement, respectively ($p < 0.01$) (Figure 4.1). These four correlations were not significantly different from each other.

Nine of the 17 topics resulted in the students achieving significantly lower scores than the veterinarians, the exceptions being internal parasites, mastitis, the perinatal period, respiratory conditions, selection and culling, skin conditions and zoonoses, where there was no difference and vaccines where the students significantly outperformed the veterinarians (Table 4.2). The results were categorised into topics to determine whether practical experience in a topic assisted students in obtaining higher scores.

Table 4.2: Results comparing veterinarians' to students' scores within topics

		All veterinarians (n = 35)	**Students (n = 89)**
Topic	**Number of questions**	**Median: IQR (Q3 ; Q1)**	**Median: IQR (Q3 ; Q1)**
Biosecurity	5	80,00 [a]: 40,00 (60,00; 100,00)	60,00 [b] : 20,00 (40,00, 60,00)
Economics	5	40,00 [a]: 40,00 (20,00; 60,00)	20,00 [b]: 20,00 (20,00, 40,00)
Ectoparasite	2	75,00 [a]: 25,00 (50,00; 75,00)	75,00 [b] : 25,00 (50,00, 75,00)
Internal parasites	9	66,67 [a]: 22,22 (55,56; 77,78)	66,67 [a]: 22,22 (55,56, 77,78)
Lameness	5	40,00 [a]: 20,00 (40,00; 60,00)	40,00 [b] : 40,00 (20,00, 60,00)
Management	8	66,67 [a]: 22,22 (44,44; 66,67)	33,33 [b] : 11,11(33,33, 44,44)
Mastitis	2	100,00 [a]: 50,00 (50,00; 100,00)	50,00 [a]: 50,00 (50,00, 100,00)
Nutrition	16	64,71 [a]: 17,654 (58,82; 76,47)	47,06 [b] : 17,65 (41,18, 58,82)
Pathology	7	71,43 [a]: 28,57 (57,14; 85,71)	57,14 [b] : 28,57 (42,86, 71,43)
Perinatal period	3	50,00 [a] : 50,00 (25,00; 75,00)	50,00 [a] : 50,00 (25,00, 75,00)
Reproduction	4	75,00 [a]: 25,00 (50,00; 75,00)	50,00 [b] : 25,00 (25,00, 50,00)
Respiratory conditions	1	100,00 [a]: 0,00 (100,00; 100,00)	100,00 [a]: 100,00 (0,00, 100,00)
Selection and culling	2	50,00 [a]: 50,00 (50,00; 100,00)	50,00 [a] : 50,00 (50,00, 100,00)
Skin conditions	4	50,00 [a]: 50,00 (25,00; 75,00)	50,00 [a]: 25,00 (50,00, 75,00)
Sudden death	9	77,78 [a]: 22,22 (66,67; 88,89)	66,67 [b] : 22,22 (55,56, 77,78)
Vaccines	7	57,14 [a] : 42,86 (28,57; 71,43)	71,43 [b] : 28,57 (57,14, 85,71)
Zoonoses	1	66,67 [a]: 0,00 (66,67; 66,67)	66,67 [a]: 0,00 (66,67, 66,67)

[a,b] Medians with different superscripts in rows, differ significantly ($p < 0.05$)

When modelling the congress attendance frequency, number of years' experience, proportion of time spent with ruminants and revised Blooms' levels, congress attendance was not a significant variable and thus, only the three remained (Table 4.3). The R-squared value for the model is 0.3398.

Table 4.3: Linear regression of variables against the veterinarians' scores

Variable	Coefficient (β-value)	p-value
Intercept	66.61	<0.01
Number of years' experience	0.25	<0.01
Proportion of time spent with sheep and goats	0.20	<0.01
Revised Blooms's Level	-5.24	<0.01

4.1.1.5 Discussion

Overall, the veterinarians outperformed the students in the assessment. This can be attributed to the fact that qualified veterinarians have clinical practical experience, as opposed to students who were considered to have very limited clinical practical experience. When comparing scores according to revised Bloom's levels the veterinarians' scores were higher than the students' scores for all revised Bloom's levels, all being significantly higher except for the applying level. However, after the veterinarians were categorised into the three groups (young veterinarians, established veterinarians and those approaching retirement), it can be seen in Table 4.1 and Figure 4.1 that cognitive level (revised Bloom's level) had a definite effect on all groups with students and young veterinarians being the most affected groups.

The young veterinarians out-performed the students in remembering and understanding (lower cognitive level), but not at the higher cognitive levels. The established veterinarians out-performed the students in the understanding and evaluating levels (Table 4.1). This indicates that more experienced veterinarians were better able to apply a higher cognitive level of thinking when answering those types of questions. They could not necessarily remember theoretical knowledge better, but they showed a better understanding of the theoretical knowledge. Those veterinarians approaching retirement were able to out-perform the students at all levels except for applying theoretical knowledge and their scores ultimately influenced the scores when all veterinarians were combined. It is clear that veterinarians with more clinical practical experience are able to operate at a higher cognitive level than the students with no clinical practical experience (Table 4.1). It can therefore be concluded that it would be beneficial to include as much practical experience as possible in an undergraduate

curriculum and careful decisions must be made in the curriculum design process on the type of practical experience and where to include it in the degree (Posner & Strike, 1976; Toohey, 1999).

It is important to note that as the assessment was set as a simulated examination paper, not all topics received equal attention and thus the number of questions per topic were not the same (Table 4.2). For the topic analysis, respiratory conditions and zoonoses only had one question each (these questions could not be categorised into another topic and were therefore analysed in their respective topics) as seen in Table 4.2. Hence the outcome for these topics was either correct (all veterinarians got the respiratory question correct) or incorrect (some students answered incorrectly thus the IQR was 0 to 100%). The students and veterinarians performed the same for the zoonoses, internal parasites, mastitis, perinatal conditions and selection and culling. There was no difference for skin conditions; however, the range was larger for the veterinarians (IQR 25 to 75) than the students (IQR 50 to 75) (Table 4.2). With these topics, an explanation for the veterinarians not outperforming the students can be that they do not encounter these cases on a regular basis as part of their practical experience. This could be clarified by a follow-up questionnaire for further research. One veterinarian commented that some topics were covered more thoroughly than others were during lectures and this could also explain the discrepancy.

From the model in Table 4.3, it can be seen that the number of practical years of experience and time spent with sheep and goats had the largest effect on the veterinarians' scores. For each year more experience, the scores increased by 0.25%. For every percentage increase in the proportion of time spent with small ruminants, the scores increased by 0.2%. Cognitive level (revised Bloom's level) also had an effect in that for each level increase in difficulty, the scores decreased by 5.24%. Congress attendance was not a significant variable in the model.

Wrenn & Wrenn (2009) discuss the importance of CPD in education. Veterinarians have to comply with CPD requirements in order to maintain registration with the South African Veterinary Council (SAVC) to be eligible to continue practicing. This gathering of information and practice in the form of CPD may also have contributed to the higher scores obtained by the veterinarians and therefore it may not be practical experience alone that contributed to higher scores. It was not assessed whether the CPD points collected by the veterinarians in this study were focussed on production animals, although the participants were rural practitioners at the time of the study. This can be the focus of further studies. It can be noted that some of the participants had moved to companion animal practice from a previously mixed practice and this could account for the discrepancy in time spent with ruminants, number of years' experience and scores. Wrenn and Wrenn (2009) concluded that the balance of theory

and practical is best achieved over the course of a curriculum, rather than within individual modules. What is interesting to note though is that congress attendance (considered a form of CPD) did not have an effect on the theoretical knowledge in the way that practical experience did, and thus did not feature in the model in Table 4.3. This can be because congresses are presented as lectures. It could be investigated in future whether congresses with more practical components have a greater influence on cementing theoretical knowledge.

An additional finding of the study was that the use of acronyms can be confusing during questions, for example PEM can be used as an acronym for both Protein-Energy Malnutrition and Polioencephalomalacia. The confusion caused by acronyms was noted by a few of the practitioners who participated in the study. It is therefore recommended not to use acronyms in assessments.

While the veterinarians received the questions in a set order, questions in a computer-based assessment are usually randomised per student to prevent students from comparing answers with their peers whilst in the assessment environment. Practitioners were less likely to refer to each other's answers, as there are time constraints in practice and this was not a high-stakes assessment for the practitioners. There was no reward or incentive for the veterinarians' participation as the results remained anonymous, and there was no competition amongst them. It may be possible that the order in which questions are presented could influence the way in which students interpret and thus answer questions (McClendon and O'Brien, 1988). In designing a written paper, lecturers will often begin the paper with a relatively easy question that most students will be able to answer. The next question may be a question that borderline students have some difficulty with, but that the majority of the class may still answer correctly, and then questions aimed at distinction candidates will be interspersed. This gives the candidates confidence (McClendon and O'Brien, 1988). When faced with a question that is aimed at distinction candidates as a first question, some students may feel despondent or intimidated and this can potentially affect the results of the test or exam. However, as the student group was much larger than the veterinarian group, the effect may be diluted. This is a topic for future studies. Though it is recommended that randomisation of questions is done in blocks according to the level of revised Bloom's taxonomy to avoid this phenomenon.

Practitioners tended to rather leave questions blank than give an incorrect answer (dealt with as missing data according to Dohoo et al. (2003)) whereas students seemed to be more comfortable with randomly allocating an answer as time allocated for the assessment ran out. Anecdotal evidence suggests that students will often do this hoping that they could guess a correct answer and thus improve their mark. Whether or not negative marking should be performed, in order to prevent guessing, is a topic of other research.

From this study, it can be seen that the greatest difference in scores was between the veterinarians and the students. Once qualified, the number of years of clinical practical experience had the greatest effect on the scores obtained for the veterinarians. Time spent with ruminants clearly also had a significant effect on their scores. These two factors determined which of the veterinarians performed the best in the assessment and that working for a number of years in a specific discipline will provide the best support for theoretical knowledge. Therefore, the recommendation is that clinical practical exposure should be encouraged from the first year of study in all possible clinical fields. It would have been interesting for this study to have the same students complete the assessment again having completed the clinical practical component of the degree. This should be included in further research.

4.1.1.6 Conclusion

It is concluded that clinical practical experience has a positive effect on theoretical knowledge particularly at a higher cognitive level. The type of clinical practical experience, and where such experience is included in a curriculum, needs further research.

Acknowledgement

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References have been moved to the Reference section of the thesis.

4.2 DISCUSSION AS CHAPTER 4 REFERS TO THE MERISTEMIC APPROACH

The importance of practical training is also determined as the third step in the meristemic approach. It is clear from this study that only clinical practical experience improved performance in the theoretical assessment of the module in the pre-clinical year. Thus, the hypothesis stands. Further discussion of this section within the meristem approach is that it is important to consider the practical training that each student needs in order to become a day one competent veterinarian. Clinical practical experience assisted veterinarians in theoretical knowledge and therefore this needs to be considered for the meristemic approach in terms of where to include such practical experience. Although the practical experience gained in the VET202 module assessed in Chapter 2 did not affect scores obtained in the above study, such practical experience still forms part of the foundation of the degree. Practical experience should be included in earlier years at lower levels to accomplish the necessary day one competencies and in so doing, will also contribute towards the cementing of theoretical knowledge. Students will not be able to perform a clinical examination on an animal if they are

not taught these skills early on in the degree. Therefore, animal handling forms the basis of the clinical practical experience just as dissections performed in the anatomy module in the second year of the degree for the basis of the surgery modules later in the degree. Pacing the practical experience throughout the degree and sequencing it correctly to allow for growth forms part of a meristem approach. For example, animal handling and procedures is covered in the VET200 module. A module in the third year of the degree covers basic clinical examination of the key domestic species and is not possible without a strong foundation in animal handling. The basic clinical examination then becomes a building block for later in the degree where students then perform specialised clinical examinations on patients that are presented to them in the clinical proportion of the degree.

Chapter 5

This chapter will cover how to determine which manner to present theoretical knowledge and whether students require more face-to-face contact during the pre-clinical year, or whether they are able to use a self-directed learning approach to integrate the knowledge that they have acquired during the previous years.

5.1 STEP 4: DETERMINE HOW THEORETICAL CONTENT SHOULD BE DELIVERED.

Content of a curriculum can be delivered in numerous ways. This includes providing sufficient learning opportunities for the students. These methods of providing learning opportunities can be in the form of traditional lectures, facilitated self-directed learning, peer instruction (Miller, *et al.*, 2015), online learning (Majeski, Stover & Ronch, 2016) and flipped classrooms (DeLozier & Rhodes, 2017). Studies on active learning (Freeman *et al.*, 2014; Deslauriers *et al.*, 2019) have shown that there is a definite improvement in scores when an active learning approach is used in the classroom as opposed to passive learning. Yet further research is needed to compare face-to-face contact time vs a self-directed learning approach.

The study in this chapter is presented as the article that is to be submitted to *Higher Education*.

5.1.1 A COMPARISON OF TEACHING METHODS AND STUDENT PERFORMANCE IN A SMALL RUMINANT MODULE

5.1.1.1 Abstract

The new generation of student entering the higher education system is described as Generation Z. These students have grown up having information readily available, yet they are described as being disorganised and unable to manage their time effectively. A term used to describe the student's inability to focus on tasks, and rather participate in other activities that are considered more gratifying, is academic procrastination. Academic procrastination has a serious impact on the students' ability to learn and students need to be taught the skills required for self-directed learning.

Students in this study were assessed by means of a computer-based assessment prior to the commencement of one of the fifth year (pre-clinical) modules in veterinary science. This provided a baseline for their theoretical knowledge. An intervention by means of two different teaching methods within the module was applied and the students were reassessed using the same assessment at the conclusion of the five-month module.

An ordinal logistic regression model was constructed for an improvement in assessment score per student using cognitive level, topic, lecturer, teaching method and attitudes towards lectures and self-directed learning as potential predictor variables. The three variables that

were significant were the cognitive level of the question ($p=0.01$), topic ($p<0.01$) and attitude towards self-directed learning ($p=0.03$).

Thus, it can be seen that teaching method does not have a significant impact on assessment scores and that academic staff must focus on students acquiring skills that will get them thinking on a higher cognitive level. Student attitudes towards learning have an effect on assessment scores. Students who have grown accustomed to being taught in a certain way can be resistant to sourcing information for themselves. Thus, a combination of learning styles needs to be incorporated in the classroom.

Further research is needed to determine which attributes enable students to benefit from a self-directed learning approach and which students would benefit more from formal teaching. This could assist with improving student success.

Keywords**:** *assessment, delivering content, veterinary education, self-directed learning, small ruminants, traditional lectures, theoretical education, veterinary graduates.*

Declaration of Interest

There is no conflict of interest to declare.

5.1.1.2 Introduction

Seemiller and Grace (2016) have described the new generation of student as Generation Z. This generation of students has grown up in an era where information is readily available on the internet. However, these students often struggle to sift through the available information to determine what is relevant and useful (Sholehah, Sangka & Hamidi, 2018). Sholehah et al. (2018) state that many factors may play a role, and these are broadly categorised as physical, psychological and environmental factors. Although Generation Z are considered to be masters of information and technology, it is clear they require guidance on how to interpret the information gathered (Seemiller & Grace, 2016). Mohr and Mohr (2017) found that students admitted to feeling overwhelmed by the amount of available information. Sholehah et al. (2018) attributed this to there being so much information that is unaccounted for, such as blogs or web pages where sources or references are not listed, making it difficult for students to distinguish fact from fiction. This results in the phenomenon known as academic procrastination where students choose to engage in other activities that they find more gratifying such as social media, rather than complete self-directed tasks (Sholehah et al., 2018). Academic procrastination can have serious negative effects on students such as increased stress and decreased quality and quantity of learning (Scraw, Olafson & Wadkins (2007). Bjork et al. (2013) refers to the self-regulation of learning as forming a central feature of most contemporary learning and instruction theories. Self-directed learning (SDL) can have

a positive impact on student learning, however, there is research suggesting that this is not widely used (Lawson et al., 2019). The reason for the limited use of SDL may be that when faced with a new curriculum or new content, clinicians tend to fall back on tried and tested methods of delivering content as opposed to newer methods, even if they previously criticised the older methods as students (May & Silva-Fletcher, 2015). May and Silva-Fletcher (2015) speculate that this may be because clinicians have very little training in education methods and lack the self-confidence to use innovative ways of teaching. In an age where information is readily available, students tend to suffer from academic procrastination as a result of their inability to manage their time effectively with SDL (Seemiller & Grace, 2016).

Katajavouri, Lindblom-Ylänne and Hirvonen (2006) found that almost half of the students in their study mentioned how important taking responsibility for their own learning and performance was, as was initiative. Their study was in a workplace integrated learning (WIL) setting and the students realised that they were able to source their own information (Katajavouri et al., 2006). This skill is necessary in undergraduate students and self-directed learning (SDL) can assist in acquiring such skills early in the degree.

Technology has made quality distance education more attainable, provided that the content is well delivered with appropriate interaction with the lecturer (Volery & Lord, 2002). This is particularly relevant for postgraduate studies (Allworth, 2014). Yet there is no reason why it should not be applied at the undergraduate level (Collins & Taylor, 2002) as a means of SDL.

Lawson et al. (2019) found conflicting opinions and conclusions in the type of students who benefitted from an SDL approach. This is mostly related to beliefs and perceptions and it is suggested that further research is required to determine the influence of beliefs and perceptions on a range of individual variables (Lawson et al., 2019).

Pintrich (2004) describes student approaches to learning, used mainly in Europe and Australia, and information processing, used mainly in North America, and states that SDL has now largely replaced information processing as it not only includes cognitive factors, but also motivational, affective and social contextual factors. He describes SDL models as having four main common assumptions:

i) active, constructive assumption where learners are viewed as active participants.

ii) potential for control assumption where students monitor, control and regulate their behaviour, motivation, cognition and even some environmental factors.

iii) goal criterion or standard assumption which assesses whether learning should proceed as is, or change (i.e. students monitor their progress).

iv) SDL activities are mediators between personal/contextual characteristics and actual performance.

Katajavouri et al. (2006) found that their students were more motivated, during practical experience, to acquire the theoretical knowledge. Thus, it is of utmost importance to include practical training in an undergraduate curriculum to improve motivation for SDL (Katajavouri et al., 2006). Self-directed learning is typically presented as learning where students will obtain their own information with the guidance of the academic staff member.

Self-directed learning is not inherent in all people in their adult years. It is something that is usually developed during childhood. Some researchers suggest that if children are not given opportunities to get bored, and in so doing learn to be creative to escape the boredom, their ability to initiate self-directed learning could be affected (Payne, 2010). This can also apply to the curriculum. If a curriculum is overloaded with information, the curiosity for students to source their own information is being stifled. Anecdotal evidence from students at the Faculty of Veterinary Science, University of Pretoria, suggests that there is a common belief that the value of face-to-face contact time is dependent on the lecturer and the method of presenting the information. Students do not gain as much learning experience from a lecture given in a traditional style as they do from facilitated hybrid learning (Deslauriers, 2019). While there are many areas where an online approach gives adequate quality education, it is the opinion of the researcher that in Veterinary Science face-to-face learning with practical application is vital and should therefore not be excluded from the teaching methods. Academics must however realise that in order for the face-to-face contact time to reach its full potential in terms of learning opportunities for students, careful planning is required (May & Silva-Fletcher, 2015).

In a recent study by Deslauriers et al. (2019) it was found that students' perceptions of learning differed to the actual learning that took place and that decisions based on students' perceptions may be the reason why academic staff are reluctant to use active instruction methods. Thus, a combination of this and the uncertainty of staff members in applying new methods as found by May and Silva-Fletcher (2015), could possibly better explain why clinicians especially are slow to adapt teaching methods.

Multiple choice question (MCQ) type assessments have received much criticism as a form of assessment when the type of question only addresses lower cognitive level type questions (Cantor et al., 2015). However, Cantor et al. (2015) explain that while one may be capable of storing vast amounts of information, such information is not always easily accessible and MCQs provide a way to access this marginal knowledge. The aim of assessments should not be merely to access information from memory, but also to be able to use the higher cognitive areas of understanding, applying, analysing and evaluating information (Anderson &

Krathwahl, 2001). It is the opinion of the researcher that assessments based on MCQ questions can provide for such higher cognitive thinking. Thus, a computer-based assessment was used for this study.

This study focuses on the second and fourth assumptions described above by Pintrich et al. (2004) and addresses whether SDL can produce the same results as face-to-face contact time. It also attempts to address the perceptions of students on whether they benefitted from the lectures or SDL, and attempts to determine the influence on scores obtained for an assessment. The hypothesis is that face-to-face contact with a lecturer results in better student performance than a self-directed approach.

5.1.1.3 Materials and Methods

Material studied

A mock computer-based assessment was compiled from a pre-existing summative assessment (base assessment) given in one of the undergraduate, pre-clinical modules (Pettey, 2014) for the purpose of this study. The base assessment had been compiled and undergone a quality control process involving both a professional education consultant from Education Innovation and academic staff within the Small Stock section of the relevant academic department. The assessment consisted of 90 items or questions with a total score of 101 marks. Each question in the assessment was analysed according to cognitive levels (Anderson and Krathwohl, 2001), henceforth referred to as the revised Bloom's levels. The questions in the pre-existing assessment were also categorised into topics and the type of question, and mark allocation was recorded. Only multiple choice or multiple response type questions were used in this study. As questions were set, the above criteria were applied so that each question in the mock assessment matched the topic, revised Bloom's level, question type and mark allocation to achieve an assessment as close to the base assessment as possible. Topics included sudden deaths, lameness, respiratory system, nutrition, vaccines/immunology, management, internal parasites, economics, pathology, zoonoses, mastitis, perinatal period/neonate, biosecurity, ectoparasites, skin conditions, selection and culling, and reproduction. Thirteen of the 90 questions could not be duplicated satisfactorily and, therefore, the original questions were used in the mock assessment.

The mock assessment was given to two academic members within the Small Stock Section and the professional education consultant to evaluate for quality control. Questions were amended according to their recommendations and again checked to ensure that all the criteria were met, and that the questions had been assigned the correct revised Bloom's category. The allocation of the 90 questions into the revised Bloom's categories were as follows: 18 questions in the remember category, 22 in the understand category, 23 as apply, 22 as

analyse and 5 as evaluate. The researcher (and predecessors who set the original paper) was unable to construct a computer-based, multiple choice/response type question that fulfilled the requirements for the “create” category. For this study it was determined that higher cognitive questions fell into apply, analyse and evaluate categories of revised Bloom. Therefore, 80% of the assessment involved higher cognitive level type questions with only 20% falling into remember and understand categories. The revised Bloom’s level values in the assessment were classified as ordinal data (Allen & Seaman, 2007).

Questionnaires were set for the students to record their experiences during the module, as well as their attitudes towards the teaching method. These questionnaires were given to the students at the end of the module. Evidence-based principles as described in papers by Berdie (1973), Montgomery and Crittenden (1977), Bailey (1978), Sheatsley (1983) and Berdie, Anderson and Niebuhr (1986), were used as guidelines to set up the questionnaire. As open-ended questions are also of value (Geer, 1988; Perkin, 1995), these were included in the questionnaire. McClendon and O’Brien (1988) suggest that the order of questions is important for subjective well-being and thus, this was taken into consideration when drawing up the questionnaire. Data from the questions were analysed as ordinal data, interval data and ratio data (Allen & Seaman, 2007) accordingly. The open-ended questions were coded and then analysed on the number of students having given similar comments. Data for the students included their perceptions of their abilities and knowledge after completion of the module. The questionnaire included the following open-ended questions: reason for participation in the trial, opinions on the module as a whole or the study, and background information including previous practical experience with sheep and goats in the selected topics. Yes or no answer questions included: whether they discussed the mock assessment after the first attempt and whether they could recall any questions at the second attempt, whether or not they prepared with additional reading before completing assignments, confidence in their abilities and knowledge at the start of the module, opinions on lectures and self-directed learning, and lecture attendance. The usefulness of Blackboard® (the learning management system or LMS used by the University of Pretoria, branded as clickUP) were set and analysed as Likert scales (Calson & Dormody, 1994; Gliem & Gliem, 2003; Likert, 1932). The questionnaire was given to the students at the end of the module after completion of the computer-based assessment.

Participants

One hundred and sixty-three students in the preclinical year of the BVSc degree who were registered for the small ruminant module (SSH 510), were approached to participate in the study. One hundred and sixteen students indicated willingness to participate by completing the informed letter of consent provided at the beginning of the study. Thus, they were informed

of the outcome of the study and their rights during the study. Only 89 students participated for the duration of the study and completed the assessment at the conclusion of the module, providing useable data. Students who participated in, and successfully completed the study, were offered the incentive of an additional 1.5% towards their year marks.

Procedures/techniques

The study was approved by the University of Pretoria's Ethics Committee (V018-17). Students were not warned previously that the assessment at the beginning of the module would take place and they were allowed the use of open resources (any resource including internet access, but excluding verbal communication with their peers) to complete the assessment. The students were ranked according to the scores obtained for the first mock assessment. They were then block randomised to either attend a formal lecture on each of the 12 chosen topics, or acquire the necessary knowledge through self-directed learning.

Six topics were presented to the class by the researcher, namely:

Topic 1: Internal parasites

Topic 2: Biosecurity

Topic 3: Skin conditions

Topic 4: Perinatal mortalities

Topic 5: Economics

Topic 6: Feet conditions/Lameness

Another lecturer in the module presented six different topics to the class, in order to ensure that the results were not affected by a specific lecturer's lecturing style. These were:

Topic A: Management

Topic B: Vaccines and immunisation

Topic C: Diseases or conditions causing sudden deaths

Topic D: Respiratory tract conditions

Topic E: Mastitis and blue udder

Topic F: Selection and culling

Lectures presented on nutrition, pathology, ectoparasites, reproduction and zoonoses, were not included in the method of teaching study and were presented to the whole class by different lecturers in the usual manner, mostly as case studies. These topics were used as a control.

Each topic included in the method of teaching data had an assignment posted onto clickUP for the students to complete. Each assignment was revealed to the students a day before the lecture was given. Feedback was given on whether they had acquired the necessary information on the topic, or whether they should do more research for both the SDL group and the group attending lectures. The assignment was assessed by a basic rubric to determine the level of effort a student made in completing the assignment. The rubric assessed engagement (whether or not the student had understood and interpreted the information in a South African context), organisation (whether the student was able to organise the information into a logical order) and facts (whether the content was correct). The students were assessed as being either novice (did not perform at the expected level), competent (performed at the expected level for a fifth-year student), or proficient (performed at a level higher than expected, i.e. a final year level). Initially students were requested to complete the assignment/task by midnight the same day of the lecture/self-directed learning, however, the students exhibited academic procrastination (Sholehah et al., 2018) in submitting their assignments and an extra two days per assignment were given to allow for late submissions. Tasks that were submitted according to the initial due dates were recorded, and scores obtained in the assessment for these topics were compared to scores obtained by students who submitted tasks late (new dates given). Assignments were marked during the same period for those submitted late and on time with the assessor unaware of whether the assignment being assessed was submitted on time or not. The scores obtained in the assessment at the end of the module were also compared for those who were on time with handing in assignments in specific topics, to those who handed assignments in late.

The module ran over a 10-week period and the topics were presented during weeks 2, 3, 4, 5, 6 and 7. Between the topics, the usual lectures given to the BVSc V (SSH 510) students were presented in the form of problem solving sessions completed under the guidance of the lecturers involved. Students were reallocated randomly before each theme so that by the end of the year each student had been exposed to three face-to-face lectures and three self-guided themes for themes 1 to 6 and likewise for themes A to F. The face-to-face lectures were structured so that they accommodated a variety of learning styles including reading, listening and various visual aids including pictures and videos, where appropriate. The students were guided as to how to go about investigating the assignment presented on clickUP. Attendance of the lectures that were not included in the study was not compulsory.

Lectures were presented in a 1/3 contact time and 2/3 time to assimilate, integrate and process the knowledge whilst completing a given task relating to the material covered during the lectures. Only 27 of the total 72 contact sessions were used for this study. Each student was allocated 15 of the 72 lecture periods where they were either on the SDL assignment or had been given time off to assimilate knowledge after the lecture and complete the assignments. The balance of the time was used for the assessment and completion of the questionnaire. During the module, the students were assessed by various methods including group presentations, peer assessment and computer-based assessment. For the purpose of the study, only the computer-based assessments were used.

During the last week of the SSH 510 module the students were given the mock assessment that was completed at the beginning of the module without prior knowledge, to complete. This was done in order to assess the impact of the teaching method, without additional studying, had on the acquired knowledge or skills of researching answers in limited time (again open resource assessment).

The face-to-face lecture material was made available to all the students after the assignments and the mock assessment had been completed, but before the final exam, so that all students had been given access to the same information.

George, Haque and Oyebode (2006) made use of a six-month test-retest period and reported that students were unable to recall most of the questions. Pettey (2014) used a two-week interval with similar results. Thus, validating the use of the same questionnaire to provide a baseline of the student's knowledge before the formal teaching of the module as well as assessing knowledge gained at the end of the five-month module.

Area descriptions

The study took place at the University of Pretoria's Faculty of Veterinary Science in South Africa as part of the pre-clinical module (SSH 510) on small ruminants.

Data analysis

The median and mean for the students' first mock assessment and the second mock assessment was calculated. The Shapiro Wilk test (Shapiro & Wilk, 1965) was used to test for normality. The difference between the scores obtained for the first assessment and the second assessment were determined, per student. The independent t-test was used to evaluate if the differences between the two groups of students (those who discussed the first test vs those who did not) were significantly different as the data for this were normally distributed. All the assignment scores for each of the themes was compared between the two groups of students (those who submitted on time vs those who submitted late) using the Mann-Whitney U test

since the data was not normally distributed. This was done for the student group as a whole and then separately for those who attended lectures and those who followed the self-directed learning path. The Kruskal-Wallis test was used to evaluate if a significant difference existed between the difference in improvement in assessment scores between the three groups: positive attitudes (strongly agreed + agreed), undecided and negative attitudes (disagreed + strongly disagreed) for the Likert type questions regarding attitudes towards lectures and self-directed learning. From a modelling perspective, it was only determined whether there was an improvement or not, and the improvement was not quantified. These were compared at a student level. Questions in the survey that were not on a Likert scale were coded and analysed separately as percentages of the cohort. Ordinal logistical regression was used to determine which variables significantly affected the improvement in student assessments scores (95% Wald confidence limits was used). This was done on a question level. A chi-squared test was used to determine if there was a relationship between students who handed in assignments on time (or late) and attitudes towards self-directed learning.

5.1.1.4 Results

The results for the initial mock test and the mock test completed after the module can be seen in Table 5.1.

Table 5.1: Students' scores (%) for the mock assessment before (Test 1) and after (Test 2) presentation of the module according to allocated lectures and self-directed learning for individual questions within topics

	Face-to-Face (n = 489)	**Self-directed learning (n = 512)**
Test 1	44.44[a] (50.00-25.00)	44.44[a] (55.56 – 22.22)
Test 2	50.00[a] (70.00 – 33.33)	50.00[a] (66.67 – 33.33)

Students indicated why they participated in the study. Some students gave more than one reason for participation. Although students phrased reasons differently, the reasons were grouped into categories with similar wording, and listed as reasons below. Two distinct areas were identified: students who wished to improve their own situation and students who participated with the intention to improve conditions for future students.

Self-improvement

a) Forced to do extra work and learn earlier for the test (17 students – 19%).

b) To help prepare for exams (15 students – 17%).

c) To develop the skill of finding my own information (5 students – 6%).

d) For the mark incentive (28 students – 32%).

e) For the experience (1 student – 1%).

f) Curious to see which was better, self-directed learning or lectures (22 students – 25%).

g) Interested to see what I knew without learning [this refers to the results of the first test] (2 students – 2%).

h) To broaden my knowledge (18 students – 20%).

Improvement for future students

a) To contribute towards improving the curriculum (1 student – 1%).

b) To improve study methods at the faculty (1 student – 1%).

c) To help improve the method of teaching (6 students – 7%).

d) To help the lecturer with her study (4 students – 5%).

Forty eight percent of students discussed the first test with their peers and 73% admitted to remembering a few of the questions with 27% remembering none of the questions (0% remembered all the questions). Seventy three percent of the students were concerned after test one with 5% being despondent, and 12% feeling that they knew their marks would improve after they had completed the module. Sixty-seven percent agreed that they benefitted from attending lectures with 90% agreeing that both lectures and assignments were beneficial. Sixty percent would have preferred traditional lectures. Forty percent agreed that SDL better equipped them for their future careers, with 43% undecided and 17% disagreeing. Seventy one percent of the students found clickUP to be useful in completing the module and 86% agreed that they valued the feedback given on clickUP.

In total 20 of the 90 students that completed the study passed (achieved a 50% or more) the first assessment. One student expressed confidence in the knowledge after the first assessment. This student obtained the sixth highest mark for the first assessment with the highest mark being only 7% higher. This student's second assessment mark improved by 10 percent. Thus, the student appeared to be consistent in the efforts at assessments and this could explain the confidence expressed after the first assessment. The other 19 students showed a similar trend with only two students receiving a lower mark for the second assessment. One of the students had both scores within 2% of each other (56% and 58% for test 1 and 2 respectively).

Additional open-ended comments regarding the module or the study included the following statements made by individuals. Here the answers were not grouped.

a) I had more questions than answers after the lectures.

b) I felt cheated by not having enough contact time with the lecturer.

c) I would have preferred broader assignment questions.

d) The work covered in class did not correspond with the assignments.

e) Self-directed learning took too much time

f) Structured, comprehensive learning objectives would have made the self-directed learning easier.

g) I was overwhelmed by the information when doing the self-directed learning.

h) I struggle to listen in lectures. This method allowed me to better utilise my time.

i) The shorter lectures and assignments were very beneficial to me

j) The lectures were more focussed and concise.

k) Lectures did not cover enough material.

l) I attend lectures for the tips given in class.

m) I was concerned that I could not remember the work from previous years.

n) I was surprised that I could remember so much of the previous years' work.

o) I preferred to attend the [lecture] sessions. It was a great idea and I really enjoyed it.

p) I did not like the study.

q) I enjoyed participating in the study and I did do better in the second test. I think more resources should be given in class so that we know what to read and how to learn for this module.

r) Sometimes it was frustrating completing the tasks on a Friday afternoon especially since going to class requires less effort and concentration. But I remembered the work discussed in class much better after I had to repeat it in the assignment.

s) I enjoyed being part of the study. I found it more useful because it gave more motivation for independent studying.

t) It was an opportunity to help determine whether we are required to learn unnecessary information. I believe that our course has a lot of information that we can rather research instead of memorise.

u) The study was successful from my perspective and I learned from it.

v) I really enjoyed taking part in this study and it has greatly improved my knowledge as seen by the increase in my mark from the first test. Also, I strongly believe that a lot of the syllabus can be self-taught but it was nice having the assignments especially in the format in which they were asked to force us to go through the work but they also made us think practically which is what is needed as a vet in the field.

There was no significant difference in improvement of assessment scores between students who discussed the first assessment and students who did not discuss the first assessment ($p=0.66$). When comparing students who submitted assignments on time to students who submitted late, students who submitted on time had a significantly higher improvement in assignment scores compared to those who submitted late ($p<0.01$). This was the case for topics where lectures were attended as well as for topics where SDL was implemented, ($p<0.01$ and $p=0.01$ respectively). Assignment scores were correlated to assessment scores for the assessment at the end of the module (test 2) resulting in a very low correlation ($p=0.14$). Sixty six percent of students handed all assignments in on time with the remaining number of students (34%) handing in one or more assignments late.

Students with a positive attitude towards attending lectures (agreed and strongly agreed that they benefitted from attending lectures) did not have a significant improvement in assessment scores compared to students who were undecided on the benefit of lectures or had a negative attitude (disagreed and strongly disagreed that they benefitted from lecture attendance) towards lectures ($p=0.66$). When comparing students allocated to lectures vs those in SDL within topics, there was no significant difference in improvement of assessment scores between those with positive attitudes ($p=0.59$), undecided ($p=0.96$) and negative attitudes ($p=0.66$). There was no significant difference between students who had a positive attitude towards SDL ($p=0.40$).

The ordinal regression model of improvement of assessment scores included the following potential variables: revised Bloom category, topic (only including those topics which were allocated as face-to-face or SDL), lecturer, teaching method, whether assignment were handed in late or on time, attitudes towards attending lectures and the self-directed learning approach. The significant variables are included in Table 5.2.

Table 5.2: Ordinal regression significance results for the model comparing revised Bloom's levels, topic and student attitudes towards self-directed learning

Variable	p-value
Revised Bloom's category	0.01
Topic	<0.01
Self-directed learning better equipped me for future career	0.02

For the modelling, revised Bloom category 1 (remember), the biosecurity topic, and disagreement (indicating a negative attitude towards SDL) with the statement, were used for comparisons.

Analysis of the revised Bloom's categories showed that category 2 (understand) had 0.609 times the odds of a lower score than category 1. Category 3 (apply) had 0.897 times the odds of a lower score, category 4 (analyse) had 0.837 times the odds of a lower score and category 5 (evaluate) had 0.914 times the odds of a lower score.

The respiratory topic was excluded by the model, as there was only one question. Topics that were more likely to obtain a lower score than the biosecurity topic included economics (0.718), feet conditions/lameness (0.688), management (0.697), mastitis (0.968), skin conditions (0.776), sudden deaths (0.821) and vaccines (0.988). Topics where students were more likely to obtain a higher mark than the biosecurity topic included internal parasites (1.241), perinatal mortalities (1.244) and selection and culling (1.860).

Regarding the statement on self-directed learning, students that responded as undecided had a 0.791 times the odds of receiving a lower score than students who disagreed with the statement and students that agreed with the statement had 0.908 times the odds of receiving a lower score than students who disagreed with the statement.

5.1.1.5 Discussion

It is seen in the results that students had difficulty in submitting assignments on time (academic procrastination as described by Sholehah et al. (2018)), and in following directions on whether to attend class, or do SDL. This is shown in Table 5.1 where the number of participants in face-to-face learning vs self-directed learning are 489 and 512 respectively. These figures indicate that students elected to miss the face-to-face contact time, but were still committed to completing the assignments, and could suggest a preference by some students for the self-directed learning approach as it allows for more flexibility. Some students did provide excuses for not being present in lectures with reasons ranging from illness to congress attendance.

These students were informed that they should then balance the numbers by attending another face-to-face session rather than the SDL. Not all students were able to do so. Some students indicated confusion as to which session to attend despite receiving an attendance register. There was no significant difference between test scores for students that attended the face-to-face sessions as opposed to the students that did the self-directed learning (Table 5.1).

Student responses to whether they could remember questions from the previous attempt at the assessment confirmed the findings of George *et al*. (2006) and Pettey (2014). Therefore, the use of the same assessment at the onset and conclusion of the module for the purpose of measuring effect of different teaching methods on scores is validated.

As the students only had 15 (out of 72) lecture periods where they would not have had contact time with the lecturers, the impact of this study on the final outcome of the module should have been negligible. However, two students expressed concern that they had "paid for contact time" and "felt cheated". Anecdotal evidence suggests that students regard fees they pay for contact time with academic staff and not for the learning opportunity. It is important that this perception be changed in order for SDL to be successfully implemented.

It has been shown that students who submitted assignments on time had significantly higher assignment scores than students with late submissions. This could be owing to academic procrastination (Sholehah et al., 2018). These assignment scores had a very low correlation to the assessment scores for the topics ($p=0.14$) owing to the fact that the assignment scores were much higher than the test scores. In addition, the low number of late assignments (16%) resulted in tardiness or student procrastination not being a significant contributor in the model. The low percentage of late assignments can be attributed to the fact that the students who participated were committed to the study and did their utmost to comply. It should be noted that of the 116 students who initially participated, only 89 provided useable data by completing most assignments and tests. It is probable that the students who may have handed in late assignments quit the study as they realised that they could not maintain the expected outcomes as given to them before the study. Had these students remained, the results could have been affected. This could be a topic of further research. It is debateable whether penalising students who submit late would be effective in encouraging them to better manage their time. Tardiness in submitting assignments on time was compared to scores obtained for their specific topics where lectures were either attended or not. The model compared final scores and thus tardiness was not a significant variable. The overall sample size for assignments handed in late (134) compared to the number of assignments handed in on time (857) was so small that this could explain why the model did not pick up the late assignments

as a significant variable. There was no significant correlation between student attitude towards self-directed learning and assignments submitted late or on time. Again, the lack of a correlation could be owing to the small sample size of late assignments.

The students who showed consistency in marks and had passed the first assessment could have already achieved a certain level of theoretical knowledge at higher cognitive levels which could explain why there was such a low difference in scores. However, it is important to note that both the assessments in the study were done without prior warning and students had to rely purely on information retained from the teaching of the module and their ability to access resources. Another explanation is that students did not improve in their ability to source information from open resources by the end of the module. It is certain that when allowed to study before the assessment the students would have improvement in the assessment scores as this would have allowed students to revise and organise the information better, thus reason through the higher cognitive level thinking. This can be the subject of future studies.

The revised Bloom's category 2 value of 0.609 times (less than 1 or can also be seen as 60% chance) is more likely than the revised Bloom's category 1 to receive a lower score hence Bloom's category 2 is the more difficult or higher cognitive level. This can be extended to all other Bloom's categories. The values in the model increased (moved closer to 1) which showed the odds of, for example, revised Bloom's category 5 receiving a lower score at 0.914 (91% chance that they would obtain a lower score) which indicates it is more certain to result in a lower score than revised Bloom's category 2. This data validates the increasing difficulty of Bloom's categories.

It is difficult to interpret the results from the topic section of the model accurately as each topic had varying numbers of questions as well as varying cognitive levels. Thus, interpretation of these results may not be a true reflection of the actual degree of difficulty of the questions in the topics and should rather be included in further research where all topics have equal numbers of questions and revised Bloom's levels.

Eighty six percent of students agreed that they valued the feedback given on clickUP. This was more than the 60% previously reported by Tormey (2015). Goos, Gannaway and Hughes (2011) describe the attributes of feedback derived from first year students. It is clear that well-constructed feedback is preferable to generalised feedback in formative assessment (Tormey, 2015). Thus, these assessments may be used as learning tools (Tormey, 2015).

The effect of feedback in MCQ test environments was also studied by Cantor et al. (2015) and they found that the feedback was only associated with new learning. Therefore, they recommended use of MCQ assessments alone, without feedback if the desired effect of the assessments is to assist with marginal recall. It is the researcher's opinion that feedback be

given in formative assessments so that the academic staff can make use of the assessments as a tool to assist with new learning towards the summative assessment.

An interesting observation is that a small number of students answered questions correctly the first time but incorrectly the second time the assessment was performed. Reasons for this may include:

1) Guessing of answers.

2) Confusion on the part of the student regarding that specific topic. The students may not have understood the question or the concepts.

3) Assumptions from students that an answer for a previous question would lead them in answering a later question (as mentioned above).

4) Students may have looked up the answers the first time and not the second time as questions are randomised to prevent students from consulting a fellow student's answers during assessments and thus, they may not have had time to look up all the answers.

5) Discussion of answers with classmates after the first attempt may have led students to believe that different answers were correct.

6) The type of question regarding revised Bloom's level could also affect the results for example remembering vs evaluating.

Ways to address these issues are discussed under the recommendations section.

Some students did well in assignments regardless of whether they were in the SDL group or in the face-to-face group. The converse is also true. This observation may be what distinguishes the stronger candidates from the borderline candidates. This study confirms what Deslauriers et al. (2019) reported that students' perceptions of learning and actual learning differed. Facilitating learning in the borderline candidates remains a challenge for any curriculum design and teaching method. It would be useful to determine what attributes the high achievers have that allowed for higher scores, so that academic staff may assist the students who struggle to achieve higher scores. Alternatively, selection for placement within certain professions can consider such attributes. This, however, would be a contentious issue.

One of the students commented that the module contained a lot of information that could rather be researched instead of memorised. The researcher agrees and this has been discussed by May & Silva-Fletcher (2015).

One of the students mentioned that it took too much time to complete the SDL. This is important for academics to note, as the students require more time to sift through all the information to determine what is useful. This task is usually done for them when they attend a face-to-face lecture. This study used the extreme of SDL to compare to a very comprehensive lecture in order to determine which method is more successful and resulted in no significant difference.

As was the case above where students struggled to identify important SDL information, some students had difficulty sifting through the information provided during lectures despite the lecturer highlighting areas of importance and repeating certain facts. Others had difficulty in putting the information into context for example, during the first lecture on internal parasites, the main internal parasites, vaccinating against pulpy kidney as well as drugs that can be used was discussed. Some drugs interact with others and the example of organophosphates (used as either for internal or external parasites) and pyrethroids (for external parasites) was highlighted. Here it was mentioned that one should ensure the correct dose – even of the ectoparasitic drugs so as to avoid toxicities. Some students then discussed dipping tanks and replenishment tanks as part of the assignment for losses owing to haemonchosis. Only five out of the 51 students allocated to the lectures appeared to have such difficulty with this assignment, yet it is important for lecturers to identify such students in order to offer additional support.

Some students appeared to have difficulty in distinguishing production animal problems from companion animal problems. One question asked for the most likely differential diagnosis for paddling and a small number of students selected “epilepsy” as the answer. Epilepsy is very rare condition in production animals in South Africa as most production animals that show neurological signs from birth would be culled.

Considering the student who commented that the lectures left more questions than answers, when a facilitation and constructivism approach is used in lectures, it is good practice to leave the students with some unanswered questions to motivate them to learn more and to research their own thoughts (Pintrich, 2004). This concept should encourage the students to have enquiring minds and to continue with research at a postgraduate level.

Regarding the comment made by one student who preferred to have the PowerPoints and additional lecture notes available for referencing, the researcher agrees, but, for the purpose of this study, the additional notes and PowerPoints from lectures could only be provided after the second assessment so as not to affect results. It is the authors’ opinion that in a normal class setting it is advisable to have the PowerPoints and additional notes available as soon after the lecture as possible, in order for students to revise.

There was some discussion with students who participated in the study as to whether recordings of lectures would be beneficial and whether this should be done in a quiet room and be edited or should the actual lectures presented to the students be recorded with minimal (if any) editing? A student commented that the fact that lectures could be re-visited was extremely beneficial and was a preferred method of revision, rather than going through the notes. The researcher suggested that the lectures should ideally be recorded in a quiet room and edited so that they flowed better and could be concise in order to maximise the use of study time. The student replied that the interaction with the class during the recording was preferred as it made the lecture more realistic and one could follow interpretations that the class had made and how the lecturer responded. Recording of such an environment is often difficult though as comments from the class may not always be clearly heard.

It is interesting to note that only 32% of the cohort participated in the study for the added 1.5% to the year mark. The remaining 68% gave other reasons for participation, with 25% being interested in what the results would show. This demonstrates a natural curiosity and may indicate students with an interest in research. Of the 120 generic reasons given, 108 were self-centred with only 12 being for the benefit of future students. Therefore 90% of the reasons were for the benefit of individual students. This demonstrates a very self-centred attitude exhibited by the students. An area for further research would be to study whether students prefer group work or individual work in a veterinary faculty and then to change perceptions so that students are more willing to give back to the community.

Student comments for the lecturer evaluations included that the lecture time was too short. The lecture time was allocated to 1 hour of new content with 2 hours to master the new content through the assignments and self-study/learning.

As there was an unequal distribution of numbers of questions per topic, as well as different revised Bloom's levels per question within topics, the researchers were unable to quantify the cognitive level per topic. This could be the reason that topic or lecturer (as the lecturer was directly related to the topic) did not show significance in the model. As cognitive level was shown to be a significant variable in the model (Table 5.2), it would have been useful to investigate this further. In the model, topics with fewer questions may not have shown significance owing to the lack of representation within the model. Although topic appeared to be a significant variable in the model (Table 5.2), not all topics were significant and the individual topics were confounded by cognitive levels, as not all topics had equal numbers of questions in each revised Bloom's category. Thus, for future studies it is recommended to have equal numbers of questions within each topic being studied even though the topics may not have equal importance within the curriculum.

Ways to address inconsistency in correct answers being given the first time and incorrect answers a second time when allowing students to sit the same assessment with a short time frame in between (George et al., 2006; Pettey, 2014) include:

1) Instruct students to leave answers that they were not sure of blank instead of guessing (this would have helped for this study but would not be useful in a graded assessment that counts towards year marks).

2) Giving thorough feedback for formative assessments (this was purposefully not done in the study in order to ensure that student's marks for the second attempt were more accurate reflections of the method of teaching rather than the learning style or simply remembering an explanation). Such formative assessments add value to a normal class setup by providing additional learning opportunities and such assessments will not be given to the students for a second time during a module. This is owing to the fact that if assessment questions are re-used in a module, they become downgraded to a lower cognitive level of remembering even though the original question was set at a higher cognitive level.

3) Encourage students to ask for clarity during assessments where questions appear to be ambiguous or unclear. Many of the students in the Faculty have English as a second language yet having the papers in several languages is impractical.

4) Have a reasonable spread of cognitive levels to cover different learning styles and to encourage reasoning and thinking.

5.1.1.6 Recommendations

The researcher recommends that students are given clear guidelines where SDL is used to assist them in identifying relevant sources of information, so that unsubstantiated claims can easily be recognised and rejected from the information base.

Students who perform well should be afforded the opportunity to decide whether they prefer to attend lectures or to do a self-directed learning approach. Providing a combination of lectures with assignments can assist the facilitator in identifying the borderline students that require additional tutoring to be able to grasp the concepts. It is important to combine lectures with assignments to determine whether students are coping with the material as a self-directed learning approach with an assignment will not differentiate whether the student has not grasped the concepts or whether the student simply used poor resources. These students that are identified as borderline students can then be given additional face-to-face time with the facilitator so that they are able to achieve the desired results.

If lectures are recorded without editing to allow for student revision, it is advisable that the lecturer repeats the questions or observations of the class so that these are clearly heard in the recorded sessions.

5.1.1.7 Conclusion

This study focused on assumptions described above by Pintrich et al. (2004):

ii) potential for control assumption where students monitor, control and regulate their behaviour, motivation, cognition and even some environmental factors.

iv) SDL activities are mediators between personal/contextual characteristics and actual performance.

This study showed that the individual lecturer and teaching method of face-to-face lectures compared to SDL did not have an effect on improvement scores obtained between the two tests, but rather that cognitive level, topic and student attitudes have a stronger influence on scores obtained.

5.2 DISCUSSION AS CHAPTER 5 REFERS TO THE MERISTEMIC APPROACH

This study showed that face-to-face contact did not necessarily result in better student performance than a self-directed learning approach and so the hypothesis is rejected. Thus, step 4 of the meristemic approach, how theoretical content should be delivered, has been concluded. In doing so, the researcher found that the learning attitude of students influence student learning, whereas the teaching method and individual lecturers do not. By being too rigid in how content is delivered, the students may not be receiving the best tuition. It has been shown that the method of delivery of content can be through face-to-face lectures, practical training sessions (as shown previously in chapter 4) or by means of self-directed learning. A combination of all styles would probably be the best approach and it is up to the individual lecturer to see which areas should be presented in which manner for the best possible outcome. Such a principle is more likely to promote a positive student attitude as well.

Chapter 6

This chapter concludes the thesis with a discussion on the meristem models and to what extent it can be applied to curriculum design.

6.1 CONCLUSIONS

Based on the findings of the above studies, section 6.1.1 summarises the study incorporating some of the information from the literature review, and important findings. Section 6.1.2 gives a summary of the methodology used in the study 6.1.3 delves into what has been learned from this research. Section 6.1.4 discusses what this study has confirmed with regards to prior research and finally, section 6.1.5 includes recommendations for policy-making, practice and further research.

6.1.1 SUBSTANTIVE SUMMARY

Owing to the need for a redesign of the Veterinary Science curriculum on an undergraduate level, it was hypothesized whether a novel approach using biomimicry could assist with curriculum design. This study aimed to determine to what extent biomimicry could be used as a curriculum design technique to refine an existing curriculum in the form of a meristemic approach. The aim of such an approach was to determine what is especially relevant to a day one competent veterinarian (or graduate, in other fields) and to focus the curriculum on teaching that content knowledge, skills and attitudes at the undergraduate level. It is argued that only once the student has graduated, specialisation can be considered. These areas of specialisation are the meristem regions and are there for further development.

The innovation of the meristemic approach is the researcher's contribution to this field and it is suggested that this approach can be applied to by curriculum designers in any discipline.

It is essential to include only the necessary foundational knowledge when preparing the curriculum in a meristemic manner (Figure 1.1), as the foundational knowledge need only be able to support the core curriculum. Additional foundational knowledge is, however, required to support specialist knowledge beyond the degree, and can therefore rather be viewed as specialist foundational knowledge.

Foundational knowledge, in the sense of the foundational modules which include Anatomy and Physiology, is essential in the core component of the Veterinary Science curriculum. This foundational knowledge is key in the macro alignment of the different modules, as can be visualised in figures 1.1, 2.1 and 2.2, and forms the bond between reasoning and factual knowledge. Although, one does not need to be a specialist in these fields to be able to practice well. A flaw in current beliefs about veterinary science education is the unrealistic expectation

that students can become specialists in all areas at an undergraduate level. The foundational knowledge must be trimmed to accommodate the essential only and can be left as meristems to be built upon in postgraduate studies, or specialised short courses. This can be seen from the responses of the veterinarians mentioned in chapter 3 where some of the questions were considered to be foundational knowledge in a fifth-year module. As one then specialises in any field in veterinary science, the branches grow from these undergraduate meristems. As with a tree, the larger the branches get, the more support is required from the roots to avoid the tree toppling over. Therefore, some of the foundational knowledge needs to be removed from the undergraduate curriculum and be considered as specialist knowledge instead.

Facilitators often presume that the relevant foundational knowledge has been retained when dealing with core competencies in later years of the undergraduate curriculum. However, when a curriculum is steered towards specialisation at the undergraduate level, some of the essential foundational knowledge is set aside and not mastered successfully, in order to retain facts or procedures that relate to an overload of core knowledge.

On the other hand, if the foundational knowledge is overloaded, it is difficult for students to determine what should be retained for use in cementing essential core knowledge. For this reason, some of the responses in chapter three, on the level of the questions, were divided in opinions as to whether a question addressed foundational knowledge, or whether it was rather set at a specialist level. Thus, it can be seen that the meristemic approach can be successfully used to determine which content should be included in specific areas within the degree.

The way in which a meristemic approach can be achieved is by following four steps as summarised below.

Step 1: Critically evaluate the current curriculum in terms of the current content, day one competencies, and delivery methods (chapter 2). For the scope of this study, the VET200 and SSH510 modules were critically evaluated in terms of purpose of the modules, the contextual factors, critical crossfield outcomes, constructive alignment, content selection, resources, sequencing and pacing, epistemic diversity, curriculum responsiveness and transformation, teaching and learning and assessment. The VET200 module aligned well with other foundational knowledge modules, and the SSH510 module also aligned well with prior modules within the degree. It was found that the areas which needed attention were the pacing and content of the VET200 module. These issues have subsequently been addressed within the module as content has been removed. Further evaluation resulted in the content being presented and assessed in a more practical way with theory being assessed mostly in computer-based assessments. Both modules delivered content in innovative ways that were suitable to the level at which these modules are presented within the degree, namely in the

second and fifth year respectively. As the SSH510 module is mostly theory based and presented as case studies which summarise the theoretical content which has been presented to the students prior to their clinical years, the assessment of the module was evaluated further in Step 2. Step 1 allows the academic to evaluate the current content and determine future content, sequencing, pacing and delivery of theoretical and practical content.

Step 2: Critically evaluate the assessment methods and content assessed in the assessments to determine whether the assessment is relevant to the content and *vice versa* (chapter 3). In the process of completing this step, an additional finding emerged in that fewer judges may be used to determine cut scores if these judges are chosen according to the proportion of time that they spend in a specific discipline. The study further demonstrated that the cognitive levels of questions asked in an assessment should be considered in assigning cut-scores. This is a factor that has not previously been considered when determining cut-scores and thus is a valuable contribution to the field. Academics therefore need to consider the cognitive level of the questions in assessments as this aspect showed significance in the assessment scores for both students and judges, and tended to improve the accuracy of criterion-referenced method of standard setting. The level that the judges assign to each question can also determine meristemic areas, such as economics and biosecurity which were highlighted in the study in chapter 3.

Step 3: Determine the importance of practical content and decide on sequencing. In this study it was established that in a veterinary programme, practical experience is vital to theoretic knowledge and that inclusion of practical clinical experience from the first year could potentially put a new graduate at the current level of a young veterinarian (chapter 4). The study also confirmed that careful decisions must be made in the curriculum design process with regards to the type of practical experience that needs to be included, as well as where in the programme if should be included. Academics therefore need to determine which content is best delivered through theoretical or practical components. Theoretical components should also be reinforced by practical examples.

Step 4: Determine how theoretical content should be delivered. In this study the focus was on face-to-face contact and a SDL approach (chapter 5). The findings indicated that the teaching method and the specific lecturer involved did not have an effect on student performance. It was however determined that the students' attitude towards SDL, the topic under discussion, and the cognitive level at which the learning was pitched, influenced the scores obtained. Therefore, academics need to evaluate the difficulty of certain topics (as was highlighted in steps 2 and 4) and that the best approach for delivery of the content is then determined. A mixed approach of blended learning which combines both face-to-face and self-

directed learning may cater best to the students' needs. The variables that were not included in this study that could further impact the attitude of students towards SDL, deserves further research to better understand how attitudes towards self-directed learning affect the scores in assessments. Students should be given clear guidelines and resources when the self-directed learning approach is used. Cognitive level in student assessment contributes greatly to student scores and must be considered in every question in the assessments. If one wants to compare topics more thoroughly, one needs to ensure that equal numbers of questions and cognitive levels of these questions are used.

Another finding of this study is that although continuing professional development is essential for practice, the number of CPD events attended by judges in the form of congresses did not have an effect on the judge's ability to set cut scores. Therefore, the manner in which such CPD courses are presented needs revision as practical skills may assist in development of theoretical knowledge. It is advisable to focus CPD courses on practical applications rather than on content sharing by means of lectures. It is suggested that theory based CPD courses will not have the desired impact and will not have an effect as great as practical hands-on demonstrations may have. The importance of practical experience is vital to remember when planning CPD events as this study has shown that practical experience assists with cementing of theoretical knowledge. This finding also contributes to the field of veterinary science. One could then argue that it would be better for practitioners to spend the additional time in practice, rather than to sit through lectures if CPD events are only presented in a theoretical manner.

Thus, it is shown that biomimicry in the form of a meristemic approach can determine which content requires re-consideration for inclusion in a curriculum and can highlight deficiencies as well. It is therefore a useful tool in curriculum design.

6.1.2 METHODOLOGY SUMMARY

To further elaborate on the meristemic approach, this study followed a mixed method approach. For example, qualitative data was used in step 1 of the meristemic approach where the curriculum was critically evaluated. The curriculum had previously been designed using the backward approach for the specific small ruminant modules. For steps 2 to 4, quantitative data was used. In order to evaluate the curriculum, day one competencies and study guide documents were used to compile an assessment and categorise all questions. Surveys of veterinarians (judges) and students were also administered. The survey for the veterinarians provided information on number of years' experience, time spent in small ruminant practice and congress attendance. The students' survey provided data on attitudes, level of practical experience and perceptions on education.

Quantitative data collected included cut-scores, assessment scores and allocations for level in terms of irrelevant information, foundational knowledge, core knowledge and specialist knowledge from veterinarians. Data collected from students included assessment scores, assignment scores, face-to-face contact topics and self-directed learning topics, assignment scores, and information on academic procrastination in terms of handing in of assignments on time, or late. Surveys of the students also provided information on reasons for participation and perceptions on teaching methods.

Statistical analyses of the data were performed using SAS software, Version 9.4 of the SAS System for Windows. The Shapiro-Wilk test was used to determine normality and where data was not normal, the Mann-Whitney U test was used. Spearman rank correlation was used for ordinal data and the Fisher's Z transformation determined significance. A power analysis was not initially performed as a convenience sample was used. However, when performed on the data afterwards, the power analysis showed that the sample sizes for both students and veterinarians were large enough to ensure a power of above 90%. The power analysis should be done at the onset of future studies. A linear regression model and ordinal regression model were used to investigate data from veterinarians' surveys, the cognitive levels of the assessment questions, and the effect of the teaching method respectively.

6.1.3 DISCUSSION ON WHAT HAS BEEN LEARNED FROM THIS RESEARCH

It takes tremendous effort to categorise the questions used in an exam according to cognitive level and day one competencies. However, this study has demonstrated the relevance of including cognitive levels in the data analysis (as seen in chapter 3), as it has an effect on outcomes and scores. Thus, careful consideration of cognitive levels should be integral in the delivery and assessment of modules within a curriculum. This study also showed that the number of DOCs covered in a question is directly associated with the cognitive level at which it is pitched and thus it is a tool to develop questions as one knows that the relevant DOCs will inevitably be covered by the higher cognitive level questions. The number of DOCs covered by a question may also assist the assigning of cognitive levels. If many DOCs are included, chances are that the question is at a higher cognitive level (as seen in chapter 3). Once this exercise of allocating a cognitive level to each question in the assessment has been done, it is easier to set future questions and to decide on the suitability of a question and what it addresses.

Setting a duplicate paper (or mock assessment) takes as much, if not more time than setting an authentic paper as a first assessment, yet it is a useful tool in determining the relevance of the knowledge in the workplace. Thus, mock assessments can be used (if duplicating the original assessment's cognitive level and content) to gauge the knowledge base of the

students and provide an early recognition system for students that may require additional tutoring (as seen in chapter 3).

When evaluating the cut-scores of an assessment, the statistics showed that a smaller sample of specialist judges may be suitable for evaluating the relevance of the questions (chapter 3). This provides a practical solution to the dilemma of involving a number of busy practitioners to assist with the assessment of students. However, one external examiner or moderator is not sufficient, and a wider view is still needed. Duplicate-type papers can be used to determine the cut-scores and are essential in preventing the intended exam paper from being "leaked" to the students. However, it is the view of the lecturers in the small ruminant section at the University of Pretoria that once a suitable and sizable bank of questions has been compiled, there is no reason why these questions cannot be given to the students before an exam, as they cannot predict which questions will be selected for the exam and will thus need to study all the questions, essentially covering the module content.

Assessing cognitive levels in every aspect of a curriculum is vital to the success of a programme. It has been shown by this study that cognitive levels affect student scores more than those of practitioners (chapter 4). This information is vital in teaching our students to think at a higher cognitive level as they would in practice. In the opinion of the researcher, this is a skill that is not adequately addressed in current curricula in various fields. It has also been demonstrated that cognitive levels have an effect on learning – whether face-to-face or following a SDL approach (chapter 5). It is therefore vital to include higher cognitive levels as early on as the foundation knowledge phase, to enable a day one competent veterinarian to be functional in a real-life practice. This way of learning and approaching problems is essential for a meristemic approach.

This study has highlighted the importance of cognitive levels in every aspect of an undergraduate veterinary degree and the veterinarian's future career, and as such deserves further research.

6.1.4 WHAT THIS STUDY HAS CONFIRMED WITH REGARDS TO PRIOR RESEARCH

Having the same assessment completed by students twice within a module did not allow for students to memorise the information in the assessment, and so did not have a direct impact on the final scores. This was also the findings of George, *et al.* (2006) who used a six-month test-retest period and Pettey (2014) who used a two-week interval. Such an assessment can for all intents and purposes be useful in providing a baseline of student knowledge and potentially identify students who made need additional support earlier in the module.

A modified Angoff method can accurately predict student performance and is a suitable method of setting cut-scores as was found by Berk (1986) Cascio, Alexander and Barrett (1988), and Fehrmann et al. (1991).

Earlier research has suggested that the number of judges in a modified Angoff method of setting cut-scores can be reduced and 15 judges was considered to be adequate (Shulruf et al., 2016). However, Shulruf et al. conceded that further research was needed because their study was performed as simulated exercises, and the number of items used was relatively low. The current study has shown that the number of judges can be reduced even further and that a group of veterinarians who spend 70% or more of their time in the under consideration, can provide accurate results with fewer judges.

The current study also confirmed that the use of cognitive levels as determined by Bloom (1956) and revised by Anderson and Krathwohl (2001), is essential to curriculum design, delivery and assessment practices in veterinary education.

Eighty six percent of the students who participated in the current study indicated that they valued the feedback given in the LMS. This is considerably more than the 60% previously reported by Tormey (2015). Goos, Gannaway and Hughes (2011) describe the attributes of feedback derived from first year students. It is clear that well-constructed feedback is preferable to generalised feedback in formative assessment. Thus, these assessments may be used as learning tools (Tormey, 2015).

A recent study by Deslauriers *et al.* (2019) confirmed that students' actual learning and perceptions of learning are not necessarily correlated. Their study involved active and passive learning (both with face-to-face time with a lecturer), as opposed to the SDL (no lecturer present) and traditional lecture methods used in this study. This study described how students tended to perform well in the SDL tasks despite having received mostly negative comments.

6.2 RECOMMENDATIONS FOR FURTHER RESEARCH

Many areas for further research were highlighted throughout the study. However, there is one final recommendation as there are a number of variables including gender, background, race or economics (and others), that could have influenced the outcome of this study, and specifically student's attitudes towards self-directed learning. There is relatively little research on the impact of attitudes towards different methods of teaching as this is difficult to determine based on these variables. Further research is therefore recommended.

REFERENCES

Ahadian, S., Ostrovidov, S., Hosseini, V., Kaji, H., Ramalingam, M., Bae, H. & Khademhosseini, A., 2013, Electrical stimulation as a biomimicry tool for regulating muscle cell behaviour, *Organogenesis* 9 (2), 87-92, DOI: 10.4161/org.25121

Allen, I.E. & Seaman, C.A., 2007, Likert scales and data analyses, Quarterly progress; July 2007; 40, 7, Proquest 64-65.

Allworth, M.B., 2014, Postgraduate distance education in sheep health veterinary education, *Small Ruminant Research* 118, 97-99.

Anderson, L., & Krathwohl, D. E., 2001, *A Taxonomy for learning teaching and assessing: A*

revision of Bloom's taxonomy of educational objectives [Abridged], New York: Addison

Wesley Longman, Inc.

Angoff, W.H., 1971, Scales, Norms, and Equivalent Scores, in: Thorndike, R.L. (ed.), *Educational Measurement*, Washington DC: American Council on Education, pp 508-600.

Bailey, K.D., 1978, *Methods of social research*, Free Press, Macmillan Publishing, New York.

Bath, G.F., Malan. F.S. & Van Wyk, J.A. 1996. The “FAMACHA” Ovine Anaemia Guide to assist with the control of haemonchosis, in Proceedings of the 7th Annual Congress of the Livestock Health and Production Group of the South African Veterinary Association, Port Elizabeth

Bath, G.F., Roger, P.A., Winter, A.C., Vellema, P., Ganter, M., Trower, C., Lewis, C. & Fthenakis, G.C., 2006, Round table discussion: specialisation in sheep health and production, *Small Ruminant Research* 62, 5.

Bath, G.F. & van Wyk, J.A., 2009, The Five Point Check © for targeted selective treatment of internal parasites in small ruminants, *Small Ruminant Research* 86, 6-13.

Benner, P., Tanner, C. & Chesla, C., 1995, *Expertise in Nursing Practice – Caring, Clinical Judgement and Ethics*, New York, Springer Publishing Company Inc (In Finnish: Juva: WSOY 1999)

Benyus, J.M., 1997, Biomimicry: Innovation Inspired by Nature, *Harper Perennial*. ISBN-10:0060533226.

Berdie, D.R., 1973, Questionnaire length and response rate, *Journal of Applied Psychology* 58, 278-280.

Berdie, D.R., Anderson J.F. & Niebuhr M.A., 1986, *Questionnaires: Design and Use.* Scarecrow Press, Metuchen, New Jersey.

Berk, R.A., 1986, A consumer's guide to setting performance standards on criterion-referenced tests, *Review of Educational Research* 52, 137-172.

Biggs, J., 1993, From theory to practice: a cognitive systems approach, *Higher Education Research and Development* 12, 73-85.

Biggs, J., 1996, Enhancing teaching through constructive alignment, *Higher Education* 32: 347-364. https://doi.org/10.1007/BF00138871

Biggs, J., 1999, Teaching for quality learning at university, Buckingham: SRHE.

Biggs, J. & Collis, K.,1982, Evaluating the quality of learning, New York: Academic Press.

Biggs, J.B., 2003, Teaching for quality learning at university, Buckingham: Open University Press/Society for Research into Higher Education. (Second edition)

Bjork, R.A., Dunlosky, J. & Kornell, N., 2013. Self-regulated learning: beliefs, techniques and illusions. *Annual Review of Psychology*, 64(1), 417-444.

Bloom, B., Englehart, M. Furst, E., Hill, W., & Krathwohl, D., 1956, *Taxonomy of educational objectives: The classification of educational goals. Handbook I: Cognitive domain*. New York, Toronto: Longmans, Green.

Brown, S., 1998, Criterion-referenced assessment: what role for research, In Black, H. & Dockerell, W. (Eds.), New developments in educational assessment, Brit J Educ Psychol, Monograph Series No 3, 1-14.

Cantor A. D., Eslick A.N., Marsh E.J., Bjork R.A., Bjork E.L., 2015. Multiple-choice tests stabilize access to marginal knowledge. *Memory and Cognition* 43(2):193-205

Cascio, W.F., Alexander, R.A. & Barrett, G.V., 1988, Setting cutoff scores: Legal, psychometric, and professional issues and guidelines, *Personnel Psychology* 41, 1-24.

Cizek, G.J. & Bunch, M.B., 2011, The Ebel Method. In: *Standard Setting: A Guide to Establishing and Evaluating Performance Standards on Tests,* Sage Publications, Inc. Thousand Oaks. ISBN: 9781412916837 pp 75-80.

Clarence-Fincham, & Naidoo, 2013, Taking a longer View: Process of Curriculum Development in the Department of Graphic Design at the University of Johannesburg, *Critical Studies in Teaching and Learning* 1, 80-102.

Clason, D.L. & Dormody, T.J., 1994, Analyzing data measured by individual Likert-type items, *Journal of Agricultural Education* 35(4), 31-35

Clason, D.L. & Dormody, T.J., 1994. Analyzing data measured by individual Likert-type items. Journal of Agricultural Education 35 (4), 31-35

Collins, G.H. & Taylor, R.M., 2002, Attributes of Australasian veterinary graduates: report of a workshop held at the Veterinary Conference Centre, Faculty of Veterinary Science, University of Sydney, January 28-29, 2002, *Journal of Veterinary Medical Education* 29, 71-72.

Critchlow, D.E. & Fligner, M.A., 1991, On distribution-free multiple comparisons in the one-way analysis of variance, *Communications in Statistics—Theory and Methods* 20, 127–139.

Crouch, C.H. & Mazur, E., 2001, Peer instruction: ten years of experience and results, *American Journal of Physics Teachers* 40, 206-209.

Davis, M.H., Ponnamperuma, G.G., McAleer, S. & Dale, V.H., 2006, The Objective Structured Clinical Examination (OSCE) as a determinant of veterinary clinical skills, *Journal of Veterinary Medical Education* 33, 578-587.

DeLozier, S.J. & Rhodes, M.G., 2017, Flipped classrooms: a review of key ideas and recommendations for practice, *Educational Psychology Review* 29, 141-151.

Deslauriers, L., McCarty, L.S., Miller, K., Callaghan, K. & Kestin, G., 2019, Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom, *Proceedings of the National Academy of Sciences* 116(39), 19251-19257.

Dohoo, I., Martin, W. & Stryhn, H., 2003, *Veterinary Epidemiologic Research*. AVC Inc., Charlottetown, Prince Edward Island, Canada 212-213

Downing, S.M., Lieska, N.G. & Raible, M.D., 2003, Establishing passing standards for classroom achievement tests in medical education: a comparative study of four methods, *Academic Medicine* 78(10), 85-87.

Ebel, R. L., 1979, Essentials of educational measurement (3rd ed.), Englewood Cliffs, NJ, Prentice-Hall.

Eraut, M., 1994, *Developing Professional Knowledge and Competence*, London, The Falmer Press.

Esfand, R. & Tomalia, D.A., 2001, Poly (aminoamine) (PAMAM) dendrimers: from biomimicry to drug delivery and biomedical applications, *Drug Discovery Today* 6(8), 427-436.

Fagan, A.P., Crouch, C.H. & Mazur, E., 2002, Peer instruction: results from a range of classrooms*, Physical Teaching* 40, 206-209.

Fehrmann, M.L., Woehr, D.J., & Winfred Arthur, J.R., 1991, The Angoff cutoff score method: The impact of frame-of-reference rater training, *Educational and Psychological Measurement* 51, 857-872

Fisher, R.A., 1915, Frequency Distribution of the Values of the Correlation Coefficient in Samples from an Indefinitely Large Population, *Biometrika* 10(4), 507-521. doi:10.2307/2331838

Fitzpatrick, A.R., 1989, Social influences in standard setting: The effects of social interaction on group judgements, *Review of Educational Research* 59, 315-328.

Fraser, S.P. & Bosanquet, A.M., 2006, The curriculum? That's just a unit outline, isn't it?, *Studies in Higher Education* 31(3), 269-284.

Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H. & Wenderoth, M.P., 2014, Active learning increases student performance in science, engineering, and mathematics, *Proceedings of the National Academy of Sciences* 111(23), 8410-8415.

Frey, B., 2018, The SAGE encyclopedia of educational research, measurement, and evaluation (Vols. 1-4,. Thousand Oaks, CA: SAGE Publications, Inc. doi: 10.4135/9781506326139

Fthenakis, G.C., 2008, Veterinary specialization in small ruminant health management: Foundation of a European College of Small Ruminant Health Management [ECSRHM], *Small Ruminant Research* 76, 49-54.

Gamage, A. & Hyde, R., 2012, A model based on biomimicry to enhance ecologically sustainable design, *Architectural Science Review* 55(3), 224-235.

Garland, R., 1991, The midpoint on a rating scale: is it desirable?, *Marketing Bulletin* 2, 66-70. http://marketing-bulletin.massey.ac.nz viewed 30/01/2017.

Geer, J.G., 1988, What do open-ended questions measure?, *Public Opinion Quarterly* 52, 365-371.

George, S., Haque, M.S. & Oyebode, F., 2006, Standard setting: comparison of two methods, *BMC Medical Education* 6, 46. DOI: 10.1186/1472-6920-6-46

Glass, G.V., 1978, Standards and criterion, *Journal of Educational Measurement* 15, 237-261.

Gliem, J.A. & Gliem, R.R., 2003, Calculating, interpreting and reporting Cronbach's Alpha Reliability Coefficient for Likert-type scales, Midwest Research to Practice Conference in Adult, Continuing, and Community Education, The Ohio State University, Columbus, OH, October 8-10, 2003.

Goos, M., Gannaway, D., Hughes, C., 2011. Assessment as an equity issue in higher education: comparing the perceptions of first year students, course co-ordinators, and academic leaders. *Australian Educational Research* 38, 95-107.

Government Gazette No 36003, 2012, Higher Education Qualifications Sub-Framework, Notice 1040 of 2012.

Government Gazette No. 36003 of 14 December 2012 in terms of the National Qualifications Act, 2008 (Act No. 67 0f 2008) and as contemplated in the Higher Education Act, 1997 (Act No. 101 of 1997), The Higher Education Qualifications Sub-Framework, As revised January 2013.

Gronlund, N.E., 2006, Assessment of student achievement, 8th Edition, Pearson Education Inc., Boston.

Hambleton, R.K. & Eignor, D.R., 1979, Competency test development, validation, and standard setting, in Jaeger, R. & Tittle, C. (eds.), *Minimum competency testing*, Berkley, CA: McCutchan.

Harasym, P.H., 1981, A comparison of the Nedelsky and modified Angoff standard-setting procedure on evaluation outcome, *Educational and Psychological Measurement* 41, 725-734.

Hecker, K., Read, E.K., Vallevand, A., Krebs, G., Donszelmann, D., Meulling, C.K.W. & Freeman, S.L., 2010, Assessment of first-year veterinary students' clinical skills using objective structured clinical examinations, *Journal of Veterinary Medical Education* 37(4), 395-402.

Higher Education Qualifications Sub-Framework, 2013. As approved by the Minister of Higher Education and Training (Notice 1040 of 2012; Government Gazette No. 36003 of 14 December 2012) in terms of the National Qualifications Act, 2008 (Act No. 67 0f 2008) and as contemplated in the Higher Education Act, 1997 (Act No.101 of 1997).

Higher Education University of Pretoria, https://www.up.ac.za , viewed 16 March 2015.

Holmes, M. & Cockcroft, P., 2008, *Handbook of Veterinary Clinical Research*, Blackwell Publishing, Oxford, United Kingdom.

Hodson, D., 1990, A critical look at practical work in school science, *School Science Review* 71(256), 33-40.

Hurtz,G.M. & Auerbach, M.A., 2003, A meta-analysis of the effects of modifications to the Angoff method on cutoff scores and judgement consensus, *Educational and Psychological Measurement* 63(4), 584-601

Irons, P.C., Holm, D.E., & Annandale, C.H., 2017, Curricular renewal at the southern tip of Africa: The 2016 veterinary curriculum at the University of Pretoria, *Journal of Veterinary Medical Education* 44(3), 440-449.

Jansen, J.D., 1998, Curriculum Reform in South Africa: a critical analysis of outcomes-based education, *Cambridge Journal of Education*, 28:3, 321-331

Kachelhoffer, P.M., Malan, S.P.T. & Knoetze, J.G. 1991, Riglyne vir kurrikulumontwikkeling, In: Malan, S.P.T. & Du Toit, P.H. (Red.) Suksesvolle Onderrig: Riglyne vir onderwysers en opleiers, (Hoofstuk 1), Pretoria: Academia, pp. 1-28.

Katajavouri, N., Lindblom-Ylänne, S. & Hirvonen, J., 2006. The significance of practical training in linking theoretical studies with practice. Higher Education 51, 439-464

Kiggundu, E. & Nayimuli, S., 2009, Teaching practice: a make or break phase for student teachers, *South African Journal of Education* 29, 345-358.

Krefting, L, 1991, Rigor in qualitative research: the assessment of trustworthiness, *The American Journal of Occupational Therapy* 45(3), 214-222.

Lawson, M.J., Vosniadou, S., van Deur, P., Wyra, M. & Jeffries, D., 2019. Teachers' and students' belief systems about self-regulation of learning. Educational Psychology Review, 31, 223-251.

Leask, R, Thompson, P.N., van Wyk, J.A. & Bath, G.F., 2013, The effect of application of the FAMACHA© system on selected production parameters in sheep, *Small Ruminant Research* 110,1-8

Lewis, M., 2019, Biomimicry: solving problems using nature's solutions, *Popular Mechanics*, June 2019 Vol 17, Number 10, p 30-34.

Likert, R., 1932, A technique for the measurement of attitudes, Archives of Psychology 140 (55).

Lin, J., Wang, X., Ding, B., Yu, J., Sun, G. & Wang, M., 2012, Biomimicry via Electrospinning, *Critical Reviews in Solid State and Materials Sciences* 37(2), 94-114.

Liu, Y& Passino, K.M., 2002, Biomimicry of social foraging bacteria for distributed optimization: models, principles, and emergent behaviours, *Journal of Optimization Theory and Applications* 11(3), 603-628.

Livingston, S.A. & Zieky, M.J., 1982, *Passing scores: A manual for setting standards of performance on educational and occupational tests,* Princeton, NJ: Educational Testing Service.

Luckett, K., 1995, Towards a model for curriculum development for the University of Natal's Curriculum Reform Programme, *Academic Development* 1(2)

Luckett, K., 2001, Responding to equity and development imperatives: conceptualizing a structurally and epistemically diverse undergraduate curriculum in post-apartheid South Africa, *Equity & Excellence in Education* 34(3), 26-35.

Majeski, R.A., Stover, M. & Ronch, J., 2016, Making asynchronous online learning more learner-oriented: An integrated conceptual model with applications for course design and instruction, *Educational Gerontology* 42(2), 109-119.

Malan, F.S., van Wyk, J.A. & Wessels, C.D., 2001, Clinical evaluation of anaemia in sheep: early trials, *Onderstepoort Journal of Veterinary Research* 68, 165-174.

May, A., 2018, Instructional design models: comparing ADDIE, Bloom, Gagne, & Merrill, https//www.dashe.com/blog/instructional-design-models-comparing-addie-bloom-gagne-merrill viewed 10/06/2020.

May, S.A. & Silva-Fletcher, A., 2015, Scaffolded active learning: Nine pedagogical principles for building a modern veterinary curriculum, *Journal of Veterinary Medical Education* 42(4), 332-339.

May, S.A. & Head, S.D., 2010, Assessment of technical skills: best practices, *Journal of Veterinary Medical Education* 37(3).

McClendon, M.J. & O'Brien, D.J., 1988, Question-order effects on the determinants of subjective well-being, *Public Opinion Quarterly* 52, 351-364.

McLennan, M.W. & Heath, T.J., 2000, The role of lectures in veterinary education, *Australian Veterinary Journal* 78(10), 702-709.

McKenna, S., 2011, Paradigms of curriculum design: implications for South African educators, *Journal for Language Teaching* 37(2), 215-223.

Millar, R., 2004, The role of practical work in the teaching and learning of science, The University of York, Department of Educational Studies, Paper prepared for the Committee:

High School Science Laboratories: Role and Vision, National Academy of Sciences, Washington, DC.

Miller G.E., 1990, The assessment of clinical skills/competence/performance. *Academic Medicine*, 65: S63-7.

Miller, K., Schell, J., Ho, A., Lukoff, B. & Mazur, E., 2015, Response switching and self-efficacy in peer instruction classrooms, *Physical Review Special Topics – Physics Education Research* 11, 010104(8).

Mohr, K.A.J. & Mohr, E.S.M., 2017. Understanding Generation Z students to promote a contemporary learning environment. Journal on Empowering Teaching Excellence, 1 (1), 9.

Moll, I., 2004, Curriculum responsiveness: the anatomy of a concept, in Griesel, H., Fish, P. & Moll, I. (eds), Curriculum Responsiveness: Case Studies in Higher Education, 1-19. Pretoria: SAUVC, 2004.

Montgomery, A.C. & Crittenden, K.S., 1977, Improving coding reliability for open-ended questions, *Public Opinion Quarterly* 41, 235-243.

Moon, J.A., 2004, A handbook of reflective and experiential learning: theory and practice, RouteledgeFalmer, New York.

Mubuuke, A.G., Mwesigwa, C. & Kiguli, S., 2017, Implementing the Angoff method of standard setting using postgraduate students: Practical and affordable in resource-limited settings, *African Journal of Health Professions Education* 9(4), 171-175. doi: 10.7196/AJHPE.2017.v9i4.631

Myers, D.G. & Lamm, H., 1976, The group polarization phenomenon, *Psychological Bulletin* 83(4), 602-627.

Nedelsky, l., 1954, Absolute grading standards for objective tests, *Educational and Psychological Measurement* 14, 3-19.

Norcini, J., Lipner, R., Langdon, L. & Strecker, C., 1987, A comparison of three variations on a standard-setting method, *Journal of Educational Measurement* 24, 56-64.

Norcini, J. & Shea, J., 1992a, Equivalent estimates of borderline group performance in standard setting, *Journal of Educational Measurement* 29, 19-24.

Norcini, J. & Shea, J., 1992b, The reproducibility of standards over groups and occasions, *Applied Measurements in Education* 5, 63-72.

Norcini, J., Shea, J. & Grosso, L., 1991, The effect of numbers of experts and common items on cutting score equivalents based on expert judgement, *Applied Psychological Measurement* 15, 241-246.

Norcini, J., Shea, J. & Kanya, D.T., 1988, The effect of various factors on standard setting, *Journal of Educational Measurement* 25, 57-65.

Osbourne, J., 1993, Alternatives to practical work, *School Science Review* 75 (271), 117-123.

Palinkas, L.A., Horwitz, S.M., Green, C.A., Wisdom, J.P., Duan, N. & Hoagwood, K., 2015, Purposeful sampling for qualitative data collection and analysis in mixed method implementation research, *Adm Policy Mental Health* 42, 533-544.

Palys, T., 2008, Purposive sampling, in L.M. Given (ed.), *The Sage Encyclopedia of Qualitative Research Methods* Vol 2. Sage, Los Angeles, 697-698.

Patton, M.Q., 1999, Enhancing the quality and credibility of qualitative analysis, *Health Services Research* 34(5), 1189-1208.

Payne KJ, 2010, Simplicity parenting: Using the Extraordinary Power of Less to Raise Calmer, Happier, and More Secure Kids, Ballantine Books

Perkin, J. 1995, Design and use of questionnaires in research, *The American Dietetic Association*, pp.111-129.

Pettey, K.P., 2014, Undergraduate veterinary education, *Small Ruminant Research* 118, 93-96.

Pienaar, M., 2014, The development and implementation of e-assessment as component of WIL: a case study, repository.nwu.ac.za

Posner, G. & Strike, K., 1976, A categorisation scheme for principles of sequencing content, *Review of Educational Research* 46(4): 665-690.

Rani Das, K. & Rahmatullah Imon, 2016, A brief review of tests for normality, *American Journal of Theoretical and Applied Statistics* 5(1), 5-12.

Rossin, K.J., 2010, Biomimicry: nature's design process versus the designer's process, Design and Nature V, Transactions on Ecology and the Environment, Vol 138, 559-570.

Russel, A.J.F., 1984, Means of assessing the adequacy of nutrition in ewes, *Livestock Production Science* 11, 429-436.

Scraw, G., Olafson, L. & Wadkins, T., 2007. Doing the things we do: A grounded theory of academic procrastination. Journal of Educational Psychology, 99 (1) 12-25.

Seemiller, C. & Grace, M., 2016. Generation Z goes to college. Jossey-Bass, San Francisco, California.

Senthong, V., Chindaprasirt, J., Sawanyawisuth, K., Aekphachaisawat, N., Chaowattanapanit, S., Limpawattana, P., Choonhakarn, C. & Sookprasert, A., 2013, Group versus modified individual standard-setting on multiple-choice questions with the Angoff method for Fourth-year medical students in the internal medicine clerkship, *Advances in Medical Education and Practice* 4, 195-200.

Shapiro, S.S., & Wilk, M.B., 1965, An analysis of variance test for normality (complete samples), *Biometrika* 52 (3/4), 591-611.

Sheatsley, P.B., 1983, Questionnaire construction and item writing, in: Rossi P.H., Wright J.D., Anderson A.B. (eds.), *Handbook of Survey Research*, Orlando, Fla: Academic Press Inc, pp.195-230.

Sholehah, S., Sangka, K.B. & Hamidi, N., 2018. Academic procrastination on digital native higher degree student: Does it really matter? *Advances in Social Science, Education and Humanities Research*, 262, 416-421.

Shulruf, B., Wilkinson, T., Weller, J., Jones, P. & Poole, P., 2016, Insights into the Angoff method: results from a simulation study, *BMC Medical Education* 16, 134-143

SSH510 Small Stock Health and Production, 2015, University of Pretoria, Onderstepoort.

Starr, C & Taggart, R., 1992, Biology: The unity and Diversity of Life 6th edn. p 473

Tongco, D.C., 2007, Purposive sampling as a tool for informant selection, *Ethnobotany Research & Applications* 5, 147-158.

Toohey, S. 1999, *Designing courses for higher education*, Buckingham: The Society for Research into Higher Education & Open University Press.

Tormey, W., 2015, Education, learning and assessment: current trends and best practice for medical educators, *Irish Journal of Medical Science* 184: 1-12. DOI 10.1007/s11845-014-1069-4

United Nations Sustainable Development Goals 2: Zero Hunger, 2015, https://www.un.org/sustainabledevelopment/hunger/ accessed 19/11/ 2020.

Verhoeven, B. H., Van der Steeg, A.F.W., Scherpbier, A.J.J.A., Muijtjens,A.M.M., Verwijnen G.M., & Van Der Vleuten, C.P.M., 1999, Reliability and credibility of an Angoff standard setting procedure in progress testing using recent graduates as judges, *Medical Journal* 33(11), 832-837. DOI 10.1046/j.1365-2923.1999.00487.x

VET200 Veterinary Ethology and Genetics, 2015, University of Pretoria, Onderstepoort.

Volery, T. & Lord, D., 2000. Critical success factors in online education. International Journal of Education Management, 4, 216-223.

Walley, S. & Albadri, S., 2015, Undergraduates' perceptions of the value of practical inhalation sedation experience in a UK dental school, *European Archives of Paediatric Dentistry* 16: 371-376. DOI 10.1007/s40368-014-0173-5

Ward, W.K., 2008, A review of the foreign-body response to subcutaneously-implanted devices: The role of macrophages and cytokines in biofouling and fibrosis, *Journal of Diabetes Science and Technology* 2(5), 768-776.

Wiggins, G. & McTighe, J., 1998, Understanding by design, Association for Supervision and Curriculum Development, Alexandria, VA, https://educationaltechnology.net/wp-content/uploads/2016/01/backward-design.pdf viewed 02/12/2019

Witheridge, A., Ferns G. & Scott-Smith, W., 2019, Revisiting Miller's pyramid in medical education: the gap between traditional assessment and diagnostic reasoning, *International Journal of Medical Education,* 10: 191-192

Woolnough, B.B. & Allsop, T., 1985, Practical Work in Science, Cambridge, Cambridge University Press.

Wrenn, J & Wrenn, B., 2009, Enhancing learning by integrating theory and practice, *International Journal of Teaching and Learning in Higher Education* 21(2): 258-265.

Addendum A: Animal Ethics Committee approval certificate

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Animal Ethics Committee

PROJECT TITLE	**A meristemic approach to veterinary education in small ruminants**
PROJECT NUMBER	**V018-17**
RESEARCHER/PRINCIPAL INVESTIGATOR	**Dr. R Leask**

STUDENT NUMBER (where applicable)	**U_02580276**
DISSERTATION/THESIS SUBMITTED FOR	**PhD**

Please provide an approval letter from OTAU. Maximum of 180 participants allowed

ANIMAL SPECIES	**Ewes (OTAU)**	
NUMBER OF ANIMALS	**45**	
Approval period to use animals for research/testing purposes		**March 2017-March 2018**
SUPERVISOR	**Prof. D Halm**	

KINDLY NOTE:

Should there be a change in the species or number of animal/s required, or the experimental procedure/s - please submit an amendment form to the UP Animal Ethics Committee for approval before commencing with the experiment

APPROVED	Date 27 March 2017
CHAIRMAN: UP Animal Ethics Committee	Signature

S4285-15

Addendum B: Day One Competencies Document

UNIVERSITY OF PRETORIA

FACULTY OF VETERINARY SCIENCE

ESSENTIAL COMPETENCES REQUIRED OF THE NEW VETERINARY GRADUATE

2009-07-02

The proposed "Day One Competences" contained in this document were adapted from the latest (2006) document of the RCVS entitled "Criteria and guidance for RCVS approval of veterinary degree courses in the UK and overseas". It follows on the recent discussions on global accreditation between the AVBC, AVMA, EAEVE and SAVC.

The RCVS document makes the following statements on competence which should be observed when reading the attached proposals:

"There are many definitions of 'competence' and many views on how it can be developed and assessed. In general terms, however, competence is a concept that integrates knowledge, skills and attitudes, the application of which enables the professional to perform effectively, and to respond to contingencies, change, and the unexpected.

This document takes a broad definition of competence as being ***"the ability to perform the roles and tasks required by one's job to the expected standard"*** *(Eraut & Boulay, 2000[12]). The advantage of this definition is that it recognises that requirements and expectations change depending on the job role and context. It also recognises that competence develops, and that an individual may work 'competently' at many different levels, either at different stages of their career, or indeed from one day to the next depending on the nature of their work".*

The proposed "Day One Competencies" which follow are to be seen as the minimum requirements of veterinary education and training in South Africa. As such, they reflect the minimum requirements of the core component in a core-elective degree programme.

It should be noted that the RCVS is also in the process of developing further minimum requirements for veterinary public health teaching in the UK schools which will also have to be considered for implementation. The current minimum requirements are as follows:

1) Recognise and advise on the consequences for human health and the environment of animals and their management, and through this contribute to the improvement of human well-being as part of a multidisciplinary team
2) Understand the scientific basis for the legislative control of food and protection of the environment
3) Advise on the suitability of animals for food production, recognise and apply the principles of food hygiene and safety, including food inspection and control, and implement the principles of health certification of food – this item is already included in the attached proposal in items B1.9 and C1.9
4) Understand and apply the principles of risk analysis, particularly as they relate to food safety at all stages of the food chain

5) Devise and operate HACCP programmes and longitudinal integrated food safety and quality assurance (LISA) systems

UNIVERSITY OF PRETORIA

FACULTY OF VETERINARY SCIENCE

2009-07-02

ESSENTIAL COMPETENCIES REQUIRED OF THE NEW VETERINARY GRADUATE

"DAY ONE COMPETENCIES"

Veterinarian – a person with professional skills, attributes, knowledge and understanding who is able to provide comprehensive services ranging from individual clinical services to a full spectrum of preventive/regulatory/control services through which an individual, communities and the country as a whole may also benefit

Common domestic species – implies cattle, horses, small stock (sheep and goats), pigs, poultry, dogs and cats in the context of this document

A 1 - GENERAL PROFESSIONAL SKILLS AND ATTRIBUTES

The new veterinary graduate should be able to:

A1.1 Recognise and comply with all legal and statutory requirements and obligations pertaining to veterinary activities

A 1.2 Communicate effectively, both verbally and in writing, with clients, the lay public, professional colleagues and responsible authorities; listen to, understand and respond empathetically to clients, use language in a form appropriate to the audience and the context (a diversity of cultures, customs, value systems and means)

A 1.3 Work as a member of a multi-disciplinary team and/or collaboratively with professional colleagues, support staff and clients

A 1.4 Recognise the ethical responsibilities of the veterinarian to the community in relation to their possible impact on the environment and society as a whole, taking into account the diversity of cultures, customs, value systems and means of the various communities (see A 1.9)

A 1.5 Recognise the economic and emotional climate in which the veterinarian operates and respond appropriately to the influence of such pressures

A 1.6 Demonstrate willingness to use his/her professional capabilities to contribute as far as possible to the advancement of veterinary knowledge in order to improve the quality of animal care and public health

A 1.7 Manage a veterinary practice through application of basic principles of:
- human resource management,
- financial management,
- health, safety, biosecurity and labour legislation,
- use of information technology,
- public liability, and

- compliance with regulatory requirements (fees, record-keeping, advertising) as determined by the SAVC

A 1.8 Understand the need and professional obligation for a commitment to continuing education, training and professional development throughout one's professional life

A 1.9 Conduct him/herself in a professional manner with regard to the veterinarian's professional, legal and ethical responsibilities in relation to individual patient care and client relations, demonstrate a mature personality, integrity, tolerance and patience and understand and apply the Code of Conduct and Practice of the SAVC (see A1.4)

A 1.10 Demonstrate and apply skills that enable him/her to competently undertake the functions expected of a veterinarian including
- literacy and numeracy,
- relevant computer skills and utilisation of modern information technology,
- critical and analytical thought,
- logical reasoning,
- problem-solving,
- finding, utilising and managing information,
- well-developed observational skills,
- adaptation to change, and
- make valid judgments and deductions on the basis of available evidence and information.

A 1.11 Develop a capacity for intellectual curiosity and desire for life-long learning, self-audit and willingness to participate in the peer-review process

A1.12 Demonstrate understanding of the scientific method and the scientific basis of modern veterinary medicine and the ability to utilise scientific principles in the practice of veterinary science and medicine

A 1.13 Recognise own professional/technical limitations and demonstrate awareness of when and from where to seek professional advice, assistance and support

(Commentary: This last item is considered to be one of the most important, and should guide all new veterinary graduates when undertaking their professional duties)

B1- UNDERPINNING KNOWLEDGE AND UNDERSTANDING

The new veterinary graduate shall have a thorough knowledge and understanding of the following:

B 1.1 Basic subjects in chemistry, molecular cell biology and physics as well as animal science (husbandry, nutrition and production) and veterinary science subjects on which everyday veterinary activities are based

B 1.2 A basic foundation in research methodology and the contribution of basic and applied research to all aspects of veterinary science

B 1.3 How to evaluate evidence including the interpretation of clinical and diagnostic test results

B 1.4 The structure and functions of healthy animals and all aspects of their husbandry

B 1.5 The aetiology, pathogenesis, clinical signs, diagnosis, pathology, treatment, epidemiology and control/eradication of the common diseases (infectious, parasitic, non-infectious and toxicities) and other disorders that occur in the common domestic species and selected non-domestic species in South Africa and the immediate surrounding southern African region

B 1.6 Relevant South African legislation applicable to the veterinary and paraveterinary professions, animal welfare, meat safety, animal improvement, medicines and related substances, hazardous substances, environment, animal diseases and notifiable/controlled diseases

B 1.7 Relevant South African legislation and guidelines on responsible sale, use, dispensing, storage and disposal of medicines and related substances in animals

B 1.8 Environmental aspects including farming practices, social and economic factors, climate and weather, water supply, conservation practices, etc.

B 1.9 The principles of disease prevention (immunisation, parasite control, housing, nutrition, management and medication) and the promotion of health and welfare, including public health and zoonoses

B 1.10 Veterinary public health principles related to food hygiene and safety, health certification of food, HACCP and zoonotic diseases

C1 - PRACTICAL COMPETENCIES/SKILLS

The new veterinary graduate should be able to:

C1.1 Obtain an accurate history of the individual animal/group of animals including relevant aspects related to the immediate environment of the animal(s)

C1.2 Approach, handle and restrain animals in ways that are effective, safe, humane, ethical and appropriate to the circumstances and instruct others in performing these techniques

C1.3 Investigate a disease outbreak, applying basic epidemiological principles

C1.4 Perform a complete clinical examination and distinguish between normal and abnormal

C1.5 Derive a well-considered diagnosis and list of differential diagnoses

C1.6 Attend to all animals in an emergency and perform basic first aid

(Commentary: problems to be handled for any species include first aid management of haemorrhage, wounds, breathing difficulties, eye & ear injuries, unconsciousness, clinical deterioration, burns, tissue damage, internal organ damage and cardiac arrest. First aid to be applied includes bandaging, cleaning, immobilising limbs, resuscitation procedures, haemorrhage control.)

C1.7 Correctly assess the nutritional status of an animal and advise the client on principles of husbandry and feeding

(Commentary: this applies to commonly presented cases and would not, for example, be expected to include advanced nutritional advice for complex cases, eg. high performance horses, high yielding dairy cows, certain exotic or zoological species.)

C1.8 Where appropriate, carry out routine diagnostic tests and procedures (such as haematology, basic clinical pathology, basic imaging) and request more advanced tests as are needed to make a diagnosis. Ensure proper collection, preservation, identification, and handling of samples, keep accurate records, interpret the results, ensure any diagnostic equipment is used safely and maintained in accordance with current regulations, while applying appropriate quality control

(Commentary: new graduates are expected to have a working knowledge of tests to be undertaken including conditions relating to infectious & contagious diseases; alimentary system; respiratory system; circulatory system; urinary system; nervous system; endocrine system; mucocutaneous system; musculoskeletal system; trauma; poisoning; obstetrics; paediatrics; parturition; reproduction)

C1.9 Use radiographic, ultrasonic, and other technical equipment which can be used as a diagnostic aid, safely and in accordance with current regulations

C1.10 Adhere to and implement the requirements of regulatory/state veterinary medicine in relation to controlled/notifiable diseases, food safety and certification of animals and animal products

C1.11 Promote and maintain human health through the application of veterinary public health principles in the provision of safe, sound and wholesome foodstuffs of animal origin, the control of zoonoses and the appropriate handling and disposal of biological waste and contaminated materials/substances

C1.12 Know and apply the requirements for veterinary certificates as contained in the Code of Conduct and Practice and Rule 5 of the Rules relating to the practicing of veterinary professions, correctly

C1.13 Access the appropriate sources of data on registered medicines; store, administer, prescribe and dispense appropriate pharmacological agents or medicines correctly and responsibly in accordance with relevant legislation, including disposal of waste and unused/expired medicines

C1.14 Carry out common surgical procedures using appropriate techniques and procedures before, during and after surgery, including correct application of the principles of sterilisation of surgical equipment and aseptic surgery

C1.15 Recognise when analgesia and/or anaesthesia are required, implement chemical methods of restraint, assess and control pain, safely induce, maintain and monitor analgesia, sedation, general and regional anaesthesia and take steps to ensure safe and humane recovery

C1.16 Assess the need for therapeutic or other intervention, advise the client accordingly (rationale, options, outcomes, human safety, costs, ethical considerations) and administer appropriate treatment with due cognisance of one’s own professional/technical limitations

(Commentary: the new veterinarian must always seek professional advice and support if presented with a case beyond his or her immediate capability - see item A1.14)

C1.17 Evaluate the need for euthanasia and, where required, carry it out safely and humanely with due consideration of the owner's consent and the feelings of owners and others. Advise on disposal of the carcass

C1.18 Carry out a routine post-mortem examination of common domestic animals, record and interpret gross post-mortem findings, and initiate further diagnostic procedures where appropriate. Derive a well considered morphological diagnosis and a list of aetiological diagnoses

C1.19 Perform ante mortem inspection of animals destined for the food chain and correctly identify conditions affecting the quality and safety of products of animal origin

C1.20 Interpret basic health and welfare records (including production records where necessary) and implement appropriate record-keeping systems

C1.21 Advise on, and carry out basic preventive and prophylactic programmes to promote health, well-being, productivity and performance (immunisation, feeding, housing, management, training, parasite control, treatment) appropriate to the species and commensurate with accepted animal health, welfare and public health standards

C1.22 Promote animal welfare

C1.23 Apply principles of bio-security to minimise the risk of contamination, cross infection and accumulation of pathogens in the veterinary premises and in the field