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Development of an accessible and relevant science based course to assist nursing students to cope academically with science subjects

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DEVELOPMENT OF AN ACCESSIBLE AND RELEVANT SCIENCE-BASED COURSE TO ASSIST NURSING STUDENTS TO COPE ACADEMICALLY WITH SCIENCE SUBJECTS

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A Dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science in Nursing

Johannesburg, 2022.

Declaration

I, Fija Maria Luijk, declare that this Dissertation being submitted for the requirements of the degree, Master of Science (MSc) Nursing, at the University of the Witwatersrand, Johannesburg, is my own work and has not been submitted before for any degree at any other institution.



Fija Maria Luijk 22 day of March 2022

Protocol number: M181047

Dedication

This dissertation is dedicated to all nursing students who start off with shiny eyes and open hearts. Always treasure your compassion.

“You can teach students a lesson for a day, but if you can teach them to learn by creating curiosity, they will continue the learning process as long as they live.”

Clay P. Bedford

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Abstract

The failure rate of science-related subjects is high among first-year nursing students. The gap between matriculation level and the first year of University commonly leads to attrition and prolonged study completion. Developing an accessible and relevant short course based specifically on the students' needs could reduce the failure rate, improve the throughput rates, and reduce the attrition rate. This will hopefully help to address the shortage of nurses and demoralization amongst the students.

The purpose of this research study was to develop an accessible, relevant, and appropriate science-based short course that will assist first-year nursing students to cope academically with science subjects as part of their university programme.

Design and development research methodology was utilised to design a short course in basic sciences for first-year nursing students at a University in Gauteng. The first phase of the study is a scoping review to explore the international attempts to structure and deliver science-based content to students. The second phase of the study describes the analysis of the students' needs as well as the nurse educators' opinions. The last phase of the study is the development and the expert review of the short course concerning accessibility, relevance and appropriateness. Both qualitative and quantitative methods were used to collect and analyse the data in the various phases of the study. The population consisted of first-year students enrolled in the B nursing programme and subject matter experts teaching the science subjects.

The generation most represented in nursing courses is currently the Gen Z group. Nursing students need academic support in basic sciences to build a foundational knowledge base of chemistry, physics, and mathematical concepts to ensure that a deeper knowledge can be acquired from the foundation as needed for application into safe clinical nursing practice. It was determined that a blended learning short course would be the preferred format in order to meet the learner's needs.

In conclusion it is estimated that the relevant and appropriate basic science concepts taught in this course will lead to a better understanding of basic science concepts and the appropriate application in clinical nurse practice resulting in safe patient care.

Keywords: Basic sciences, nursing students, Gen Z, nurse education, short course, chemistry, physics, nurse mathematics, student support, academic development, safe nursing practice.

Acronyms and abbreviations

ADDIE	Instructional design model – Assessment, Design, Development, Implementation and Evaluation
CINAHL	Cumulative Index to Nursing and Allied Health Literature
DDR	Design and Development Research
ERIC	Educational Resources Information Centre
HOD	Head of Department
OER's	Open Education Resources
P	Participant
PRISMA-ScR	Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews
RN	Registered Nurse
TBL	Team-based Learning
UDL	Universal Design for Learning

Table of Contents

Contents Page

DECLARATION II

DEDICATION III

ACKNOWLEDGEMENTS IV

ABSTRACT V

ACRONYMS AND ABBREVIATIONS VII

TABLE OF CONTENTS VIII

LIST OF FIGURES XIII

LIST OF TABLES XIV

CHAPTER ONE - OVERVIEW OF THE STUDY 1

1.1 INTRODUCTION 1

1.2 BACKGROUND 1

1.2.1 OVERVIEW 1

1.2.2 SCIENCES AND NURSING 3

1.2.3 APPROACHES TO TEACHING AND LEARNING RELATED TO SCIENCES 4

1.3 DEFINITIONS 7

1.3.1 SCIENCE-BASED 7

1.3.2 ACCESSIBILITY 8

1.3.3 RELEVANCE 9

1.4 PROBLEM STATEMENT 9

1.5 PURPOSE OF THE STUDY 10

1.6 RESEARCH QUESTION 10

1.7 OBJECTIVES 10

1.8 SIGNIFICANCE OF THE STUDY 11

1.9 OVERVIEW OF THE METHODS 11

1.10 ORGANISATION OF THE DISSERTATION 11

1.11 CONCLUSION 12

CHAPTER TWO - RESEARCH METHODOLOGY 13

2.1 INTRODUCTION 13

2.2 RESEARCH PARADIGM 13

2.3 RESEARCH DESIGN 16

2.4 METHODOLOGY IN PHASES 16

2.4.1 DESCRIPTION 16

2.4.2 PHASE 1: PROBLEM IDENTIFICATION 17

2.4.3 PHASE 2: NEEDS ANALYSIS (STUDENTS AND EDUCATORS) 24

2.4.4 PHASE 3: DESIGN AND DEVELOPMENT OF THE COURSE 33

2.4.5 PHASE 4: EVALUATION OF THE COURSE (EXPERT REVIEW) 36

2.4.6 PHASE 5: SHARING THE RESULTS 39

2.5 TRUSTWORTHINESS / RIGOUR OF THE STUDY 39

2.5.1 CREDIBILITY 40

2.5.2 TRANSFERABILITY 41

2.5.3 DEPENDABILITY 42

2.5.4 CONFIRMABILITY 42

2.6 ETHICAL CONSIDERATIONS 42

2.7 CONCLUSION 44

CHAPTER THREE - SCOPING REVIEW 45

3.1 INTRODUCTION 45

3.2 AIM 45

3.3 METHOD 45

3.4 CHARTING THE DATA 45

3.5 COLLATING, SUMMARIZING AND REPORTING OF THE RESULTS 52

3.6 SUMMARY 60

3.7 CONCLUSION 61

CHAPTER FOUR - NEEDS ANALYSIS 62

4.1 INTRODUCTION 62

4.2 STUDENTS' NEEDS ANALYSIS 62

4.2.1 DEMOGRAPHIC QUESTIONS 62

4.2.2 THEMATIC ANALYSIS OF THE ANSWERS TO THE OPEN-ENDED QUESTIONS 64

4.3 NURSE EDUCATORS' OPINION 73

4.4 DISCUSSION 75

4.5 CONCLUSION 78

CHAPTER FIVE - DEVELOPMENT OF THE SHORT COURSE 79

5.1 INTRODUCTION 79

5.2 DESIGN AND DEVELOPMENT OF THE SHORT COURSE 79

5.3 COMPONENTS OF THE SHORT COURSE 79

5.3.1 SETTING 79

5.3.2 COURSE DESCRIPTION AND MODULE DEVELOPMENT 79

5.3.3 DETERMINE THE COURSE GOAL 81

5.3.4 LEARNING OBJECTIVES 81

5.3.5 TEACHING ACTIVITIES 81

5.3.6 ASSESSMENT TASKS 82

5.4 IMPLEMENTATION 82

5.5 EVALUATION OF THE SHORT COURSE 82

5.5.1 EVALUATION METHOD 82

5.5.2 EXPERT REVIEW FEEDBACK 83

5.6 DISCUSSION 84

5.6.1 ACCESSIBILITY 85

5.6.2 RELEVANCE 85

5.6.3 APPROPRIATENESS 85

5.6.4 INNOVATIVE TEACHING METHODS 85

5.7 CONCLUSION 85

CHAPTER SIX - CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS 86

6.1 INTRODUCTION 86

6.2 SUMMARY 86

6.3 MAIN FINDINGS 87

6.4 LIMITATIONS 88

6.5 RECOMMENDATIONS FOR NURSING EDUCATION 89

6.6 RECOMMENDATIONS FOR NURSING RESEARCH 90

6.7 RECOMMENDATIONS FOR NURSING PRACTICE 90

6.8 CONCLUSION 91

REFERENCE LIST 92

APPENDIX A: ETHICAL CLEARANCE CERTIFICATE 103

APPENDIX B: PERMISSION FROM THE NURSING EDUCATION DEPARTMENT 104

APPENDIX C: STUDY INFORMATION SHEET – STUDENTS 106

APPENDIX D: STUDENT SURVEY QUESTIONNAIRE 108

APPENDIX E: FORMAL REQUEST LETTER PARTICIPATION NEA MEMBERS 109

APPENDIX F: STUDY INFORMATION SHEET - NURSE EDUCATORS 110

APPENDIX G: NURSE EDUCATORS QUESTIONNAIRE 112

APPENDIX H: TEACHING PLAN - BASIC SCIENCE COURSE FOR NURSING STUDENTS 113

APPENDIX I: REQUEST FOR THE EXPERT REVIEW 116

APPENDIX J: LANGUAGE EDITING CERTIFICATE 118

List of figures

Chapter 2

Figure 2.1: Prisma diagram 22

Figure 2.2: The steps of the ADDIE framework 34

Chapter 4

Figure 4.1: Age and matric year of matriculation 63

Figure 4.2: Subjects in matric 64

Figure 4.3: Participants' confidence with science subjects 69

Figure 4.4: Course presentation style 73

List of tables

Chapter 1

Table 1.1: Outcome of the midyear chemistry and physics exam 2

Table 1.2: Organisation of the chapters 12

Chapter 2

Table 2.1: Demographic questions and the reason for inclusion 28

Table 2.2: Nurse educators' work environment 32

Table 2.3: Description of course design quality 38

Chapter 3

Table 3.1: Scoping review data matrix 46

Chapter 4

Table 4.1: Nurse educators' opinions 74

Chapter 5

Table 5.2: The evaluator's feedback and researcher's response according to criteria 83

CHAPTER ONE - OVERVIEW OF THE STUDY

1.1 Introduction

This chapter provides an overview of the research process and states the research question, objectives, and purpose statement. It further provides the reader with background information on the importance of basic sciences for the nursing profession.

1.2 Background

1.2.1 Overview

Basic science is any combination of science subjects such as biology, chemistry, physics, and mathematical principles fundamental to the study of medicine (Pangaro, 2010).

According to Wilson-Strydom (2010), students' unpreparedness to enter university has become progressively more challenging as South African universities struggle to guarantee student success where schooling no longer provides satisfactory university preparation.

According to the Wits website (Wits, 2016), the Bachelor of Nursing degree is a four-year honours' equivalent degree that prepares nursing professionals for nursing and midwifery practice. The degree programme includes theoretical study and clinical training at University-affiliated hospitals, including specialist units and community clinics.

Nursing courses commence in the first year of study with fundamental courses that form the basis for the subsequent years of study. The curriculum includes a core of knowledge in the biological, natural, physical, and social sciences and nursing science theory and practice. A strong emphasis on the sciences is a characteristic of a Wits Bachelor's degree in Nursing. Students have to complete chemistry, physics and general biology courses in the first year of study.

The failure rate of science-related subjects is high among first-year nursing students. The gap between matriculation level and first-year University commonly leads to attrition and prolonged study completion. The spokesperson for the office of student support at the Health Science Faculty at the University of the Witwatersrand revealed some of the midyear results for first-year nursing students in 2017 (Greyling, 2017). The results showed: the number of registered students for the first year was sixty-one (61), with five (5) students repeating science subjects. From the cohort, eight (8) students did not do physical science in matric, only life science; however, only two (2) of the eight (8) students did not qualify to write the midyear exam in physics and chemistry. The outcome of the exam was therefore only calculated on fifty-nine (59) students and is summarised in table 1.1

Table 1.1 Outcome of the midyear chemistry and physics exam.

	Number of registered first-year students	Students did not do matric physical science	Students did not qualify to write the midyear exam	Midyear exam candidates	Students failed chemistry	Students failed physics
Total	61	8	2	59	34	34
Number of students repeating 1st year	5					
Percentage of group	8%	13%	3%	97 %	58%	58%

To bridge the gap between school and university, the University has introduced an orientation program for new nursing students. This orientation program was offered in 2014, where students were attending tutorial sessions covering basic science topics. Although there has been an improvement in students who have attended this orientation program, not all students attended these tutorial sessions, and failure rates of science-related subjects remain high. The orientation program was offered over two weeks prior to the start of the official programme. The reasons for poor

attendance might be due to logistical reasons such as access to University (new prospective students only register one week before the start of the university) and accommodation during the two weeks before the official nursing programme commence. Poor attendance justifies a needs analysis under the first-year nursing students to explore different methods to present the course material relevant to the subject matter.

It is envisaged that developing an accessible and relevant short course based specifically on the students' needs should reduce the failure rate in science-related courses. With the new technology available and widespread availability of free internet, new ways should be investigated to prepare students and bridge the gap from school to University.

1.2.2 Sciences and nursing

A sciences background (chemistry, anatomy, physiology, biochemistry, pathophysiology, pharmacology) joins forces with human sciences background to bring an informed viewpoint to the nursing practice. Once a student understands the basics, it is essential to build on those basics.

Khadem-Rhezayan et al. (2015) noted that a lack of basic science training might lead to less understanding of clinical topics. Many disease processes, diagnostics, and therapeutic matters are strongly related to basic sciences roots.

Birks et al. (2014) argue that biological, social and behavioural sciences inform the professional nursing practice. In undergraduate nursing programs, biological sciences typically include anatomy, physiology, microbiology, chemistry, physics, and pharmacology. The current gap in the literature results in a lack of information about the content and depth of biological sciences being taught in nursing curricula. Birks et al. (2014) aimed to establish what priority is given to the teaching of science topics in nursing programs to currently understand the importance placed on this subject area in nursing education. It is interesting to note that the main feature of nursing curricula such as science is hindered by a lack of research on what must be taught to provide the best preparation for students moving towards the nursing practice. Birks et al. (2014) concluded that the delivery of quality science content requires observational

information to ensure educational competence and up-to-date relevance. Current approaches to delivering science in nursing programs should prepare graduates to practice in a complex environment that requires clinical application of various basic knowledge concepts and skills.

Chemistry and physics included in a nursing programme have to cover topics that have direct application in clinical nursing practice, e.g., understanding the present condition of the patient, detection of vital signs, how to administer the right medicines to patients and how different tools and machines work (Balázsiová, 2017). The application of this knowledge without errors will prevent harm to patients' health. Critical thinking is part of a nurse's everyday responsibilities while attempting to accurately define patient care problems, make the best decisions from different possibilities, safely implement the nursing care plan, and evaluate the results of the delivered care. It is imperative that nursing students question, analyse, and make decisions based in part on appropriate scientific knowledge. The significance of a good understanding of chemistry in nursing is that it leads to critical thinking while making scientific decisions (Brown et al., 2012).

According to Hunter Revell and McCurry (2013), nurses must be fluent in mathematical basics as a communication language. Nurses routinely use addition, fractions, ratios and algebraic equations each workday to deliver the right amount of medication and fluid volume to their patients or monitor changes in their health. To provide safe care, nurses must understand different measurements such as weight and volume and how to convert units of measurements (for example, grams to milligrams), work with time calculations, understand fractions, ratios, and conversion. Nurses must calculate the intake and output of their patients as well as using calculators. Math is a good mental exercise in logic and critical thinking**.**

1.2.3 Approaches to teaching and learning related to sciences

Basic sciences are crucial for medical sciences education, but science students prefer basic science topics to be presented in a more clinically oriented manner, applied and practical (Khadem-Rhezayan et al., 2015). It was also stated that early exposure to clinical issues might trigger the students' motivation and interest in the

topic, which consequently enhances students' learning outcome. Integrated clinical discussions can also improve the students' performance in practice. Although this research (Khadem-Rhezayan et al., 2015) proved that some medical and dentistry basic science curricula were revised to be more clinically relevant according to professional needs and the tendency for early exposure to clinical issues, studies for such revisions in the nursing program seems to be scarce. Revision to basic science content in nursing should be done with both students' opinions and clinical and basic science educators of nursing schools. Physiology is one of the major foundational sciences for the medical curriculum and is built upon a basic physics conceptual foundation. Modern students struggle to master physiology due to ineffective basic content achievement and retention. A small group, active learning, physiology in-course enrichment program improves the ability of low-performance students to effectively identify important course content, recognise and explain core concepts, understand and apply core physiological concepts and master integration of physics concepts into everyday nursing practice (Powell et al., 2019).

The multimedia education method has more lasting effects than the lecture education method (Mollazadeh. et al., 2014).

Recent teaching strategies were mostly teacher-centred. The lecturer presented a lecture, and the students were merely passive listeners. Very little active learning took place. When student-centeredness and teacher-centeredness are properly combined, they jointly contribute to mutually reinforcing features of a learning environment. A high-quality learning environment is an environment that provides challenges with proper safeguards; it encourages students to work independently while concurrently providing ample support. This approach emphasizes the constructive nature of learning and stresses that both students and teachers aim at realizing the same goals (Elen et al., 2007). The distribution of responsibilities of the learning process is decided interactively. In challenging but safe learning environments, students assume full responsibility for the construction of their knowledge. Lecturers render their activities as effective as possible in a comfortable context that offers targeted support. The lecturers’ support gradually evolves from providing a clear and well-structured basis of a safe knowledge foundation to more distant monitoring of the learning process (Elen et al., 2007). A high-quality university

curriculum includes elaborating comprehensive, well-sequenced research-based content and a systematic deliberation of students' support needs.

Modern students may develop higher-order thinking skills and creativity through active learning strategies (Roehl et al., 2013). This research studied "Flipping" the classroom after facing challenges of involving modern students in lecture-based classrooms. This teaching approach employs easy-to-use, readily accessible technology in order to free class time from the lecture. A flipped classroom allows a wider variety of learning activities during class time. According to Roehl et al. (2013), greater teacher-to-student mentoring, peer-to-peer collaboration, and cross-disciplinary engagement will occur if class time is used for active learning instead of lectures only. Roehl et al. (2013) further concluded that when educational institutions face increasing demands to improve learning experiences and capture modern students' attention, the flipped classroom strategy provides an opportunity to address both these concerns. Active learning did lead to more powerful learning outcomes, increased depth of knowledge and knowledge retention.

Herr (2007) stated that active learning is an important basis for learning science concepts. Students learn well by doing. During active learning, the responsibility for learning moves from the lecturer to the student. Problem-based learning and group projects, and cooperative learning during small group tutorials are examples of active learning. A well-presented lecture can also lead to active learning if students process and filter information as it is provided.

Herr (2007) further states that intelligence is a property of the mind that includes many related abilities such as the capacities to reason, plan, solve problems, comprehend language and ideas, learn new concepts, and think abstractly. This is known as the theory of multiple intelligences and implies that people learn better than others through certain modalities, and the science teacher should design teaching interventions to involve as many modalities as possible. Of the seven modalities described by Herr (2007), the following are most important for nursing students and were incorporated in the development of the short course. Logical or mathematical intelligence is used when thinking conceptually and classifying. Naturalist intelligence is used to question, investigate, and experiment, while bodily kinaesthetic intelligence is used to process knowledge through bodily sensations, movements, physical

activity, and manipulation. Interpersonal intelligence is used when learning through cooperative learning experiences, group games and dialogue. Intrapersonal Intelligence is applied when learning through studying and self-assessment (Herr, 2007). During the development of a science-based short course in this study, the classification of human thought, Bloom's Taxonomy, was woven into the short course. Benjamin Bloom and his research team wrote extensively on the subject, particularly on the six basic levels of cognitive outcomes they identified – knowledge, comprehension, application, analysis, synthesis, and evaluation. The development of students' higher-order learning is a critical component of education. Higher-order learning can be enhanced by building a base of factual knowledge and engaging in complex questioning and materials (Agarwal, 2019). Bloom's taxonomy is hierarchical, with knowledge, comprehension, and application as fundamental levels, and analysis, synthesis and evaluation as advanced cognitive levels. Nursing students have to apply the basic science knowledge acquired during their training to practice.

1.3 Definitions

This study contains certain concepts. The concepts relevant to nursing and basic sciences are explained, including the concepts applicable to the study's purpose and objectives.

1.3.1 Science-based

In this study, science-based means the underlying basic concepts to chemistry physics, and mathematics as needed to build advanced nursing knowledge. Basic sciences are any combination of the science subjects including biology, chemistry, physics and mathematical principles fundamental to the study of medicine (Pangaro, 2010). Basic chemistry is a study of the connections of matter with other matter and energy (McFavilen, 2016). Physics is the most basic science in biology, a study of the most important measurable quantities in the universe (e.g., velocity, electric field, kinetic energy) and the relationships between them (e.g., Newton's Laws and conservation of energy) (Balázsiová, 2017). Nurses mathematics is the basics of

math and measurement skills as applied to drug and volume calculations (Boyer, 2019).

1.3.2 Accessibility

This refers to how educational institutions and policies attempt to ensure that students have the same and fair opportunities to take full advantage of their education (De Bie & Brown, 2017).

A wide variety of student perspectives in a classroom leads to an enriched learning environment (Kumar & Wideman, 2014). This improved diversity emphasizes the need for tuition to plan for the different learning needs of the students. In order for a learning environment to be inclusive of all learners' needs, the learning materials and an understanding of the learning materials must be accessible to all learners (Kumar & Wideman, 2014). Because accessibility is partially subjective, it is difficult to define and achieve. What is accessible to one student may not be accessible to another. For educators to design learning environments accessible for diverse learner populations, principles of the Universal Design of Learning (UDL) framework may help. The three UDL guiding principles are providing multiple means of representation (presented in multiple formats as guided by the students' needs in this study), expression (choices built into assessments to allow students multiple means of expressing their understanding), and engagement (small group tutorial was the main teaching method chosen by the students in this study to ensure that all students had the opportunity to discuss the content with peers collaboratively).

The barrier to education comes from a learning environment exclusive in its design and delivery (Kumar & Wideman, 2014). UDL may promote the development of an inclusive learning environment in which all students have a fair opportunity to succeed. To have an inclusive course, it must be accessible. Students must be able to both access and understand course materials to learn and must be offered means of expressing their learning accessible to them. The disability in learning may arise due to socially constructed barriers rather than factors inherent to the individual. The students are who they are, and if they cannot access course materials, then it is the course that must be changed, rather than the student. UDL is a workable approach

that asks for a change in the course design and delivery methods to warrant greater flexibility where more students can benefit.

1.3.3 Relevance

Relevance is the opinion that something is interesting and worth knowing. In education, the term relevance refers to learning experiences that are either directly applicable to students' personal aspirations, interests, or cultural experiences (personal relevance) or connected in some way to real-world issues, problems, and contexts (life relevance).

When successfully incorporated into instruction, personal relevance can increase a student’s motivation to learn, engagement in what is being taught, and even knowledge retention and recall. Life relevance is intended to equip students with practical skills and knowledge to apply in various educational and career contexts throughout their lives. Life relevance can improve engagement, motivation, and learning acquisition (Brown et al., 2012).

The health sector environment undergoes rapid changes and advances in knowledge through research and new technologies. Nurses must update and complement their academic training to offer quality care and practice based on scientific evidence (Ortega et al., 2015). Nursing students must understand how the basic sciences provide value in their future nursing practice.

1.4 Problem Statement

The failure rate of science-related subjects is high among first-year nursing students. The gap between matriculation level and first-year University commonly leads to attrition and prolonged study completion. The University offers orientation programmes to help students adapt both socially and academically; however, the failure rate in science subjects among nursing students remains high. An orientation programme related to the sciences has been offered in the department of nursing for some years. Although there has been an improvement in students who have attended this course, not all students attended, and the failure rates remain high.

Developing an accessible and relevant short course based specifically on the students' needs might reduce the failure rate, thereby improving the throughput rates and reducing the attrition rate. The subject matter experts' opinions on what content need to be included in the course are required for appropriateness. Throughout this study, the researcher will show how the students' needs were determined to provide access to the content and how the appropriateness of the course content was determined.

1.5 Purpose of the Study

This study aims to develop a science-based short course that will help first-year nursing students cope academically with science subjects by providing an accessible and relevant course.

1.6 Research question

The research question for the study: How can a science-based short course for first-year nursing students best provide access to the learning material and relevance to the student's needs?

1.7 Objectives

In order to answer the research question, the following objectives for this study were set:

- To review international and national attempts to introduce science-based courses to undergraduate students.
- To identify first-year undergraduate nursing students' needs concerning structure, content, and delivery of a science-based course.
- To develop a science-based short course for first-year nursing students considering nurse educators' opinion.
- To evaluate and review the developed short course.

1.8 Significance of the Study

The improvement in basic science knowledge will reduce high failure rates and help students finish their studies in the planned time, decreasing costs for the student and the University.

An accessible and relevant short course will assist in meeting this objective. The University will benefit from being able to demonstrate improved academic results and throughput.

This, in turn, will promote an image of academic expertise and improve recruitment rates and ensure a higher number of qualified nurses are available to the South African health care system.

1.9 Overview of the Methods

The research methods employed in this study are aligned with Design and Development methodology. Design and Development research is described as a way to create new procedures, techniques and tools based on specific needs analysis (Van den Akker et al., 2006). Design and Development Research focus on a specific product, and examines the entire design and development process from analyses to evaluation. The systematic process of collecting data during development of the course and then throughout the study allowed for continued development and improvement of the product. Qualitative and quantitative questions were asked during the online surveys. The research methods will be described in chapter 2.

1.10 Organisation of the Dissertation

Table 1.2 itemises the chapters of the dissertation.

Table 1.2 Organisation of Chapters

Chapter	Content
Chapter 1 – Overview of the study	Description of the background of the study, the research question and objectives.
Chapter 2 – Research methodology	The research process explained in phases to answer the research question
Chapter 3 – Scoping review	Phase 1 of the study – explored the international and national attempts to structure and deliver science-based content to students
Chapter 4 – Needs identification	Phase 2 of the study – describes the analysis of the students' needs as well as the nurse educators' opinions
Chapter 5 – Development and evaluation of the outlined science-based short course	Phase 3 of the study – present the development and the expert review of the short course concerning accessibility, relevance and appropriateness.
Chapter 6 – Conclusion	Summary of main findings, limitations and recommendations for further research and conclusion.

1.11 Conclusion

This chapter provided an overview of the research and laid the foundation for the next chapters. The research methodology that was applied to all the phases in this study is described in chapter 2.

CHAPTER TWO - RESEARCH METHODOLOGY

2.1 Introduction

In this chapter, the research methodology utilised for this study is described in detail.

Research methodology talks about how the researcher sought the answers to the research questions (Brink et al., 2021). Polit and Beck (2017) also refer to the research methodology as the “structure of a research study” and the systematic manner in which the study was carried out.

This chapter will discuss the research methods used to design and develop a short course to teach basic sciences to first-year nursing students. This chapter explains the research design and methodology; thus, it provides detail of the research paradigm, the research process, and the rigour applied in this study.

2.2 Research Paradigm

A research paradigm can be defined as an all-inclusive belief system, framework or worldview that guides the research process to influence practice. In other words, it is a way of appreciate the reality of the world and studying it (Rehman & Alharti, 2016). All researchers have different beliefs about the world. These worldviews are important as they effect the interpretation of a study’s results (Brown & Dueñas, 2019). Current literature argues that there are four (4) research paradigms in the science education research domain (Kivunja & Kuyini, 2017), of which pragmatism is one.

Pragmatism calls for the conjunction of quantitative and qualitative methods and various data analysis methods while being guided mainly by the researcher’s desire to produce socially useful knowledge (Feilzer, 2010). Pragmatists claim that research should not aim to most correctly represent reality but to be useful (Feilzer, 2010). Therefore, a single research method will not provide an applicable answer to the research question, but multiple and applicable methods will be more suitable. The

pragmatic paradigm stresses the fact that social experiences have various layers, and a single method cannot provide answers to all the layers. However, to enhance understanding, the phenomenon should be viewed from different viewpoints, allowing the appearance of new dimensions. The different layers exposed in this approach do not mean it is chaotic (Feilzer, 2010). The researcher tended towards a pragmatic paradigm because of its focus on a practical application of research findings, solving the research problem by integrating different viewpoints to interpret data. The different viewpoints of nursing students and nurse educators were taken in consideration in this study. The Design and Development methodology was followed which utilizes a variety of methods and not per se a mixed method approach.

A pragmatic worldview further emphasizes the practical applicability in research and the adoption of a research design and methods best suited for the study's purpose, discovering and gaining knowledge and making connections to understand the context (Feilzer, 2010). In this research, qualitative survey questions were chosen because the students' needs can best be described with qualitative data collection methods (Johnson et al., 2016).

The creation of practical solutions to problems, also known as outcome-oriented research, focuses on the pragmatic paradigm (Shannon-Baker, 2016). The researcher in this study attempted to develop a practical solution in the form of a supportive science based course.

A research paradigm consists of four (4) elements, namely: Ontology is the element that describes the researcher’s view on the nature of reality and the belief on how it can be explained. Epistemology refers to the view of the knowledge, means of generating knowledge and the standards applicable to call something knowledge. Axiology involves studying value and ethics (including social justice), and methodology refers to the style followed to produce knowledge and decreases the uncertainty surrounding result interpretation (Brown & Dueñas, 2019).

In the pragmatic paradigm, the research problem defines the ontology, epistemology, and axiology of the research rather than what method to apply.

The pragmatic paradigm is concerned with a non-singular ontology (reality is constantly evaluated, debated, interpreted in light of its usefulness in new

unpredictable situations because there is no single reality), relational epistemology (In research, relationships are best determined by what the researcher feels is appropriate to that study), value-laden axiology (Research was done to benefit people and not only to find out the why) and a methodology that makes use of various methods with emphasis on the qualitative component in the online surveys (Kuvinya & Kuyini, 2017).

• Ontology, or the reality of basic science education, is being debated and interpreted within the nursing course curriculum. Because basic sciences as a subject were taken out of the nursing curriculum, the value of teaching basic science concepts as a foundation for further knowledge and how to integrate this basic content in nursing courses is assessed as to be fit for purpose.

• Underlining the pragmatist epistemology is the assumption that knowledge is always based on experience. Our social experiences influence one's perceptions of the world, and therefore everyone's knowledge is unique (Kivunja & Kuyini, 2017). The epistemology underlying this study is based on "intuitive knowledge (based on intuition, beliefs and faith and human feelings are more important than reliance on facts)", authoritarian knowledge (based on information that has been acquired from factual sources), logical knowledge (new knowledge created through logical reasoning) and empirical knowledge (relies on unbiased, accepted facts) (Dudovskiy, 2011). The pragmatic approach centres on methodology and its connection to epistemology. The researchers' epistemological understanding of the world is reflected in the interpretation of the findings. Pragmatism acknowledges that knowledge produced is relative and not absolute, recognising and accepting that relationships exist but is subjective to change due to various factors that require the researcher to be curious, adaptable, and reflective (Wagner, 2005).

• Axiology in pragmatism is value-laden because of the benefits applicable to the participants, research setting and community as a whole. The results of this study might even be beneficial to patients. Results are analysed with transferability into other settings in mind (Feilzer, 2010). The students' needs in the teaching and learning of basic sciences were of uttermost importance in this study.

2.3 Research Design

The research design refers to the overall strategy to clearly and logically integrate the study's different components, thereby ensuring that the research problem will effectively be addressed. It establishes the outline for the collection, measurement, and analysis of data. The research problem determines the type of design to be used (Kirshenblatt-Gimblett, 2006). A Design and Development approach was followed. Design and Development Research (DDR) is an orderly study of design, development, and evaluation processes to create a practical basis for the formation of instructional products and tools. The process is often recurring analysis, design, evaluation and revision activities until a satisfying balance between ideals and realization has been achieved (Van den Akker et al., 2006). The research cycle of analysis, design and evaluation has direct and obvious relevance to practice (Koshy, 2005). DDR is a flexible and practical type of research design that provides a way to authenticate practice, form “new procedures, techniques and tools based upon a methodical analysis of specific” circumstances (Van den Akker et al., 2006).

Educational DDR goals are to understand the theory, develop knowledge and solutions, make predictions, and improve practice (McKenney & Reeves, 2012). The design and development approach is central to education, especially in designing a short course and includes a common set of characteristics, such as a focus on measurable goals and outcomes derived through an initial analysis phase, the selection of content and strategies that match these goals, a process of routinely evaluating the products before finalizing the project, and the assessment of the learning and performance outcomes. (Van den Akker et al., 2006). The emphasis is to improve understanding of how to design for implementation.

2.4 Methodology in Phases

2.4.1 Description

Research methodology describes the way research was performed systematically. This includes a rigorous analysis of the research methods “to ensure that the conclusions drawn are valid, reliable, and credible” (Brink et al., 2021). In order to

meet the objectives in answering the research question, this section explains the various phases of the study as guided by Design and Development Research (DDR):

Phase 1: identify problem (scoping review), Phase 2: needs analysis (students and educators), Phase 3: development of course, Phase 4: evaluation of course (expert review), Phase 5: sharing of results

2.4.2 Phase 1: Problem identification

A research study starts with an understanding of a problem (Gall et al., 2007). The initial phase of the design involved the purpose of this research which was to achieve new insights into the phenomenon of teaching basic science concepts. A scoping review was utilised to find out what was known at the time of the research about developing a science-based short course to teach basic science. The literature review revealed that few earlier studies were done.

An understanding of a problem is established, and plans are made for some form of intervention (Gall et al., 2007). The analytic phase of the design involved the purpose of this research which was to achieve new insights into the phenomenon of teaching basic science concepts.

2.4.2.1 Scoping review method

A scoping review was used in this study to review the current literature on the topic. A scoping review is an exploratory project that systematically finds, maps and reviews the literature available on a topic, identifying key concepts, theories, sources and types and extent of evidence and gaps in the research (Arksey & O'Malley, 2005). It is a tool to help researchers during the literature review to decide which knowledge creation is most suitable for the research question. The scoping review has become an ever more popular approach for creating research evidence (Daudt et al., 2013).

The scoping review method, as stated, is designed to allow for searching rather than appraisal and includes all forms of evidence (Tricco et al., 2018). Scoping reviews can "map a body of literature with relevance to time, source (e.g. peer-reviewed or grey literature), and origin (e.g. healthcare discipline or academic field).

The driver behind this study was the high failure rate of science-related courses among first-year nursing students. The gap between matriculation level and first-year University commonly leads to attrition and prolonged study completion.

The research topic provided direction in the literature review choice, and key concepts related to the teaching of basic sciences to modern nursing students had to be identified and explored. Identifying key features of the concept “teaching of basic sciences” fits into one of the indicators for conducting a scoping review, as mentioned earlier.

A scoping review was chosen for this study as it was a quicker option than a systematic review (Arksey & O'Malley, 2005). Due to the specific nature of the research question, a scoping review allowed a wider body of literature to be investigated. The search included peer-reviewed research in order to obtain a broad overview and guided more focused research.

Rigorous documentation of methods used will provide a scientific basis for replication, increasing the reliability of the scoping review (Tricco et al., 2018).

2.4.2.2 Objective for the scoping review

The first objective of this study was to review international and national attempts to introduce science-based courses to undergraduate students. The overall aim to conduct a scoping review is to identify and map evidence (Tricco et al., 2018). Because little is known about the topic, an exploratory scoping review identified key concepts, theories, sources and types of evidence and gaps in the research.

2.4.2.3 Scoping review process

The methodological guideline for conducting a scoping review (Tricco et al., 2018) was applied in this study and included the following steps:

(1) Identify the research question; (2) identify the relevant studies; (3) study selection; (4) charting the data; (5) collating, summarising and reporting results. An optional step of the consultation was not followed in this study.

These five steps will be discussed below as it applies to this scoping review.

- *Identify the review question*

Arksey and O'Malley (2005) stated that the formulation of a review question is most important in a scoping review as it highlights the focus and boundaries of the scoping review. The review question will then direct the objectives and inclusion criteria used in the subsequent steps (Peters et al., 2015).

As suggested by scoping review methodology (Levac et al., 2010), the review question was formulated to be broad and formulated using the mnemonic PCC, representing the Population, Concept and the Context of the phenomenon being studied. The population is undergraduate healthcare students, the concept is teaching of basic sciences and the context is undergraduate nursing curricula.

The scoping review aimed to identify what is currently known about the best way of teaching basic sciences to first-year nursing students, demonstrated in the international literature. The review question that guided this scoping review was: "What is the best method to teach science-based subjects to undergraduate students?"

- *Identification of relevant studies*

In order to find literature, a search strategy should be developed from the beginning and documented for reproduction purposes (Arksey & O'Malley, 2005). Literature for scoping reviews can be searched from various sources such as electronic databases, reference lists, hand-searching key journals or existing networks.

The initial search was conducted in March 2019 with the assistance of a research librarian from the University accessing PubMed and using the phrase "science courses", "nursing", and "development". The research librarian and the researcher have formulated search strategies, and the researcher did screening of eligible studies for final study selection. To prevent an overwhelming amount of articles the librarian suggested three appropriate databases CINAHL, ERIC and Science Direct. The databases were carefully chosen to be extensive and to cover a broad range of disciplines. It would embrace all disciplines of healthcare students to allow for a comprehensive cross-sectional summary of available literature. No limits on date, language, subject or type were placed on the database search. The search query consisted of terms considered by the researcher to describe science courses, nursing and development. The search query was tailored to the requirements of each

database. A decision based on practicality was made to screen only the first 300 hits in each database. The decisions for the search process were set, and the outcomes of the search are illustrated in figure 2.2 below.

- *Study selection*

The selection criteria were based on setting inclusion and exclusion criteria to minimize the chance of including irrelevant studies. Arksey and O'Malley (2005) stressed the importance of defining terminology from the beginning to enable breadth and not depth with selecting articles for inclusion and inclusion and exclusion criteria to be applied to all articles. The librarian contributed during the initial formulation of the research question and the development of the database search strategy (Need to balance breadth and depth, and comprehensiveness). Decisions taken at this early stage can have dramatic consequences for the amount of articles retrieved, which could become unmanageable (Morris et al., 2016). The databases must be carefully chosen to be all-inclusive and to cover a wide range of disciplines (Pham et al., 2014). The initial search revealed that articles written before 2014 were not relevant to modern teaching methods or Gen Z students.

The following criteria were used to include sources:

- The date parameters were set for articles from 2014 until 2019 (selected literature published six (6) years or less from the time of the review).

- Literature that broadly described modern methods to teach science-based subjects to undergraduate students.

- Full text peer reviewed articles available to the researcher in English, Afrikaans and Dutch because the researcher is proficient in these languages. To ensure inclusiveness, the reference lists were accessed.

Keywords: Teaching methods for Gen Z students, modern content delivery methods, teaching science concepts.

The exclusion criteria covered the following:

-Articles unavailable in full text and articles not available to the researcher due to institutional journal subscriptions' limitations.

-Because of limited resources for translation, articles published in languages other than English, Afrikaans and Dutch were excluded.

-Articles that described the teaching of sciences on primary and secondary school level were excluded from the search.

-When the same data were reported in more than one publication (e.g., in a journal article and electronic report), only the article reporting the most complete data set was used.

Bibliographic data and abstract content were collected and analysed using the PRISMA-ScR tool developed by Tricco et al. (2018). The search was done in phases. The identification phase used the key phrase “modern methods to teach science-based subjects to undergraduate students and searched for English, Afrikaans and Dutch language articles. The phrases produced four hundred sixty-eight (468) articles.

The screening phase firstly removed duplicate articles. The remaining articles (n=455) were screened by title and abstract for mention of “teaching of science concepts”, ”modern teaching methods” and meeting this criteria were included in the next phase.

The exploratory phase determined what (if any) current literature was available on how science-based short courses are introduced worldwide to undergraduate students. The eligibility phase scanned the full text articles for relevance, and the article was included if it met the objective “to explore the international attempts to structure and deliver science-based content to undergraduate healthcare students”.

The number of articles included for the review, which met the search criteria, was thirteen (13). The reference lists of the included articles provided another source of evidence. Articles from the reference lists discussing the struggles nursing students had with basic sciences were accessed. Although it fell outside the initial search inclusion criteria due to the search words, five (5) additional articles were included in the review using the same selection and eligibility criteria. The final number of articles that were reviewed was eighteen (18). This scoping review began with the appointment of a research team consisting of the researcher and three reviewers (Levac et al., 2010). The reviewers screened the included articles for search terms.

The eighteen articles included in the final review illustrate the historical development of an accessible and relevant science-based course for undergraduate nursing students internationally. Figure 2.1 illustrates the prisma diagram.

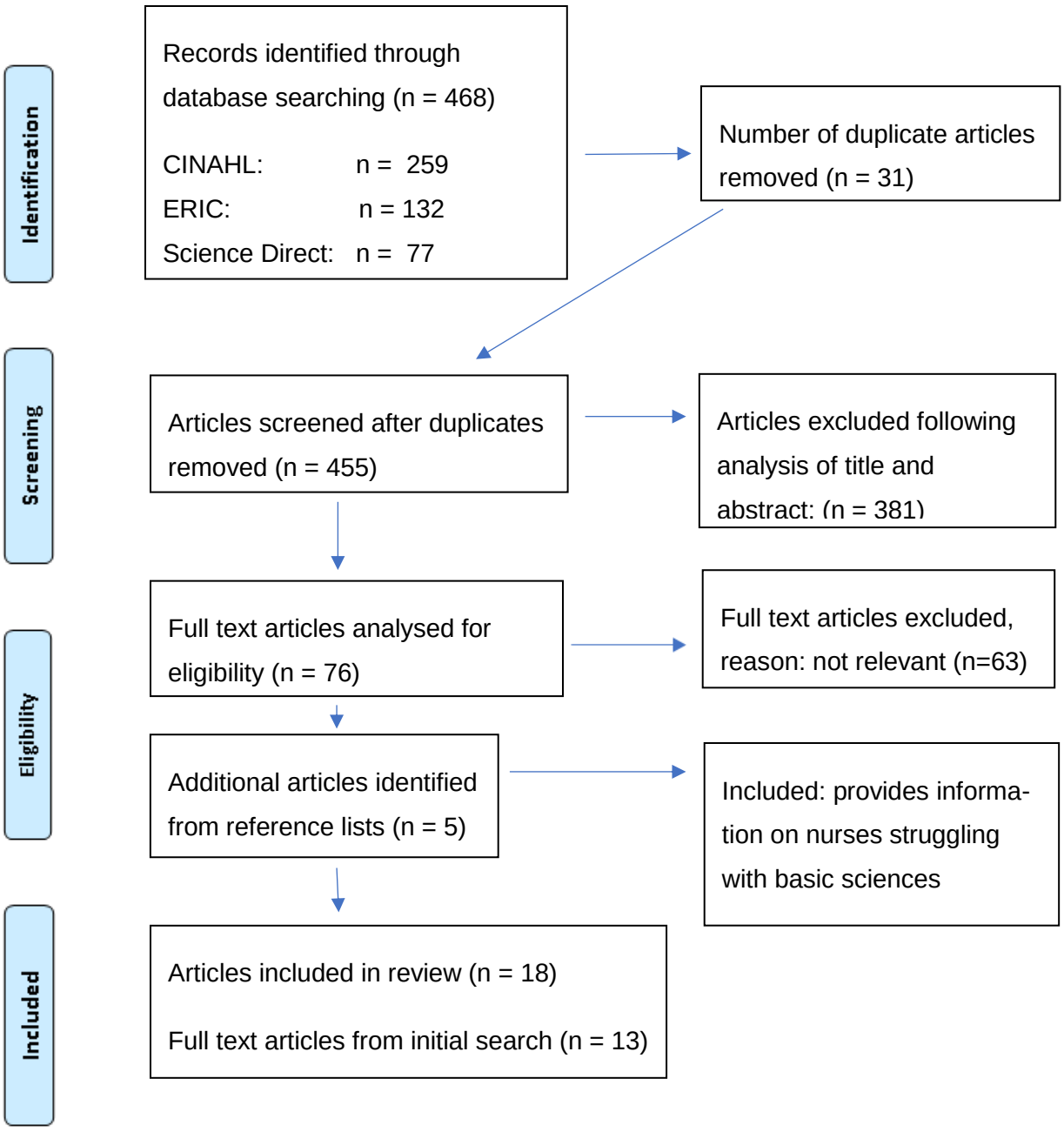


Figure 2.1 Prisma diagram

- *Charting data*

This process includes the decisions about what information is necessary for analyses from the screened articles and should be aligned with the scoping review question and objectives for the review (Arksey & O'Malley, 2005).

Data extraction is a rational summarised description of the results and is called charting of data, where data is taken out from each involved study to allow consequent information description. This process provides the reader with a "logical and descriptive summary of the results that align with the objectives and question of the scoping review" (Pham et al., 2014).

The findings are presented in chapter 3.

- *Collating, summarising and reporting of results*

This step involved the representation of the results. As Arksey and O'Malley (2005) stated, it is important to present an overview of all material reviewed.

A thematic analysis was done where the researcher undertook an initial reading of included studies as guided by the search terminology.

Thematic analysis is a systematic "method of identifying, analysing and reporting patterns (themes) within the data" (Creswell, 2014). The researcher based her thematic analysis on the guidelines provided by Creswell (2014):

• Familiarising one's self with the data: this involved the researcher actively by repeatedly reading the articles.

• Generating initial codes: codes were identified in the data through highlighting interesting and related segments within the text that are linked to the question being asked in the review. The three reviewers appointed by the researcher, were involved in this step by highlighting related phrases in the text.

• Searching for themes: codes were gathered into themes; the researcher grouped ideas with similar meanings together, for example modern teaching methods and student centred learning.

• Reviewing themes: this step involved re-reading the articles to confirm or add to the existing themes.

• Defining and naming themes.

• Producing a report: the report provides a description of the themes and highlights the important aspects of modern teaching methods in the teaching of basic sciences to undergraduate nursing students.

The findings are presented in chapter 3.

2.4.3 Phase 2: Needs analysis (students and educators)

This research focused on gaining insight into the subject area via a needs analysis of students and educators (phase 2).

2.4.3.1 Phase 2a: Needs analysis of the students.

2.4.3.1.1 Description of the student needs analysis

In developing a short course that offers access and relevance to a basic science course, the main purpose was to determine the students' needs in providing access to content and determine the appropriateness of course content. To create content that is learner-centred and motivating, a developer should understand the learners' needs first. The HOD was consulted before it was decided to make use of online questionnaires reasoning that an online questionnaire would allow all students to take part in the needs analysis and because of the extended time needed for in-person interviews and the full academic program, only a small number of students could have been interviewed.

All the first-year nursing students during 2019 at the research setting were invited to participate in an electronic survey with open-ended questions. The electronic information letter sent to the students included the link to the online survey (Appendix C). Implied consent was indicated when the students responded to the survey. The survey questionnaire is attached under Appendix D. The researcher looked at the anonymous results. The responses were gathered and summarised to provide an

easy-to-understand explanation of what nursing students were thinking about basic sciences in the curriculum (Kojuri et al., 2015).

Successful course design involves great content and proper student analysis (Andriotis, 2016).

The findings are presented in chapter 4.

2.4.3.1.2 Objectives of the student needs analysis

The second objective for this study was to identify the needs of the first-year undergraduate nursing students concerning structure, content and delivery of a science-based course.

The objective for the needs analysis phase was to learn what the participants knew, felt, and thought about basic science education to allow the researcher to determine what educational products and services were needed and to understand what the researcher could do to make the educational product (a short course in basic sciences) accessible and relevant to the first-year nursing students.

2.4.3.1.3 Research setting for the student needs analysis

This is the site where research is undertaken and depends on the research question being answered and the type of variables that apply to the study (Brink et al., 2021). The study setting was purposively selected as a university in South Africa, Gauteng, which offers a Baccalaureate Degree in Nursing, which is science-based. Students are a culturally heterogeneous group coming from all parts of South Africa.

All research was conducted in a natural setting like a classroom.

2.4.3.1.4 Population and sampling for the student needs analysis

The population during this phase consisted of first-year undergraduate nursing students following a Baccalaureate programme leading to registration as a Nurse (General, Community and Psychiatric) and Midwife in South Africa. For the needs analysis, nursing students enrolled in the first year programme during 2019 were invited to participate in the study (N=51).

A total sample was taken for the needs analysis. All fifty-one (51) first-year nursing students were invited to participate in this study. Forty-two (42) students participated

in the study by completing the online web survey. This resulted in a realized sample of n=42 first-year undergraduate nursing students.

2.4.3.1.5 Data collection during the student needs analysis

An online self-administered questionnaire was used. A questionnaire is a research tool containing questions for the purpose of collecting data from respondents (Polit & Beck, 2017). Questionnaires can be seen as a type of written interview. Information can reliably be obtained, and the content is limited only by the extent to which people are able and willing to respond (Polit & Beck, 2017).

Questionnaires can measure the attitudes, feelings, opinions and intentions of large numbers of participants more quickly and at reasonable cost than other methods. An important difference is between open-ended and closed questions and means both quantitative and qualitative data can be obtained. Another benefit of a self-administered questionnaire is the fact that the questions are identical. All respondents are asked identical questions in the same order. This ensures that a questionnaire can be replicated to check for trustworthiness. To check that the results are reliable, another researcher can also use the questionnaire (Polit & Beck, 2017).

The steps followed during the students' needs analysis were 1) create, validate and pilot the questionnaire, 2) collect the data, 3) analyse the data (Andriotis, 2016).

The creation, validation and piloting of the questionnaire

According to Bhatia (2018), it is crucial to revisit the research objectives to identify the questions answered through the collected data. The researcher revisited the research objectives and developed the questions relevant to the objectives. To collect qualitative data, open-ended questions were added for a deeper understanding of the students' needs (Polit & Beck, 2017); the focus area were attitudes and expected outcomes (Andriotis, 2016). Open-ended questions allowed the students to engage reflectively (Andriotis, 2016).

Initially, a report was acquired from the Nursing Department in the research setting about the failure rates of first-year nursing students in basic science subjects. This was explained in chapter 1. This report showed that nursing students struggle specifically with chemistry and physics. The researcher's own experience with nurses

in practice and their inability to correctly calculate medication dosages resulting in errors and unsafe patient care guided the researcher to include mathematics as a subject under study.

The findings from the scoping review (chapter 3) helped the researcher focus the questions around the above three subjects.

This study was designed to identify first-year undergraduate nursing students' needs concerning the structure, content, and delivery of a science-based course. Understanding the students' needs regarding how they want the content to be delivered and why they want it delivered in that way will provide information on how to structure the course. The findings of the needs analysis will show if South African students want a different delivery mode than what was presented in the literature review.

The structure, content and delivery of an appropriate and relevant science-based course guided the researcher to develop valuable questions.

The tool used was an online questionnaire, including mostly open-ended questions. Answers to open-ended questions allowed the researcher to gather information about the respondents' attitudes, thoughts and behaviours around Chemistry, Physics, and Nurse Mathematics.

The questionnaire was validated. Two of the researchers' peers tested the questions for contextual and face validity. The most basic data validation is different question types, which were included in the surveys. The researcher ensured that the indicators and measurements were cautiously developed based on relevant existing knowledge to ensure that the measurement method matched the concept being measured (construct validity) (Polit & Beck, 2017). The content of the questionnaire did cover all relevant parts of the research question and the questions were formulated from information obtained from the department and the scoping review (content validity). Face validity was ensured by using language appropriate for the students to understand. The questionnaire only included questions about the learners' needs around the relevance and access to basic sciences education.

To pilot the questionnaire, it was given to five (5) nursing students from a different institution and not included in the main study to confirm the face and content validity

and to ensure the questions provide meaningful data to answer the research question.

The first-year nursing students' lecturer was consulted about the best way to collect the data. Since little time could be spent on individual interviews or focus groups, the online survey platform, Monkey Survey, was utilised (Monkey Survey Inc.). The tool used was an online questionnaire, including mostly open-ended questions. Answers to open-ended questions allowed the researcher to gather information about the respondents' attitudes, thoughts and behaviours around Chemistry, Physics, and Nurse Mathematics. Demographic data questions were included for the purpose of the proposed course development and are explained in table 2.1

Table 2.1 Demographic questions and the reason for inclusion.

Demographic data question	Reason for inclusion
1. Age	To better understand the learning behaviour of the students participating in the study, it is important to know the age of students (Arrowsmith, 2017). Research showed that the age group circumstances (for example, use of technology) would influence how students learn and how they want to be taught (Holubova, 2015).
2. Year of matric	The period between school and first year of nursing studies is an important factor influencing academic performance in science-based subjects. Processes like memory and the ability to recall previous knowledge will change over time (Van Kesteren et al., 2018).
3. Subjects in matric. You can choose more than one: - Life science - Physical science - Mathematics	Secondary school science knowledge is important in understanding undergraduate nursing science subjects (Swart et al., 2015). The scoping review in this study revealed that nursing students struggle with basic science subjects. To know what subjects the respondents studied in matric will provide information about prior knowledge and the baseline of knowledge the student had when entering the first year of nursing training.

The title for the survey was “Science help for nursing students – a needs analysis”. University e-mail addresses were used because they do not reveal personal data of the students. The group lecturer provided the list with e-mail addresses to the researcher.

A Study Information Sheet (Appendix C) was sent to all fifty-one (51) first-year nursing students in the setting during June 2019. At the end of the information sheet, the invitation link to the survey was provided. The online questionnaire is added under Appendix D. Informed consent was implied when the students responded to the survey. The benefit of an online survey is that the participant remains anonymous (Hammersley and Traianou, 2012).The Survey Monkey platform ‘anonymous responses’ was selected to ensure confidentiality and this option excludes all respondent information including first name, last name, email address, IP address, and custom data from the results.

A total sample was taken for the needs analysis. All fifty-one (51) first-year nursing students were invited to take part in this study.

The sending out of the questionnaire was done electronically via Survey Monkey. From February 2019 until March 2019 reminders were send on a weekly basis to the whole study cohort to complete the questionnaire. The online questionnaire was accompanied by a cover letter that explained the study to the participants (Appendix C).

2.4.3.1.6 Analysis of the data gathered with the questionnaire

Forty-two (42) students participated in the study by completing the online web survey. This resulted in a total sample of n=42 first-year undergraduate nursing students.

The researcher looked at the anonymous results. The responses were gathered and captured on an excel spreadsheet to provide an easy-to-understand explanation of what nursing students were thinking about basic sciences in the curriculum (Kojuri et al., 2015). The quantitative data was analysed and reported as graphs

A thematic analysis grouped the answers to the open ended questions under themes and subthemes (Creswell, 2014) and included the following steps:

- Get familiar with the data: The researcher read the data several times to get familiar with it and started looking for patterns. Transcribing of the data was not needed because the online survey collected data in a written format.

- Develop a framework: Also known as coding, the researcher recognised general ideas, thoughts, behaviours, or phrases and assigns codes to them. Concepts such as the positive or negative response to a question were used. Coding is helpful in organising and grouping the data. According to Creswell (2014), “coding is the process of analysing qualitative data by taking them apart to see what they yield before putting the data back together in a meaningful way.”

- Identify themes: The data were coded. The researcher recognized themes (the most common reactions to questions) and identified data or subthemes that could answer the research questions.

The findings are presented in chapter 4.

2.4.3.2 Phase 2b: Nurse educators’ opinion

2.4.3.2.1 Description of the educator needs analysis

In developing a new course, the analysis of the educators’ opinions is extremely important (Fournier et al., 2019). The role of the nurse educator in the design and development of an accessible and relevant basic science course is multiple. It includes setting course goals and deciding on course content and teaching methods (Fournier et al., 2019). During this research, the nurse educators’ opinion about what they feel should be included in a basic science course for first-year nursing students, was assessed via an online survey.

2.4.3.2.2 Objective of the educator needs analysis

The purpose of acquiring nurse educators’ opinion was to learn how they conceptualize and describe the structure, content and delivery of an appropriate and relevant science-based course to first-year nursing students (Artino et al., 2014). The purpose of this phase links to the third study objective (chapter 1) which is to develop a science-based short course for first-year nursing students considering nurse educators’ opinion.

2.4.3.2.3 Research setting, population and sample for the educator needs analysis

The experts being consulted for this phase of the study were nurse educators teaching nursing subjects with either a foundation of basic sciences or integrated basic sciences. The nurse educators who are members of the Nursing Education Association (NEA) Pretoria were approached. In the first week of October 2019, a formal request for sending a questionnaire to the members of NEA was sent to the vice-chair of the Pretoria NEA Branch (Appendix E). During the last NEA workshop of the year on 25 October 2019, the researcher was allowed to speak (and hand out contact details) to the 14 members attending. After introducing the research project, a list was circulated for those members willing to answer the questionnaire to acquire their contact details.

Inclusion criteria: Nursing educators who use basic sciences either in clinical practice or in teaching theory as well as nursing educators who are involved in developing of curricula. Post graduate educators were included since the post graduate degree in nursing education includes a module on the teaching of basic sciences.

Exclusion criteria: Nursing educators who do not teach basic sciences or develop curricula.

From the 14 members attending, nine (9) completed the list (N=9).From the list of nine (9) educators, five (5) met the inclusion criteria (n=5). The five (5) nurse educators who met the inclusion criteria were included and a research information sheet (Appendix F) was sent to them with the link to the online survey. The Survey Monkey platform was utilised, and consent was implied if the educator responded to the questionnaire. The realised sample was n=4 as only four (4) responded and completed the survey which is an 80% response rate. The electronic survey was named “What nurse educators would like to teach first-year nursing students”. The questionnaire is under Appendix G.

2.4.3.2.4 Data collection during educator needs analysis

The questions were formulated by the researcher and the supervisor, based on the scoping review and were validated for face- and construct validity by two nurse educators at another institution.

To evaluate the face validity, the nurse educators were asked to indicate the appropriateness of the questions. To test the construct validity of the questions, the nurse educators were asked if the questions were relevant to the construct being measured (Polit & Beck, 2017). The reliability (the extent to which the answers produced by a particular set of questions is constant and reproducible) was deemed high because open-ended questions were used (Artino et al., 2014). An open-ended question about their teaching environment was included to acquire the nursing education background of the participants. The rest of the questions allowed the respondents to elaborate on the content and teaching methods applicable to chemistry, physics, and mathematics.

Pilot with nurse educators was done but does not form part of the main study. No changes were required based on the responses from the pilot.

2.4.3.2.5 Analysis of the data gathered in the educator opinion questionnaire

The responses were captured on an excel spreadsheet. The quantitative data was analysed and reported as graphs.

The work environment and specific student groups that the participants are involved with are described in Table 2.2

Table 2.2 Nurse educators' work environment

Job description	Place of Work	Description (Year group, subjects)
Lecturer	University	Teaches Research to under- and postgraduate nursing students. Teaches postgraduate Nursing Education. The post graduate course includes a module on the teaching of basic sciences.
Lecturer	Private Nursing School	Teach Primary Health Care to undergraduate nursing students

Clinical Facilitator	Private Nursing School	Facilitates Clinical Nursing to various students (BC1, BC2, Midwifery)
Educator	Private Higher Education Institution	Bridging 1st-year Anatomy, Physiology, IGNS, Ethos

The qualitative information was analysed by thematic analysis (Creswell, 2014) and included the same steps as discussed under the students' needs analysis. The open-ended questions were coded according to themes (Creswell, 2014).

The findings are presented in chapter 4.

2.4.4 Phase 3: Design and development of the course

The design and development of the artefact (phase 3) in this research study is driven by the ADDIE framework. During this phase repetitive processes are followed in order to refine the artefact (Van den Akker et al., 2006). In this study, the predictions from a scoping review and needs analysis were used to design and develop a science-based short course. The steps of the ADDIE model are detailed in 2.4.4.1.

2.4.4.1 Description of the design and development of the short course

This design and development phase connects the intervention being developed to the problem driving the development.

The validation processes are presented during this phase. Students no longer attend separate full courses on chemistry and physics; however, the principles of basic sciences have been integrated into the nursing subject matter and are presented as concepts. Not all the students have a scholastic background in these subjects and lack the knowledge of basic science concepts. An appropriate science-based short course will greatly support students in gaining a deeper understanding of the science-based principles that underlie the nursing practice.

Van den Akker et al. (2006) described the importance of the rigorous documentation of alternative solutions and the decision-making process in developing the intervention. The development phase is guided by the ADDIE framework. The ADDIE framework is a process used by training developers and educational designers to design and effective learning experiences.

The continuing steps of this model include analysis, design, development, implementation, and evaluation in a circular flow (Molenda, 2003). Each step has the same level of importance (Figure 2.2) and the steps are detailed below.

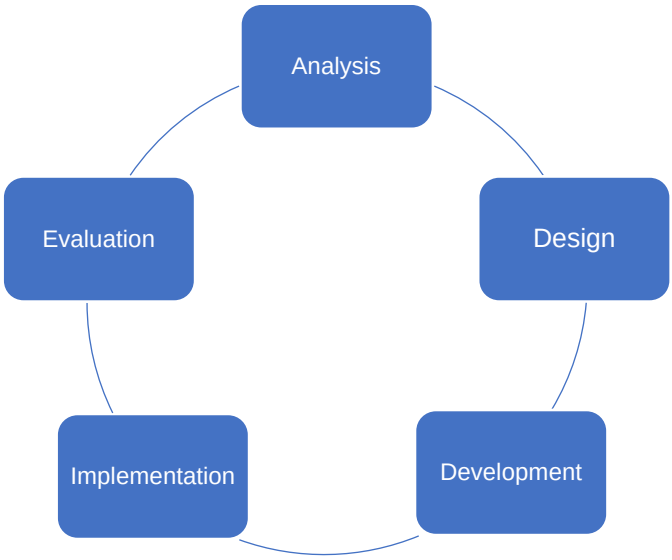


Figure 2.2 The steps of the ADDIE framework (Ellis and Levy, 2010).

Step 1: During the analysis the researcher used information from the scoping review and needs analysis to identify what should be included.

Step 2: The design involves the educational theories to design the course. .In order to develop and design a science-based course, the researcher explored teaching and learning approaches and theories. The researcher has drawn on different educational theories which influenced the design and development of the short course. These principles were applied during the development of the short course. This was only possible because the students' needs were known to the researcher. The University in the setting follows a blended learning (BL) approach. Blended learning is a

combination of classroom learning and virtual learning (Singh & Kaurt, 2016). This is possible because of the extensive accessibility of information and communication technologies. Another benefit of blended learning is the transformation of “teaching and learning from a teacher-centred model to a learner-centred model” (Jani et al., 2018).

Blended learning has a positive effect on “student motivation and performance” as indicated by Lu et al. (2018). BL helps facilitators involve students in active learning that encourages skills such as communication, information knowledge, creativity and teamwork. BL is a flexible approach and can quickly adjust to circumstantial changes; cost-effectively (Oakley, 2016). These pedagogical benefits were all kept in mind with the development of the short course in this study.

Step 3: This step focused on describing the process of mapping and building creative solutions informed by theory and empirical finding until a workable solution for the problem was reached. The third objective in this research was to develop a science-based short course for first-year nursing students. In this stage, the researcher used the data collected from the two previous stages (scoping review and needs analysis) to create a teaching plan for the short course that will convey what needs to be trained to particular students.

The development of the artefact is the course outline as presented in Appendix H and detailed in chapter 5.

Step 4: The course could not be implemented due to the fact that the University in the research setting did not take in first-year nursing students in the same year. The developed material was presented to experts to review the course for accessibility and relevance.

Step 5: The evaluation included a review of the expert feedback and the changes made accordingly compared to standards to achieve objectives.

2.4.5 Phase 4: Evaluation of the course (expert review)

2.4.5.1 Description of the evaluation

An expert review is one of various ways to validate the modified artefact. In this study an expert review is used to validate the artefact to determine if the modified artefact meets the identified requirements, is supported by the literature and that the value of the artefact is accepted within the review process (Ellis & Levy, 2010).

The outlined short course was evaluated by subject matter experts, after which the modifications were implemented in the short course.

Independent nurse educators and a nursing and education specialist from different universities were consulted to evaluate the teaching plan. Three nurse educators did the short course evaluation to review the short course in relation to accessibility, relevance, and appropriateness. Purposeful sampling was done to find the specific subject matter experts (Polit & Beck, 2017). One of the nine recipients receiving the questionnaire for nurse educators responded that she could not participate initially but was willing to undertake an expert review of the developed short course. This expert was qualified as a nursing educator and educational researcher with insight into the mind of nursing students, design and development research, the minimum required content of the course and real-world insights. This expert described her expertise as follow:

“I have a doctoral degree in Nursing Education with both my Masters and PhD focussing on student support. My research niche area is scholarship of teaching and learning. I have conducted a number of funded research projects in this field. I supervise both M & D students in the field of teaching and learning. A number of my students have developed teaching programmes and plans, models for teaching and learning, strategies and guidelines. I have also published widely in this field, both nationally and internationally.”

Thereafter two (2) unrelated educators were asked to evaluate the course according to the framework used by the original evaluator. The expert review was conducted independently, using a tool, expertise and a qualitative assessment approach. The teaching plan for the short course was assessed, taking into account the adult learning theories and the criteria of clarity, comprehensiveness, adaptability,

applicability, credibility, validity, and general feedback (V Rensburg, 2020). These concepts are explained as follow:

Clarity: The course objectives must be precise, accurate and dependable, thus clearly stated and achievable (Muro, 2018).

Comprehensiveness: All the content of the course must be included during evaluation.

Adaptability: The extent to which the course is open and flexible so that it can address new challenges by incorporating emerging issues (Muro, 2018).

Applicability: How can the newly developed course be applied to the target audience?

Credibility: The course must proof confidence that the results (from the perspective of the participants) are true, trustworthy, and acceptable (Forero et al., 2018).

Validity: in education refers to the numerous sources of evidence to support the use and explanation of various aspects of the course content (Cumyn & Harris, 2012) and generalize decisions about a program to diverse circumstances.

2.4.5.2 Aim of evaluation

The aim of the evaluation of the educational intervention by an expert review was to evaluate if the short course met the requirements of accessibility, relevance and appropriateness.

2.4.5.3 Evaluation tool

Above criteria was compiled from the literature (Plomp, 2013) and used to adapt an existing evaluation tool for the purpose of this study. A finalised educational intervention should fulfil four quality criteria (Criteria described in table 2.3). The criteria are ordered, and if the foregoing criteria are not achieved, the subsequent criteria cannot be met. For instance, the intervention will not be effective unless it is practical in the setting for which it was intended. Consistency (construct validity), for that matter, can only be established regarding relevance (content validity) (Plomp, 2013).

Table 2.3 Description of Course Design Quality

Criteria	Description
Relevance (Content validity)	The course and its design must be based on scientific knowledge, must be suitable for the context, addressing the contextual needs in the method and goal.
Consistency (construct validity)	The course must be well planned and integrated. The elements and connections between them must be well defined. The final product must be fluent, showing a flawless process of thought and a firm approach concerning design and implementation.
Practicality	Expected: The course must be deemed as valuable and functional in the setting and context for which it was designed.
Effectiveness (catalytic validity)	Expected: The intervention must be judged as achieving the preferred results for which it was designed.

Source: Plomp (2013)

The criteria for evaluation are applicable during different phases of educational design and development research. The actual practicality and effectiveness could not be evaluated during the expert review (Plomp, 2013).

The University in the research setting did not have a student intake for the 2019 year, and therefore no impact evaluation could be done by the users. A semi-summative evaluation was chosen, which focused on alleged practicality and value and did not require a complete application to assess if the anticipated results were achieved (Archer, 2019). The evaluation of this intervention was done before implementation by a subject matter expert in nursing and education. It is important to develop the intervention (short course in basic sciences) in the context of the problem to provide a suitable solution to the identified problem. The intervention developed must meet the requirements set. Ellis and Levy (2010) proposed that information be sourced from literature to set the intervention requirements. To evaluate the intervention against the set requirements will ensure validity.

The evaluation results are included in chapter 5.

2.4.6 Phase 5: Sharing the results

During this last phase, the communication of the results (phase 5) contributes to the body of knowledge and can reflect both the research process and / or the design process (Ellis and Levy, 2010).

2.5 Trustworthiness / Rigour of the Study

Trustworthiness refers to the value, genuineness, and honesty of findings of qualitative research. It relates to the degree of reliance that readers have in results. Rigour is the strength of the research design and the suitability of the method to answer the questions.

The issue of validity, reliability, and trustworthiness was complicated due to the pragmatic nature of this design and development research. Cole et al. (2005) described rigour, as it applies to design and development research, as rooted in pragmatism where truth and utility are indistinguishable and must pass both science and practice tests. Design and development research is not only interested in developing a product but also wants to add to the basis of knowledge. In educational design and development, the two main activities are building and evaluating.

Design and development research must balance rigour and relevance, also known as internal and external validity (Ross et al., 2010). A balance might be difficult to reach because of different perspectives of internal validation and external validation. Internal validation and external validation are done with different objectives (biases vs relevance), from different perspectives, and based on different measures which are not comparable. These are defined by the content and context of the concerned research cycle. According to Van den Akker et al. (2006), rigour, applicable to design and development research, must result in usable and dependable design principles, and the research has to meet rigorous standards. Research in natural settings will involve issues like internal and external validity, reliability and application of the research.

The researcher, therefore, applied rigour following the four (4) criteria identified by Guba and Lincoln (1985), namely credibility, transferability, dependability and confirmability, as it applies to design and development research.

2.5.1 Credibility

Polit & Beck (2017) explained credibility as the “confidence in the truth and interpretations of data”. The researcher must attempt to create confidence in the truth of the findings for the participants and the readers. The researcher should acknowledge that various realities exist and should, therefore, outline personal experiences and viewpoints from the onset, identify bias in methodology and confirm the data presented accurately represents the participants view.

Steps followed to ensure credibility in all phases of the study included:

• The researcher used well-known research methods in all the phases.

• The researcher applied integrity in the methods undertaken and precision in accurately reflecting the findings from data, and therefore added validity.

• The researcher ensured that the results are trustworthy by using a scoping review which leans towards transparency (Tricco et al., 2018).

• The researcher kept precise records, demonstrating a clear decision track and ensured that interpretations of data were constant and crystal clear.

• The researcher provided a detailed description of the actual situation and context in each phase.

• The researcher demonstrated clarity in terms of thought processes during data analysis and consequent explanations.

• Reduced researcher bias by recognising biases in sampling and continuing precarious reflection of methods to ensure adequate depth and relevance of data collection and analysis.

• The researcher applied reliability in the consistent description of the analytical procedures.

• Triangulation of data sources was achieved using multiple types of data such as participants' different views resulting in a more stable view of reality. Another data source was seeking support from a literate to relate findings to the existing body of knowledge.

• The accuracy of the data was maintained by verifying emerging ideas and themes during data analysis, seeking out uniform and different responses to ensure that various perspectives were reported on.

• The researcher engaged with the research process on all levels, being reflective and responsive and accounting for personal biases, which may have influenced findings.

• The researcher was able to adapt (after evaluation of the teaching plan) to deliver an accessible and relevant teaching plan for the teaching of basic sciences.

2.5.2 Transferability

Transferability refers to the amount to which results can be carried over and applied to other contexts (Polit & Beck, 2017). Providing enough and rich contextual information might help the reader to transfer information into other settings. The researcher cannot make these inferences for the readers but must provide sufficient descriptive data so that users can assess the suitability of data to other contexts. For this reason, it is more appropriate to report on applicability than transferability. How applicable a study is to other settings and groups depend on factors such as resemblance, ease and effectiveness of implementing an intervention and research specific factors such as the setting and methods used.

Relevance is appropriate to the resemblance in this context. An important requirement for this is that the researcher must have a good understanding of the target setting and be conscious about research and development activities taking place in natural settings. For design and development research to be relevant for educational practice, the design and development activities must be studied in collaboration with educational professionals (Gall et al., 2007).

This study was specific to the context of one university in South Africa, but the problem under investigation is a national and international phenomenon, as illustrated during the scoping review. The developed teaching plan can be applied with ease to other settings as each methodological process was described.

2.5.3 Dependability

According to Polit and Beck (2017), dependability relates to data stability over time and conditions. The meticulous documenting of the research process followed accounted for changing conditions. This dissertation detailed the research design, how it was planned and executed. It provides operational detail on all the phases of the design and development process. During the scoping review, an all-inclusive and organised search of the literature was undertaken to make the most of the inclusion of relevant information, provide reproducible results, and decrease possible bias from inconsistent implementations (Tricco et al., 2018).

2.5.4 Confirmability

Polit and Beck (2017) refers to confirmability as objectivity, in other words, how accurate, relevant, and meaningful independent people will find the data. Proper documentation of decisions around methods used, sampling, and analysis will ensure an accurate account of the project and limit researcher perspective or bias.

In this study, confirmability was maintained by providing clear reasoning on methods, showing how findings lead to recommendations, triangulation of information sources and describing limitations.

2.6 Ethical Considerations

The ethical considerations applied to this study were drawn upon an educational, ethical framework, as explained by Hammersley and Traianou (2012). Commonly recognised principles include:

- Minimizing harm. Harm includes negative effects for the people being studied (economically, reputational) and for others, as well as for any researchers studying the same setting or people in the future. The risk-benefit ratio speaks to minimize the risk and maximize the benefits for the participants, researcher, context, and society. The researcher carefully considered each method to ensure the participants' best outcome and represented high-quality standards based on current practices.

- Respecting autonomy. The research process must show respect for people in allowing them to make choices for themselves, among other things, participation. This also talks about ongoing respect for participants, including confidentiality, anonymity, and data management principles. The researcher engaged with the participants in a respectful manner by ensuring confidentiality and anonymity throughout the research process. Participants were made aware of how the results and findings will be disseminated at the onset of the process. The researcher asked critical questions and built understanding, and ensured that the process added value and achieved the best outcome.

- Protecting privacy. A main goal of the research is to make descriptions and explanations publicly available. However, confidentiality and anonymity of the participants were ensured throughout the research process.

- Mutual benefit. Researchers rely on being allowed access to data, which may implicate people collaborating in several ways, such as giving up time to be interviewed or to complete a survey. The research process can also unsettle people’s lives in many ways and to varying amounts. The participants were not given anything in return from researchers.

- Treating people equitably. No one was unjustly favoured or discriminated against in this study. The fair selection of participants is applicable. The decision to use purposive sampling methods in all the phases was based on the methods and objectives of the research. The knowledge gained from the participants has a straight impact on the relevance of the study to practice and the local context.

According to Hammersley and Traianou (2012), other aspects can be extrapolated from the above principles and are also important, such as the following:

- Social value as part of mutual benefit refers to the benefits of participants without wastage of resources. The research methods employed in the study enable the documenting of everyone's perspective. The research methods used also drawn on the inclusion of best practices in product development to ensure it is feasible for implementation. The researcher was aware of the time demand on participants, and choices on methods reflect this aspect.

- Scientific validity also fits in with the benefit aspect and expects to use valid methods related to the research problem and objectives. Scientific validity was maintained through applying principles of rigour and trustworthiness in each phase of the study. Each choice can be justified with the contribution it makes to research.

- Independent ethical review is governed by the Human Research Ethics Committee of the university from where approval was obtained (Appendix A), and permission to conduct the research was requested from the Department of Nursing Education (Appendix B).

- Informed consent included aspects of honesty, sincerity, fairness and truth (Appendices C and F). By responding to the online questionnaire, consent was implied. The researcher applied these aspects from the onset of the research being open with participants about their participation, what is expected from them and what they can expect from participating in the study. The implications were discussed, and changes were communicated timeously to be mutually beneficial.

2.7 Conclusion

This chapter described the various methodology used in this study. The sampling, setting and data collection were discussed in detail, with ethical considerations being emphasized as an important aspect of this study. The next chapter (3) will describe the scoping review.

CHAPTER THREE - SCOPING REVIEW

3.1 Introduction

This chapter provides details of a scoping review conducted as the first phase of developing a short course for the teaching of basic science concepts to first-year nursing students.

3.2 Aim

The aim of the scoping review was to assess international literature to explore what is currently known about the design and development of an accessible and relevant basic science course for undergraduate first-year nursing students.

3.3 Method

The background of the search strategy is described in chapter 2 of this study.

3.4 Charting the Data

For the purpose of this study, the information charted on the data extraction tool was: the author(s), the year of publication, the country of origin, study objectives, population and sample (if applicable), study design and lastly, a column reporting key terms related to the teaching of basic sciences identified in the results/findings section of each study. Bibliographic data and abstract content were collected and analysed using the PRISMA-ScR tool developed by Tricco et al. (2018).

Table 3.1 Scoping review data matrix

Article number **Authors** **Year**	**Objectives** **Sample** **Setting**	**Research design/ method**	**Key phrases related to modern teaching methods, teaching of science concepts, Gen Z students and nurses' struggles**
1. Alwahab *et al* 2018	-To explore the correlations between Team-Based Learning (TBL) scores and final examination scores and student perceptions of a TBL system -101 second-year students -College of Medicine	Single-stage cross-sectional survey with random sampling	Modern educational tools - clinical reasoning Communication skills Interpersonal skills Critical thinking skills Problem solving Self-reflection Student-centred learning Preferred learning styles Active learning Team-based learning Small groups Immediate feedback Peer evaluations Basic concepts in actual clinical situations Rapidly changing practice Inter-professional and team-oriented skills Medical students
2. Birks *et al* 2015	-To identify how science should be taught to nursing students, and by whom. -30 academics who teach science in undergraduate nursing programs -University	Cross-sectional design using online surveys	Bioscience Curriculum content (crowded) Curriculum design (lack of decision-making responsibilities) Nursing education Science (most difficult part in curriculum) Lack of confidence Priority to basic concepts Strong theoretical foundation Clinically relevant case studies Meaningful integration of theory and practice Safe and effective nursing assessment Demands of contemporary nursing practice Lack of research (content and depth of science teaching) Chemistry and parts of physics rated lowest
3. Chetty, N 2014	-To analyse how teaching interventions in in physics training encourage student success. -3 student cohorts -School of	Mixed-modal approach with quantitative and qualitative analysis	Problem-based learning, active learning Holistic learning, link subjects Student-centred instruction Emotional, physical and knowledge development (time management) Throughput, factors influencing academic performance (food insecurity, lack of accommodation or funding) Extended curriculum Undergraduates physics programme

	Chemistry and Physics, University		Language of physics Collaborative problem solving in small groups Conceptual understanding and application E-learning Lecturers are facilitators
4. Craft *et al* 2017	-To explore new graduate registered nurses' reflections of bioscience courses during their nursing programme and the relationship between bioscience content and their clinical practice. -22 registered nurses -Faculty of Technology, Health University	Descriptive cross-sectional mixed methods study	Bioscience is challenging Clinical practice Nursing education Registered nurses Undergraduate courses Lack of biological confidence Extended bioscience course Relate theory to practice Nursing related biosciences
5. Gdanetz *et al* 2018	-To gain an understanding of how technology influences the development of interpersonal relationships between the student and faculty in a virtual learning environment. -10 articles -University School of Nursing	Interpretive qualitative meta-synthesis	Online nursing courses Continuing education Caring educator Virtual learning environment Technology alters communication Educator's technological proficiency Access versus utility Caring, compression and integrity Student engagement Barriers to learning
6. Gordon *et al* 2017	-To examine final year nursing students' experiences with bioscience, with a focus on the relationship to nursing practice.	Cross-sectional exploratory survey	Bioscience Theory and practice integration Challenging, difficult, anxiety Science confidence Nursing students Nursing education Nursing practice Nursing curriculum Patient safety School science an advantage

	-126 final year nursing students -Metropolitan Australian university		Nursing lecturers impact student attitude
7. Grugnetti *et al* 2014	-To evaluate the effectiveness of a Clinical Skills Workshop on drug administration that focused on improving the drug-dosage calculation skills of second-year nursing students, with a view to promoting safety in drugs administration. -77 nursing students -Northern Italian University- Educational Simulation centre	Descriptive pre- and post-test design.	Nursing education Preparatory basic mathematical course (basic concepts) Teaching strategies Tutors abilities Integration and innovation Drug administration Students and mentors Mathematical competence Drug calculation skills Clinical simulation Online platform with case studies Summative assessments Patient safety
8. Johnston *et al* 2015	-To find out what the learning needs of nursing students are in anatomy and physiology in order to meet these needs -231 first year undergraduate students -University	Survey	Biosciences Complex science concepts Hands-on learning activities Group work Fun and engaging content Science phobia, fear of failure Human anatomy Human physiology Student needs Learning styles Blended learning Nursing student perceptions Teaching skills Face-to-face time Cost- and time-effective electronic resources
9. McCutcheon *et al* 2018	-To test whether undergraduate nursing students who received clinical supervisee skills	Post-test only randomised controlled trial.	Patient safety Blended learning Nurse education Online learning Face-to-face learning preferred Student satisfaction Clinical skills

	training via a blended learning approach would score higher in terms of motivation and attitudes towards clinical supervision, knowledge of clinical supervision and satisfaction of learning method, when compared to those students who received an online-only teaching approach. -122 pre-registration nurses -UK University		Lack of social presence and instructor feedback
10. Moore *et al* 2017	-To explore the changing needs and expectations of Generation Z students and discuss potential changes in the classroom -University	Exploratory review	Generation Z Technological immersion Educators challenged to adapt to speed of technological change Undergraduate education Group learning Individualized education Independent, self-paced learning Prefer face-to-face Integrate video games in learning Regular assessment and feedback Generations
11. Ndawo 2014	-To describe supporting strategies to improve the performance of nurse educators in teaching and learning. -104 nurse educators -Nursing college	Qualitative, explorative, descriptive and contextual design	Lecturer-student relationship Classroom computer technological gadget Negative peer group influences Higher level entry requirements Early identification of at risk students Academic workload Clinical responsibility Self-efficacy Nurse educators' quality Teaching support Case based learning Student-centred learning Suitable learning recourses Positive learning outcomes
12.	-To explore and	Contextual,	Nurse educators' challenges Content laden curriculum

Ndawo 2015	describe the challenges experienced by nurse educators on the delivery of content laden curriculum -20 nurse educators -Nursing college	qualitative, exploratory and descriptive design with phenomeno logical individual semi-structured interviews.	Superficial coverage of content Academic preparedness Prior knowledge High-order thinking skills Large groups and disruption Negative attitude Authentic constructivist approach(team-based, case studies) Bridging programmes Essential learning Reflective, interactive pedagogical strategies Effective technology use
13. Owens & Moroney 2017	-To determine which of three different interventions would assist student performance in a nursing bioscience unit -63, 44, 263 bioscience students per intervention -University school of nursing	Systematic quantitative comparative research	Student assistance Recent prior learning Student-focused learning Adaptive online learning Complex knowledge base Science anxiety Anatomy and physiology Collaborative learning High school leaver Self-efficacy Good patient outcomes Active engagement Online assessments Early identification of learning challenges Smart and accommodating teaching design
14. Rogers-Shaw *et al* 2018	-To discuss and elaborate on the history and philosophy of UDL followed by an explanation of how the principles of UDL were used to improve an existing online course for adult learners -University	Design and develop-ment research	Accessibility Online learning Hands-on learning activities Adult learners Equitable learning environment Small group learning Assessment options Presentation modes Timely feedback Self-reflection
15. Seemiller & Grace 2017	-To get insights on Gen Z' perspectives, styles, preferences, concerns, and beliefs as they relate to,	Qualitative survey	Learning preferences of Generation Z students Use of technology Hands-on and applied learning Applied basic knowledge Independent learning Collaborative group work Video based learning

	motivation, communication, social issues, community engagement, relationships, leadership, and learning. -750 Gen Z students -Higher education institutions		Flipped learning
16. Taylor *et al* 2015	-To review the biosciences component of pre-registration nursing programmes through the experiences and perceptions of lecturers involved in nursing education -10 institutions -Higher education institutions	Survey approach for quantitative and qualitative feed-back.	Biosciences Science confidence Clinical decision-making Nurse education Challenges of teaching sciences Basic concepts underpinning competent practice Safe patient care Curriculum development Innovative teaching methods Student feedback Pre-registration e-learning Face-to-face Entry criteria Blended learning
17. Williams & Davis 2016	-To examine the effects of maths anxiety on healthcare students' ability to accurately calculate drug dosages by performing a scoping review of the existing literature -8 Databases -Literature	Scoping review	Dosage calculation Medication Errors Students, Nursing Psychosocial Factors Anxiety Self-efficacy Teaching approach Learning style Numerical ability Patient safety
18 Yung Ngan et al 2018	-To explore the feasibility of adopting blended learning in anatomy teaching and evaluates the learning	Cross-sectional quantitative evaluation	Blended learning Active learning Health profession education Micro-module Medical education E-learning Gamification

	experiences of students. -53 second-year full-time undergraduate Pharmacy students enrolled in an introductory course in anatomy and physiology. -University school of Public Health		Teaching anatomy and physiology

3.5 Collating, Summarizing and Reporting of the Results

Data collection during the scoping review was aimed at answering the question about what the best method would be to teach science-based subjects. A thematic analysis was done where the researcher undertook an initial reading of included studies as guided by the search terminology. For ease of presentation, the results of the included studies are grouped according to the primary themes (Mendelsohn et al., 2015).

The articles were numbered alphabetically from1-18 and are indicated as such with in-text referencing (e.g. Article 1). The data matrix (table 3.1) shows the number allocated to the specific article. This scoping review of the development of a science-based short course for health care students has recognized that past research has focused on the struggles nursing students experienced with basic sciences. No one study was found which examined the development of a science-based short course per se. In addition to modern teaching methods, teaching basic science concepts to undergraduates and Gen Z students, the struggle with basic science concepts has been widely shown to have a long-standing history in nursing (Beall et al., 2014).

During the scoping review, it was highlighted that many studies were undertaken on the struggles nursing students have with basic sciences. The findings of the five (5) research articles about nursing student struggles included in the scoping review will be incorporated into the main themes.

Theme 1: Teaching strategies for basic science concepts

This theme highlighted the most appropriate strategies that revealed the best outcomes for students relating to basic science concepts.

The findings are presented in two sub-themes.

Sub-theme 1: Content overload and relevance

In article four (4), it was concluded that bioscience courses with large volumes of content are difficult. Science content with relevance to the application in clinical nursing practice is considered important. Many registered nurses (RN's) need a "better understanding of the basics of bioscience" (Article 4). Many reasons are given in this article why nursing students struggle with sciences such as the volume of content in insufficient time and lack of sufficient prior knowledge in science. The registered nurses in article 4 understand how important a foundational knowledge in science is for clinical practice (Article 4). The educator should replace "non-essential topics in basic science education with more important applicable ones" (Article 2).

Many nurses worldwide struggle with chemistry, physics, and applied mathematics and do not see these subjects' value as part of nursing studies. The findings of a study described in article 2 suggest better integration of science content throughout the nursing curricula after a formal "basic science subject in the foundation year" (Article 2). Most RN's and nurse educators partaking in this study thought that "nurses should teach science" (Article 2).

Improving the ways in which students learn sciences will impact on nursing practice, with the potential to improve patient care (Article 4).Theory must be integrated in practice. Nurse Educators should focus on the alignment of bioscience with nursing practice subjects, especially earlier in the curriculum (Article 5).

A study described in article 16 was undertaken to review the depth and extent of the biosciences component in a pre-registration nursing programmes in higher education institutions (Article 16). The student feedback in this study concluded that "students consistently requested more time and greater priority for biosciences in their programme" (Article 16). Multiple concerns were expressed in this study about the challenges of teaching difficult bio-scientific concepts to large groups in a limited

time. Greater clarity in national guidelines was suggested to ensure that all nurses were “adequately educated and continuously assessed in bioscience subjects” (Article 16). This study revealed a “widespread failure by student nurses to understand the relevance of thorough bioscience knowledge for safe and competent clinical nursing” (Article 16).

Sub-theme 2: Theory-practice integration

Basic science is essential for clinical practice but will have better educational outcome if “clinical (practical) and theoretical issues are combined” (Article 8). Theory-practice integration is a “powerful approach to scientifically prepare students for clinical practice” (Article 8) and may “enhance students’ motivation and improve academic learning and performance”. The integration of theory and practice provides a scientific “biological basis for patient care to nursing students” (Article 4).

Early exposure to clinical issues may trigger the students' motivation and interest in the topic (Article 2).

In many of these articles it remained a concern how nursing students' can learn and apply bioscience knowledge to their clinical practise. In article 5, it was concluded that “Team-teaching that employs active learning strategies and teaching by different members of the multidisciplinary team, will improve the integration of bioscience theory with clinical nursing practice” (Article 5). This article noted that “team-teaching was effective in integrating pharmacology with bioscience, and then translating this into nursing practice” (Article 5). A simulation laboratory is seen as a safe learning environment. Real-life “simulation models is one of the most appreciated features in bioscience courses” (Article 18) because anatomic structures in the human body are much better illustrated then in textbooks. A vital part of student learning in nursing is the understanding and application of science concepts for safe and effective nursing practice. Nursing students found “bioscience subjects more demanding than nursing subjects” and are “anxious about the difficulty of the sciences they are learning” as well as the “depth of knowledge required to deliver safe, competent nursing care” (Article 18).

Article 6 described a study building upon the standpoint that simulation leads to interactive learning (Article 6). This article highlighted that “Mathematical and

calculation skills are key nursing competences for effective and safe patient care" (Article 6) and "Weaknesses in mathematical competence may lead to the administration of miscalculated drug doses, which in turn may harm or endanger patients' lives" (Article 6). Appropriate teaching and learning strategies were identified that will help nurses to develop drug-dosage calculation skills. "Clinical Skills Workshops (Simulation) may encourage the development of drug-dosage calculation skills" (Article 6).

Theme 2: Educational strategies for better outcomes

The scoping review revealed that various negative feelings associated with basic sciences impact learning and teaching outcomes and spiral through to clinical nurse practice. To build a classroom filled with positivity, encouragement and excitement for learning, the focus should be on engaging the current nursing students who are mostly part of generation Z.

The findings are described in four subthemes.

Subtheme 1: The use of modern technology

The challenges in teaching science content are well documented, but little evidence is available about "educational strategies to improve educational outcomes". Article 11 recommended that technology should be integrated into learning in order to promote life-long self-directed learning. The majority of nursing students are "academically underprepared for higher education (lack basic reading, writing and arithmetic skills needed in nursing)" (Article 11). Tertiary institutions were forced to "lower the level of teaching standards so that learner nurses could understand the content" (Article 12). The nurse educators must reorganize the curriculum by only teaching necessary content which should promote meaningful learning. Effective teaching and meaningful learning is crucial for the development of higher-order thinking skills (Article 12). Through reflective, interactive pedagogical strategies and effective use of technology, higher-order thinking skills in learner nurses will be developed. As a result these nurses will become "self-directed life-long learners required for global nursing care of complex disease profiles in the 21st century"

(Article 12). The nursing curriculum learning content must “reflect the dynamic changes of today’s health care system” (12).

Article 4 found that online teaching is an exciting modern teaching method. Previous studies were interpreted in order to understand the influence of modern technology on the relationships between the student and learning facilitators in a virtual learning environment. This study focused on “caring and relational aspects of online nursing education” (Article 4) and showed that technology alters communication.

Technology and innovative teaching methods will get the most out of the extent to which younger generations feel engaged (Article 7). The study described in this article concluded that the “Gen Z students can’t live without digital technology and will be motivated to study physics if they can use modern technology like mobile phones, but teachers have to upskill themselves in order to use devices for training” (Article 7). Gen Z students feel they “should be able to access a big portion of their teaching materials online” (Article 15). This article described Generation Z students as “unique student populations”. Internet-based games help with critical thinking and makes modern learning fun (Article 15).

Sub-theme 2: Blended learning

Blended learning with in-person instruction concentrating on small group tutorials, and the self-directed learning mostly done online, proofs to yield the best results. Blended learning is explained in article 9 and is believed to “offer improvement of students’ motivation and attitudes, student satisfaction and students’ subject-specific knowledge in relation to clinical supervision” (Article 9). In article 18, it is described that “Blended learning to facilitate active learning among students was perceived positively by most students” (Article 18). This article further suggested that online resources may be the preferred mode of study to overcome institutional barriers in accessing resources. Online resources help students build up a deep conceptual understanding of the subject (Article 18). An article revealed that “lectures only are an inadequate teaching strategy for bioscience” (Article 5).

Sub-theme 3: Active and cooperative learning during small-group tutorials

Article 11 recommended the “restructuring of classrooms to allow small group discussions and collaborative learning, which will promote active learning” (Article

11). The nurse educators should create rapport with students. This article highlighted the importance of “nurse educators adopting an individualized self-regulated approach for less able students” (Article 11). The educators must know the students in order to pick up and appropriately refer social problems. Article 11 elaborated on a caring environment in the classroom and motivated for small group tutorials. This article further suggested that “if lectures have to be used, the educator should plan small group activities towards the end to prevent boredom and restlessness” (Article 11).

A small group tutorial as learning approach is becoming fashionable in medical education and leads to student-centred learning with active involvement and self-directed learning (Article 3). During small group tutorials participants are encouraged to share inter professional knowledge and respect (Article 3). Article 12 described research about the challenges experienced by nurse educators on delivery of loaded curricula (Article 12). During this study, it was found that “large classes did not allow nursing students the time to engage with content and students are afraid to ask” (Article 12). This article argued that the lecture method was preferred to cover content until recent years. Student understanding, lack of development of higher-order thinking skills in students, minimal learner-educator interaction and lower academic achievement were not deemed important (Article 12).

Article 10 revealed that “Gen Z students prefer to learn and be taught in groups and need help in developing creativity” (Article 10). A student's precision on drug calculation may be influenced by maths anxiety (Article 17). Healthcare students must “overcome this barrier of anxiety when calculating drug dosages in order to avoid administering the incorrect dose to a patient (with potentially serious complications) when in the clinical setting” (Article 17). The reduction of maths anxiety is vital. Practicing maths in smaller groups will lead to lesser anxiety (Article 11). Team-based learning (TBL) can encourage problem-solving and shared learning in feedback-rich small group learning environments (Article 1). It was further demonstrated in this study that “small group dynamics leads to a significant amount of interaction among learners, which creates ownership and enthusiasm” (Article 1).

Generation Z (Gen Z) students feel they are “loyal, thoughtful, compassionate, open minded, and responsible but being critical of their peers” (Article 15). In this study,

they did not believe they are “creative but being excited, yet fearful, about the future”. This article described ways to assist college-level instructors how to relate to and support Gen Z students effectively (Article 15). Gen Z students don’t like working with others, but at the same time do not want to miss out. Facilitators must carefully explain the “reasons for working in groups” (Article 15). Generation Z students love to use or create relevant YouTube videos with their phones and can then do group projects about a subject (Article 10). By allowing students to bring their own devices into class, will increase group work involvement. Gen Z students “prefer flipped courses and rely on YouTube as a primary self-instruction source” (Article 10). Group work assignments add to the overall collegiality of a class (Article 9).

Article 14 described a study about the guidelines for Universal Design for Learning (UDL) in order to develop “accessible online teaching” (Article 14). UDL offers principles and practices that shift learning from individualistic approaches to the teaching-learning transaction. The UDL focuses on the learner-centred approach, collaboration and community (Article 14). The pillars of UDL are “multiple means of representation, multiple means of action and expression, and multiple means of engagement” (Article 14). This shift will lead to better accessibility, effectiveness, and enjoyment of the learning process for all learners (Article 14). Applying UDL principles to course design and educational practice will address issues of justice and inclusion (Article 14). UDL “encourages the design of learning environments that can accommodate the increasing diversity in the growing population of adult learners, particularly in the online context” (Article 14). The UDL approach is justice-oriented and creates better opportunities for success for more people of the life-long learning population (Article 14).

According to the needs analysis done in this study (see results in chapter 4), most current undergraduate students are part of Generation Z. Article 13 summarised that “Bioscience has a long history of being challenging to teach and learn within nursing courses and little has been published on new ways to assist students in their learning” (Article 13). Interventions with strong student-focused activities contribute to proper teaching and appropriate learning within the bioscience unit (the Human Body Club and an online learning platform known as LearnSmart). These resources added support and shifted the bulk of the teaching and learning to the students. In this article it proved to be the most effective interventions in assisting students to pass

the bioscience unit (Article 13). In article 15, research about Gen Z students revealed that “Students want face-to-face interaction” (Article15). Gen Z students perceive themselves as “influential, thoughtful, loyal, compassionate, open-minded, and responsible” (Article 15). They feel overwhelmed by the availability of information and need help in evaluating it. Nurse educators must narrow sources of information to boost competence and keep students engaged. Instructors must equip “Gen Z students with skills and attitudes that will enable them to function in future work roles” (Article 15).

Article 1 described research about team-based learning (TBL) and argued that TBL is “a tool that caters to the needs of the rapidly changing practice of medicine” (Article 1). TBL facilitates team-oriented skills which direct attention to the student. TBL encourages students to be actively responsible for their learning outcomes (Article 1). TBL is known to “promote cooperation and generate critical thinking because students actively participate” (Article 1). Additionally, they “had opportunities to learn basic concepts in the context of actual clinical situations, maintaining high levels of motivation throughout the course” (Article 1).

Article 8 described a study about “the various learning styles of nursing students” (Article 8). Nursing students value various learning - and study tools (Article 8). The study in this article aimed to “develop activities for students in order to promote discussion and allow students to interact easily and repetitively with content” (Article 8). It was concluded that “hands-on learning activities that are cheap and easy to produce can cater to a range of styles” (Article 8). Hands-on activities can improve nursing students’ academic success in biosciences courses (Article 8).

Sub-theme 4: Educator skills

Nurse educators should “implement innovative teaching methods to allow the development of problem-solving and higher cognitive skills” and must be “upskilled in the use of self-directed, student-centred, innovative pedagogical strategies in order to fully engage students” (Article 11). The educators should have “a deep knowledge, expertise and experience of the subject matter” (Article 11). Nurse educators should apply various teaching strategies to “capture students’ attention and curiosity” (Article 11). Critical thinking skills are crucial for safe and comprehensive nursing care. To enhance the development of critical thinking, nurse educators need to keep “the

teaching/learning process captivating and interesting using active learning environments" (Article 11). Gen Z students can be academically successful if "Good pedagogy is the foundation for modern educational techniques" (Article 10).

Most of the nurse educators in South Africa are used to traditional education, which is "teacher-centred" (Article 11). The teacher dominates the class while the learners are "passive bystanders" (Article 11). Only few students can learn when being passive in class. It is essential to make learning more "active" for adult students. In this study, 98 % of the participants were older than 18 years; thus, adult learners.

Article 11 recommended that "early assessments for weak and at-risk students should be undertaken" (Article 11). This study noted that "Course scheduling and pacing must be done according to students' needs" (Article 11). Gen Z students prefer that feedback is provided according to the individual student's needs (Article 15). A student-centred approach with "continuous feedback, engaging materials, blended learning and self-assessment- skills will lead to successful learning in modern students" (Article 15). The study results in article 1 implied that "immediate feedback obtained during TBL sessions, ensures that the students never doubt the content of the sessions" (Article 1).

3.6 Summary

The aim of the scoping review was to assess international literature to explore what is currently known about the design and development of an accessible and relevant basic science course for undergraduate first-year nursing students.

From the scoping review it is evident that the future students in nursing courses are part of the Generation Z.

The scoping review revealed that the teaching method for basic sciences should be engaging and facilitate higher order thinking skills. The content of the course should focus on basic science concepts as well as the relevance and application into nursing practice. The course should incorporate a variety of platforms to encourage critical thinking, interactive and self-directed learning. Educational principles which were underscored in the review highlighted continuous feedback and practical hands-on

learning activities, are key to the success of students and should be incorporated into any course design.

3.7 Conclusion

In chapter 3, the scoping review was described in order to meet the first study objective to find current literature on the design and development of an accessible and relevant science-based short course for health care students. The recommendations from the scoping review will be considered in the following phases. In chapter 4, the students' needs analysis, and the nurse educators’ opinion will be described.

CHAPTER FOUR - NEEDS ANALYSIS

4.1 Introduction

In developing a short course that offers access and relevance to a basic science course, the main purpose was to determine the students' needs in providing access to content and determine the appropriateness of course content. The needs analysis and the educators' input are linked to the second objective or the research study.

The main purpose of the needs analysis was to learn what the participants knew, felt, and thought about basic science education to allow the researcher to determine what educational products and services were needed.

In this phase the students' needs and the educators' opinions were explored and will be presented in this chapter.

4.2 Students' Needs Analysis

4.2.1 Demographic questions

The questions presented here are about the respondent' age, year of matriculation as well as the subjects completed in matric.

4.2.1.1 Age and year of matriculation of the participants

The majority of participants were school leavers and applied to university immediately after completing matric (84% were 18 or 19 years of age during matric). One participant indicated the age as 30 years and worked a few years after school before enrolling in nursing. The students in the age group of 20 – 22 years might be repeating students. Therefore, most of the group (98%) fits the Gen Z student group's definition, and learning activities should, therefore, be adjusted to meet their needs.

Figure 4.1 explains the age composition and year of matriculation of the participants.

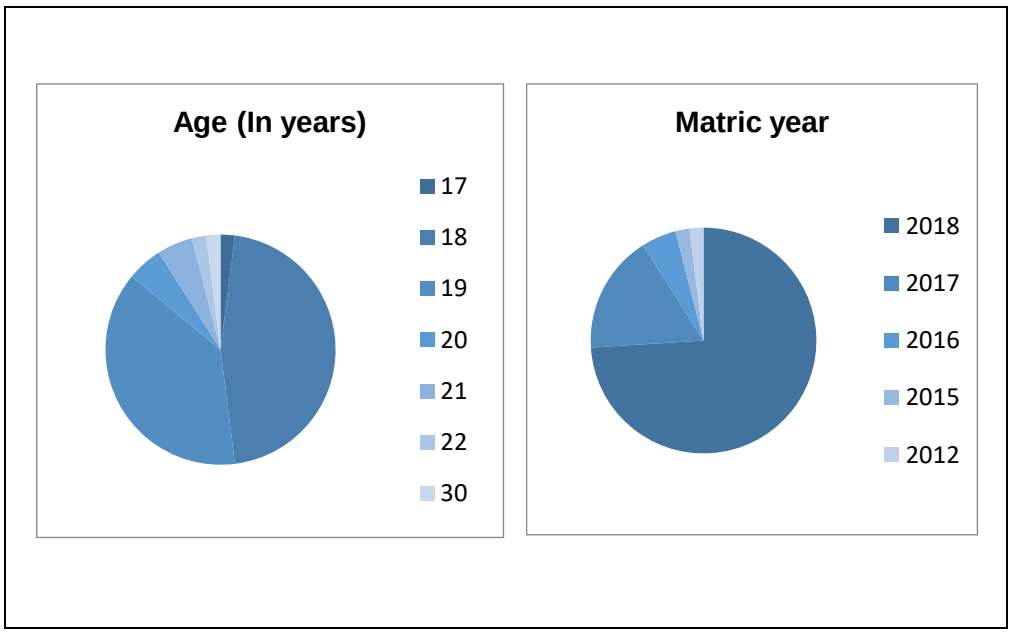


Figure 4.1 Age and year of matriculation

4.2.1.2 Subjects in matric

Life science covers human genetics, human reproduction, the endocrine system, and homeostasis and was taken as a matric subject by forty (40) of forty-two (42) participants, 95%.

Physical science in matric includes basic concepts of physics and chemistry like laboratory skills, molecules, Doppler waves, chemical reactions, acids, bases and electrodynamics. This subject forms the basis for basic sciences in University and was a matric subject for thirty-nine (39) of the participants, 93%. It can be derived that 93% of the respondents in this study had a good baseline of basic science knowledge from school.

Mathematics in matric is compulsory in South Africa, and all the participants finished matric with mathematics. Included at least in mathematics is solving equations, sketching graphs, the concepts of ratio, proportion, statistics, and building on the knowledge acquired since grade 10 like symbols and measurement.

Figure 4.2 explains the number of study participants and their science-based matric subjects.

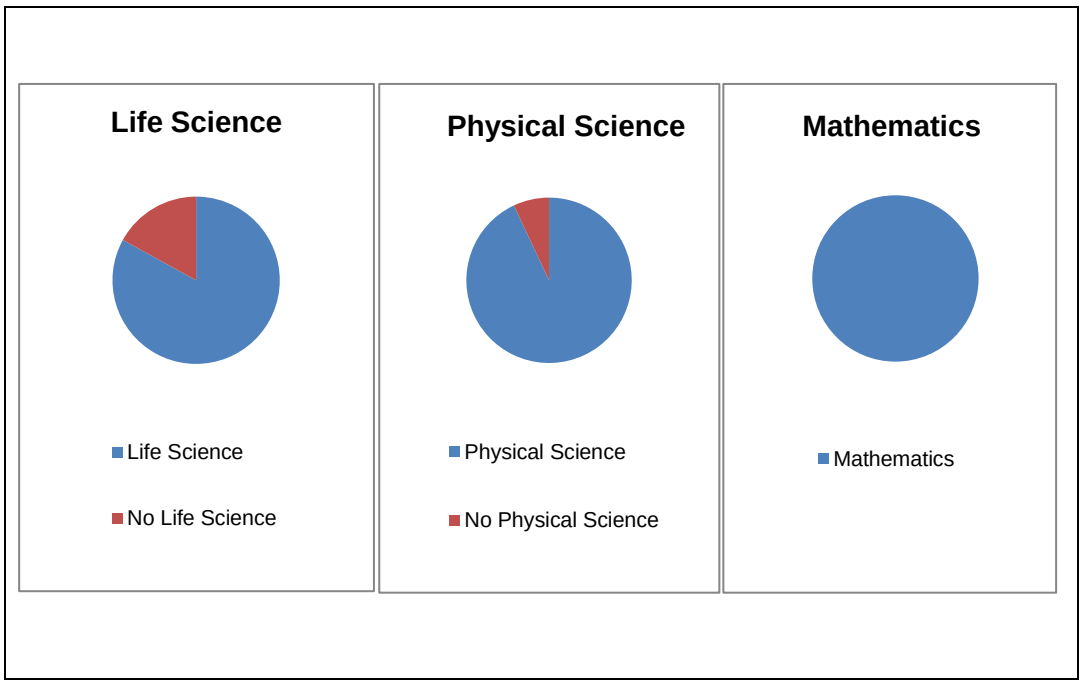


Figure 4.2 Subjects in Matric

4.2.2 Thematic analysis of the answers to the open-ended questions

The coding process was started by conceptualizing the data. The main concepts were grouped where after patterns were identified and allocated to themes and subthemes. The respondents were randomly numbered P1-42. The respondent number is added after the comment in brackets.

Theme 1: Importance of basic sciences

The respondents were asked in the survey what science subjects mean to them and if they believe basic sciences are relevant and needed in a nursing course.

Subtheme 1: Science subjects are essential in a science-based course like nursing

The overall responses to the questions were equally negative and positive towards the basic sciences. Respondents explained that science subjects form the basis for scientific studies about the world and the human body. “Science is essential for any student to broaden your perspective in a scientific field” (P3). Only three respondents answered about the importance of a basic science knowledge for clinical nursing and

safe patient care, “teaches me a scientific way of helping patients” (P11). According to one of the respondents, science subjects are a “Great way to conceptualize what the world means in scientific way” (P25). Some respondents answered “give an understanding of courses in health science faculty” (P2, P14). The literature (Taylor et al., 2015) shows the importance of basic sciences in the undergraduate nursing course. Even some of the respondents realize the essence of a proper scientific background and the application in nursing practice for safe patient care. The need for a firm base of knowledge about basic science concepts was summarised by participants as “Gives me platform to learn and explore scientific ways of helping patients” (P29) and “Help to make clinical decisions” (P14). Another respondent felt that basic science subjects gave the student the basis to “explore new, helpful things” (P4).

A participant answered that science subjects “allows one to understand human life, world and everyday life better…it challenges thinking skills and intelligence but based on facts” (P8). One respondent explained that “my love for living organisms during anatomy and physiology brought me to nursing” (P33). The “love of learning about the human body” is what makes basic science subjects appealing to other participants (P17, P20).

It is demonstrated in the respondents’ answers that almost half the group understand the importance of basic sciences. “Need basic sciences for anatomy and pharmacology” (P37), “Life science is crucial because it is body-related” (P6, P19), “Nursing is a science degree after all” (P25), “Life science and math are priority” (P15). Basic sciences are important as a foundation for further nursing studies as explained by two of the respondents, “If you want to study some other degree after nursing” (P37) and “broaden my perspective into a broader career field” (P37). One of the respondents believed that basic sciences are important but should not weigh so much (P33). Integration between theory and practice is important as noted by one respondent, “Less theory but more applied to practical work” (P15).

Subtheme 2: Students don’t see the relevance of basic science knowledge to nursing

The participants who did not see the need or relevance of basic sciences in nursing were almost as many. The presumed irrelevance of basic sciences to nursing is represented in answers like “Don’t understand why you need physics in nursing”

(P31, P36), “Struggle with physics and chemistry concepts and only do because it is part of syllabus” (P40), “Don’t see the relevance in clinical nursing” (P42). The comments made by the respondents about the irrelevance of basic sciences reveal a lack of insight in the importance of a scientific foundation for safe and compassionate patient care. “Nursing does not require basic science knowledge” (P7), “Basic sciences have nothing to do with caring for others” (P31) and “We don’t do any calculations in the wards” (P12). Two of the respondents believe that basic science is a waste of time, “Rather spend that time on practical work and nursing skills” (P18) and “The physics and chemistry is a repetition of schoolwork and thus a waste of time” (P22). A comment like “Not needed if want to be a nurse after the degree” (P16) demonstrates the complete dissociation in thoughts about the nursing profession and what it entitles. A few respondents indicated that a lack of time for theory is the reason why they don’t see the importance of basic sciences. “Nurses don’t have enough time because of going to the clinical area” (P4, P7) and “Nursing students do not have time enough with clinical hours and back to back lectures” (P21). The comment “There should not be a lot of scientific theory work in nursing because it is hard and boring, and requires too much time in a busy, practical schedule” (P37) shows a complete lack of appreciation for the importance of foundational science knowledge.

About 25 % of the respondents felt that chemistry is important for nurses but almost half the respondents noted that physics is not needed in nursing. A few respondents noted that they feel more positive about chemistry than about physics and mathematics, “I loved sciences; chemistry and life sciences in school” (P1). It appears that the hands-on laboratory time with experiments turned school science into a positive learning experience as noted by about 10 % of the respondents, “Love chemistry, experiments and lab work” (P15, P25, P30 and P34). This shows that previous positive teaching environments and hands-on learning is an advantage for future learning. The scoping review for this study revealed the same sentiment (Ndawo, 2015). Chemistry and physics were perceived as related to nursing and pharmacology (P17, P29), “Chemistry is relevant” (P23), “Chemistry is important for pharmacology” (P11).

Mathematics and physics are more problematic then chemistry. “Don’t like math” (P32), “Math always my weak point” (P21), “Science subjects mainly about

calculations, I hate calculations in physics (fearing not to know where to start) and prefer to apply theories" (P39). Previous bad experiences like academic deterioration in any of the science subjects, is proven to show a bad outcome for these students. The previous experience in these subjects had a negative influence on the attitude towards the subjects in the undergraduate course as explained by two respondents. "Became bad in math and physics in matric" (P22), "never enjoyed physics in school" (P16).

Many participants revealed the sentiment that only parts of physics content is needed like "gravitation (Elevation, angles, stop bleeding)" (P31). A respondent revealed that the application of physics is not clear "and is out of the line of nursing" (P36, P40, P42).

Subtheme 3: Science subjects provide critical - and creative thinking skills

A few respondents believe that science subjects provide critical - and creative thinking skills. The science subjects help "to think out of the box" (P23) can be seen as proof that science subjects enhance critical and creative thinking skills.

A few respondents explained that the science subjects are "fun because they are challenging" (P5, P19) and "loved the challenges" (P6, P41), while another one responded, "love the complexity" (P9). The fact that nurses need excellent critical thinking skills, which are developed by science subjects, was reflected as "Science subjects mean deep critical thinking, solving complex deep problems, forced to think carefully, quickly and broadly" (P26).

Two of the participants expressed that all the subjects were important "All the basic science subjects help us acquire problem-solving skills and critical thinking (P26, P30),

Theme 2: Emotional effect: Basic sciences cause stress, fear, anxiety and frustration

The negative feeling of many of the respondents has to do with the anxiety, fear of failure and previous negative experiences the respondents had with these subjects. The feeling of anxiety towards basic sciences was described as relevant to more than 50 % of the respondents. "Physics causes anxiety" (P15), "These subjects are

stressful (require lot of time, energy and understanding)-Lack of last because of many required practical hours" (P10, P12, P16). Strong emotional words like love, hate and fear were used to describe the respondents' feelings and attitudes towards basic science subjects. "Loved the challenge but not getting an answer is frustrating" (P35), "Hate calculations in physics (fearing not to know where to start)" (P27), "Science subjects are scary - physics hard"(P24), "Math and physics stresses me out" (P18), "I fear failing them" (P38), "Never liked it because hard to pass, and no fun but do need it to follow my passion- nursing"(P28), "Struggle with all science, struggle and hard to grasp"(P7), "My brain is not inclined for science and I experience stress and pressure to pass" (P12). One of the respondents is of the opinion that basic sciences are added in the nursing curriculum as a way to maintain a high failure rate in order to gain financially from repeating students. It is filtering through that students are scared of basic sciences and 50% of the respondents felt that basic sciences are not important

Theme 3: The impact of a science-based short course on science confidence

A question in the survey asked the respondents to rate their science confidence. The following question guided the respondents to elaborate on their feelings about a science-based short course and if such a course will improve their confidence.

Subtheme 1: Lack of science confidence

The higher the confidence of a student in science subjects, the more critical understanding of a subject the student will have, leading to the safe application of the basic science concepts into nursing practice (Sihotang et al., 2017). The results showed that 17 % of the respondents had no confidence in science subjects at all, while more than a third (36%) of the respondents revealed that they had little confidence (2) in science subjects. These two groups combined made up more than half the participants in this study. In other words, one out of every two student nurses in this study believed they do not have sufficient confidence in basic sciences in order to make them safe nursing practitioners. The biggest portion (40 %) of the respondents had moderate confidence in science subjects, and very few students

(7%) had high confidence. From the responses it can be deferred that students don't rank their science confidence as high.

Figure 4.3 illustrates the level of confidence with science subjects.

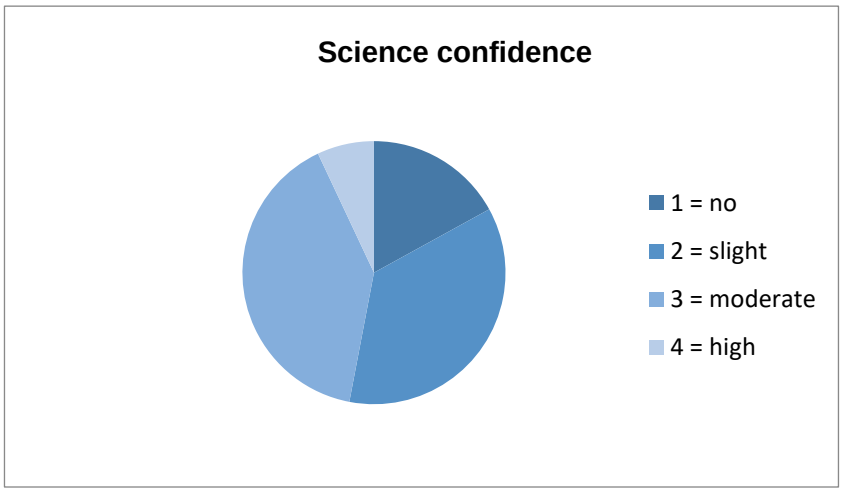


Figure 4.3 Participants' confidence with science subjects

Subtheme 2: A short course will improve confidence in basic sciences

Three out of four respondents feel a short course will help to explain the basic concepts underlying sciences, "Hopefully, it will break down and link the concepts and apply them to the nursing field" (P12, P27 andP38). A respondent verbalised the insight that a short course "Will help to build up from basics and grasp topic better" (P9). Three respondents express the hope that a short course in basic science concepts will help them refresh the knowledge from school, "It will revise topics not sure about from school" (P20, P30 and P41). One of the respondents benefited from the introductory science course offered by the university in the setting as illustrated by "Did attend similar one before, helped a lot" (P23).

The respondents' reasons why they will benefit from a science based short course reveal that the lack of understanding the basic sciences concepts leads to poor academic results. "Especially for biology, chemistry and physics-any help will be good to improve understanding" (P23), "Will help target and balance weaknesses" (P6, P16 and P39).

The few participants (5%) who did not think a short course will improve their science confidence explained that a course is not needed since there is a foundation laid in school and it is better to study hard in all subjects during the nursing course. “I think real studying and practicing will reap excellent results” (P34), “I have the basics from high school already” (P25).

Theme 4: A science based short course should include various topics

It is revealing that 24% of the respondents prefer physics to be included. This correlates with the number of respondents who struggle with physics. Some respondents felt this is not needed as reflected by “Physics are not relevant” (P42) and “No physics” (P36).

On the chemistry content, the respondents elaborated on different aspects of chemistry which they felt were important like “different methods to get to same answer” (P39), “EVERYTHING in Chemistry” (P7), “Chemistry related to pharmacology” (P12) and “Organic chemistry” (32), “Medication (working of chemicals, pros and cons)” (P18).

Few respondents (5%) elaborated on their need to have Mathematics included “math revision” (P37) and “I need more help with equations” (P18).

Various responses were noted that show the insight of some of the respondents, like the fact that the content of a short course should be in relation to nursing as explained by one respondent, “Nursing issues, treatments and why they work in relation to physics, chemistry, biology (integrated learning)” (P6). “Study methods” (P16) was mentioned by one respondent.

The highlighted content for inclusion in a short course shows that medical related science with implementation into nursing practice must be embedded in the short course.

Theme 5: The preferred presentation style is a small-group tutorial

The respondents were asked how a basic science short course should be presented. They had one choice between lectures, small group tutorials, online tutoring and

online course with self-assessments or other. They were then asked to explain their choice.

More than half the group (54%) chose small group tutorials. The participants' responses are coded into the following subthemes:

Subtheme 1: Closer contact and individual attention from the lecturer helps with better learning

"Will allow students to interact and engage with lecturers and ask more questions than during a lecture" (P6,P24) "Easier to learn and ask questions in smaller groups"(P31), "Human interaction usually helps people understand information more, especially with a good teacher" (P12), "More easy to pay attention than during lectures" (P19), "Lecturers will have enough time to attend to particular students who need help" (P8) and individual attention was an important benefit from small group tutorials, "Lecturer will know individual students' weaknesses and strengths better"(P10). A few respondents feel that group work leads to positive learning experiences because "students learn and compare different methods of problem-solving" (P22, P16). According to one of the respondents lectures are "too extensive and at a fast pace" (P11) whereas a small group can be adjusted to students' individual needs.

Subtheme 2: Small groups are more intimate, less intimidating and improve confidence.

The following comments from respondents illustrate that small groups cause less anxiety: "There is shyness in front of big group and then too nervous to ask questions" (P19), "Scared to admit if not understand in big group" (P24), "Less intimidating" (P4) and "More intimate and easier to voice opinion" (P37).

One in four (25%) respondents preferred an online course with self-assessments because this will assist with self-directed learning. "I can't focus in lectures, small group tutorials gives me anxiety thus online course with self-assessments will be good" (P32) "This will help me to get used to self-study" (P15) "Allow me to assess myself" (P28), "I learn better from error and correction if I understand what I did wrong" (P9), "If don't understand you can replay unlimited times" (P4), and "Can pause if needed" (P2, P41). The respondents added that basic concepts will help

with foundation for further understanding. “Everything will be explained step-by-step” (P13) and “Online videos will help me to explain the basics” (P23).
The convenience of online training with self-assessments was an important factor as illustrated by “I don’t have to attend classes but can do these at home” (P36) and “Time-efficient” (P41).
Only 12% of the respondents preferred lectures because of the efficacy “Lectures are more effective” (P7). Another participant felt that lectures fit into his/her learning style “I am a verbal learner and grab it better when hearing it” (P19).
Four students (9%) would like to have online training in basic sciences. Convenience is the main benefit for these respondents, “This training will always be available” and is, therefore, “more convenient” (P22). Online training will allow participants to study at their own pace and revisit the basic concepts as needed, “It might include a question and answer section as well” (P28), and “minor detail will not be overlooked”(P1). One of the respondents replied that the reason for not choosing online tutoring is the fact that it is more likely that the student will attend a compulsory group session.

No participant suggested other teaching methods for a science-based short course. In summary it can be concluded that most of the respondents want close interactions with learning facilitators and fellow students but on the other hand want to be self-directed and independent with little interaction. These two opposite poles will be considered in the development of an accessible and relevant course. It appears that most students prefer small group tutoring because of a fear of science which results in a low science confidence. In the development of a science-based short course this fear needs to be overcome.

Figure 4.4 illustrates the method of presentation as preferred by the respondents.

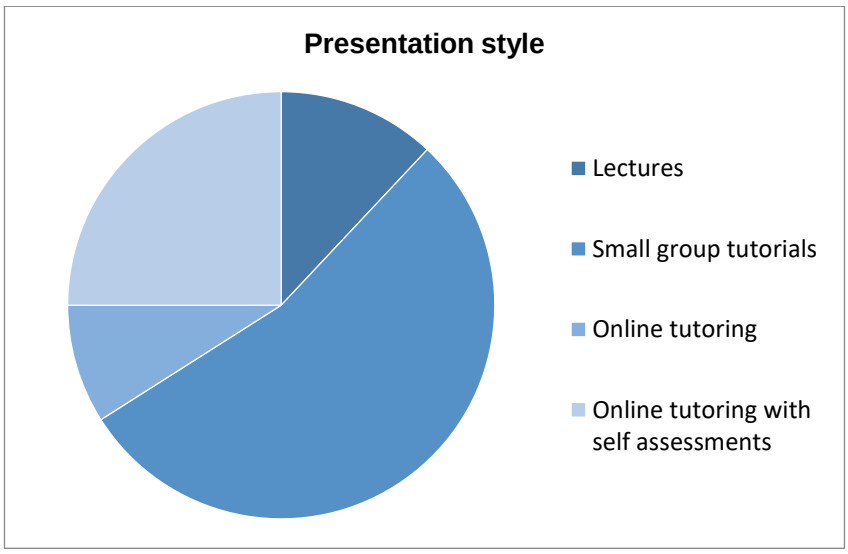


Figure 4.4 Course presentation styles

4.3 Nurse Educators' Opinion

The survey results are as follow:

Theme 1: Content, teaching methods, competencies and outcomes

The nurse educators were all in agreement that basic science concepts should be taught as separate entities in the nursing curriculum but integrated and the students must understand why the subjects are important for nursing practice. One of the educators feels that "If you incorporate basic science concepts into other subjects, the in-depth discussion is lost. The educator will assume that the students know the basics; while they don't. Keep it separate, but make it practical and applied". The need to first explain the foundational concepts in all the basic sciences and then explain the reason for and way of application into clinical nursing is well described by the educator who says "Students must realize that the sciences are fundamental to their practice - the nursing care decisions they make are based on their understanding of the sciences and how that influences the patient". "Nurses' ability to account (or not) for their nursing care decisions is based on their understanding (or not) of basic science". Understanding the basics is important; however, science is difficult and "therefore it must taught by someone who love teaching it and really find interesting teaching aids that makes it realistic and easy to comprehend". The

function of the educator is to “assist students to understand the value of chemistry, physics and mathematics”.

The clinical facilitator is of the opinion that “These subjects should have been passed in Gr 12 and should be selection criteria prior to entry into a nursing course”. This comment highlights the nationwide struggle of preparing scholars for their undergraduate studies.

All the respondents feel that small group tutorials the best presentation style is. The nurse educators’ opinions on the content, teaching methods, competencies and learning outcomes for the teaching of basic sciences is summarized in table 4.1

Table 4.1 Nurse Educators’ opinions

Content	Teaching method and materials	Competencies and outcomes
Chemistry fundamentals	Applied exercises after teaching the basics in chemistry	Problem solving Critical thinking Define basic terms like atoms, molecule and compounds. Explain advanced processes like diffusion, osmosis, pressure, gas/fluid concentration.
	Interactive subject material on e-learning platforms	Critical reading from handbooks and research articles
	Visual material such as videos	
	Experiments	
	Small group tutorials	
Physics	Build on basics	Define basic terms Explain advanced physics
	Theory-practice integration	Understand the basic principles of physics Explain the application of physics in nursing.

	Practical input during lectures like diagrams, illustrations, YouTube videos, small experiments	Explain difficult concepts
	Make learning fun – animated videos, mind maps, modern manikins and models	”
	Small group tutorials	
Mathematics	Build on the current basic knowledge	Teach basics first for example the metric system
	Application to nursing practice (case studies, nursing care plans, prescriptions and medication administration charts)	Apply maths to nursing practice such as calculating dosages, weights and dosage, administering IV fluids and calculating the amount of fluids and drugs (IM/ IV/ PO).
	Scenario based training	Epidemiological calculations like ratios, weight, height, intake & output formulas applied; BMI calculations.
	Make math fun (games) and understandable - Bring in practical items.	
	Small group tutorials	

4.4 Discussion

The findings of the students' needs analysis and educators' opinion are important to develop an appropriate, relevant and accessible science-based course. The main findings were considered while developing the course.

The generation most represented in nursing courses currently is the Gen Z group (98%). The nursing students have individual needs, and most prefer small group tutorials (54%).

Although at least 79 % of the study participants had basic science concept training in matric, the failure rate remained high in first-year chemistry and physics in previous groups. The nurse educator participants predicted that it will not be effective to remove the subjects' chemistry, physics and nurses math from the curriculum and incorporate the concepts into other subjects. The student participants echoed this

sentiment by expressing feelings like “These subjects are difficult and need a lot of time to practice” and “hard to understand” but also “loved the challenge but not getting an answer is frustrating”. The importance to know the basics before understanding how to apply advanced knowledge in practice is proven by a comment like “hate calculations in physics (fearing not to know where to start)” and “never liked it because hard to pass and no fun but do need it to follow my passion- nursing”..

A relevant and accessible course is vital to support nursing students in understanding and applying the basic science concepts into nursing practice. As part of the objectives, it must be made clear why every concept being taught during the course is important and relevant to safe patient care. Proper knowledge of basic science concepts will form the foundation for nursing students to expand their knowledge and practical application thereon.

The nurse educator respondents in this study believe that critical thinking and problem-solving skills are of uttermost importance for safe nursing practice. They were collectively of the opinion that fundamentals will form the basis of the content with applied exercises to implement in nursing. The basic science concepts should be taught as separate entities in the nursing curriculum, and the students must understand why the subjects are important for nursing practice. The nurse educators felt that interactive subject materials must be provided and that all teaching must be according to the key teaching principles. They further asked to make mathematics fun but understandable and applicable to nursing practice. All of the nurse educator respondents requested that the very important integration between theory and practice must be addressed in the course. Games can be used to bring an element of fun. Case studies, nursing care plans and the calculation and administration of medication in a simulation environment will assist with the application of basic concepts in safe clinical practice. The content in this short course was chosen to teach basic science concepts as they apply to nursing practice.

The educator participants in this study responded that students must realize that the sciences are fundamental to their practice and that nursing care decisions they make are based on their understanding of the sciences and how that influences the patients. The subjects of foundational chemistry, physics and basic mathematics

must be taught as separate subjects and should not be incorporated into other subjects.

Only a few student participants revealed that science subjects provide critical - and creative thinking skills and are essential in a science-based course like nursing. Some felt that basic sciences are important as a foundation for clinical nursing and further studies. Many of the respondents (34%) do not understand why basic sciences are relevant in nursing, with some not seeing the relevance of physics only. Basic sciences cause overwhelming stress, fear, anxiety and frustration to more than half the respondents.

Bayram-Jacobs and Hayirsever (2016) suggested some changes to move from teacher-centred to student-centred learning. Lecturers can facilitate group work with continuous peer group evaluation and informal correction and give students the choice of topics but cover the whole curriculum. Let students evaluate their learning. The learning environment does not have to be an always quiet classroom but can be effective with some noise and activity (Nagaraju et al., 2013).

The student participants in this study echoed the above suggestions. The most preferred method for teaching basic sciences in this study is the small group tutorial (54%). The nurse educators opted 100% for the small group tutorial. The small group tutorial will allow student-centred learning because the lecturers can enhance learners' self-image and confidence by building on personal strong points and by encouraging students to participate (Brame and Briel, 2015). Lecturers should reflect a caring attitude in the nursing education context (Nagaraju et al., 2013), and this is possible during small group tutorials. Caring lecturers might lessen stress, fear and anxiety. The small group tutorial will lead to closer contact and individual attention from the lecturer, which helps with positive learning experiences because it caters to different learning styles (Nagaraju et al., 2013). The students feel safe and less intimidated to ask questions in small groups and indicated that direct contact with lecturers will help "grasping the content better". The students responded that the lecturer will better understand individual students' weaknesses and strengths in small group tutorials. The students responded that attending small groups increases their understanding of and confidence in basic sciences. One of the participants in this study explained this as follow: "Group work with different strengths and weaknesses

is beneficial to all," and this "will help students learn and compare different methods of problem-solving".

The significance of the findings from the needs analysis resulted in the development of a short course with the focus on basic science concepts in chemistry, physics and mathematics, and the application in clinical practice in a simulated environment. The preferred method will be small group tutorials during blended and student-centred learning. This will develop creative and critical thinking skills in a safe and low stress environment.

4.5 Conclusion

In chapter four, the needs analysis of the students and the opinions of nurse educators are described. Moving forward with the development of a relevant and accessible basic science course, the student's needs and the educators' opinions must be taken into account for appropriate content delivery. The next chapter will describe the design and development of the short course, including the evaluation.

CHAPTER FIVE - DEVELOPMENT OF THE SHORT COURSE

5.1 Introduction

This chapter describes the creation and pre-implementation evaluation of a short course to teach basic and applied science concepts (chemistry, physics and mathematics) to first-year nursing students. The ADDIE framework is used to explain the steps of the development of an educational intervention. A brief overview of the ADDIE model, which was used during the development of the short course, is described in chapter 2.

5.2 Design and Development of the Short Course

This phase of the design and development research process is developing an intervention that was the short course to teach basic sciences to first-year nursing students. The key findings from the scoping review and needs analysis and their significance are fully described in chapter 2, 3 and 4.

5.3 Components of the Short Course

5.3.1 Setting

The science-based short course will be implemented as part of the Undergraduate Nursing Degree in the same setting as in this study. This ensures the possibility of doing a post-implementation study to assess if the basic sciences course improved the academic results.

5.3.2 Course description and module development

The initial drive behind this research was to study what can be done to improve the high failure rates of students in physics and chemistry during their first year of undergraduate nursing studies (chapter 1). The scoping review (chapter 3) revealed that one of the reasons for the countless medication errors in nursing practice is a below standard knowledge of basic mathematics.

The students' needs analysis (chapter 4) showed that many students do not understand the reason for including physics teaching into the nursing curriculum while others struggle with complicated chemical formulas. The basic concepts of chemistry, physics, and mathematics applied to clinical nursing were chosen as the most important content for the short course. Course content can be broken down into smaller units called modules. This will help the developer to write specific objectives appropriate to each module.

The underlying chemistry and physics concepts applicable in nursing were combined into one module and nurse mathematics as another module. Understanding basic science concepts will help the students with problem-solving and critical thinking skills and apply the above basic science concepts to the nursing practice. This will ensure a safe nursing practice.

The teaching plan represents a short course to support students with basic sciences. A short course is structured content that can be studied from a few hours to a year or more (Bolton & Lortan, 2019). A period of two (2) months at the beginning of the first year of nursing studies was chosen in order to provide the students with appropriate concept knowledge of basic sciences. Suppose the course is presented at the beginning of the first year of nursing studies. In that case, it will provide a baseline of conceptual knowledge in Chemistry, Physics and Mathematics, enabling the rest of the nursing course to build on an implement into clinical practice. Another benefit of teaching this science-based course at the beginning of the first year is that the students will easier recall knowledge acquired in school.

The course is aligned with the teaching philosophy of the research setting, namely blended learning, which is a combination of in-person and online learning activities (broken up into tasks). The scoping review and needs analysis guided the decisions for development and supported the blended learning approach

This course will be compulsory but at no extra cost to the students. Since the content is foundational to other nursing subjects, the university's cost will be incorporated into the overall course fee. A certificate of successful completion of this course will allow the students to carry on with anatomy and physiology in the second half of the first-year nursing studies.

5.3.3 Determine the course goal

A course goal is a broad explanation about the recommended outcomes of the course and should not contain detail about measurement. The goal of this science-based course is:

- Students will learn the basic concepts of chemistry, physics and nursing mathematics to help students prepare for the rest of the nursing course and standardized exams.
- The students will describe and apply basic science concepts in nursing practice and exercise mathematical calculations and formulas.

5.3.4 Learning objectives

A well-constructed learning objective is an announcement of what learners must be able to do and know after successfully completing a course. It will include the conditions under which the task must be performed like the tools available and a measurable outcome such as a number of correct responses (Barsuk & Salzman, 2020).

Different kinds of learning objectives relate to different domains of learning

The three levels of learning according to Professor B. Bloom (psychomotor or physical ability, cognitive or knowledge and affective or emotionally) must be kept in mind when objectives are created (Krathwohl, 2002).

To have appropriate learning objectives, the researcher considered the overall aim of the course to decide what the students must be able to do after the course and how these changes will be measured. In order to meet these expectations, the appropriate, relevant and accessible content was structured.

The various learning objectives applicable to both modules are described in the teaching plan (Appendix H).

5.3.5 Teaching activities

Appendix H explains the teaching plan for this short course, included is how the content will be delivered, the specific teaching activities, the time allocated for each module, the notional hours and the related assessment tools.

5.3.6 Assessment tasks

The assessments correspond to the stated learning objectives and must show that effective learning and teaching happened. The assessment activities during the short course delivery are explained in the teaching plan (Appendix H).

5.4 Implementation

Implementation could not be carried out in this study since the University in the setting did not have an intake of first-year nursing students.

5.5 Evaluation of the Short Course

5.5.1 Evaluation method

The purpose of the research was to develop a science-based short course that will help first-year nursing students cope academically with science subjects. The international attempts to introduce science-based courses to undergraduate students were reviewed. First-year undergraduate nursing students' needs concerning structure, content, and delivery of a science-based course were identified via a needs analysis. The criteria to evaluate the developed course were guided by the scoping review findings and the student's needs analysis and nurse educators' opinion (chapters 3 and 4) and identified as accessibility, relevance, and appropriateness (described in chapter 1).

The research method used to evaluate this short course was an expert review as part of process evaluation before the short course could be implemented. The responsibility for evaluation was assigned to nursing education experts. The experts were asked to undertake an expert review of the short course before implementation. The experts reviewed the short course and reported which processes could be implemented well, areas for improvement and suggested actions to improve processes. The request for the expert review is attached as Appendix I.

5.5.2 Expert review feedback

On completion of the expert review, the course developer consolidated the comments and suggestions from the reviewers. The course was amended accordingly to improve the accessibility, appropriateness and relevance. The feedback from the evaluators and the researcher's responses are summarized in table 5.1. The initial evaluator, who developed the evaluation tool, re-evaluated the course after the corrections were applied. There were no further changes suggested.

Table 5.1 The evaluators' feedback and researcher's response according to criteria

Criteria	Evaluator's feedback	Researcher's response
Requirements for the course - desired outcomes	The outline of the content is comprehensive and will meet the needs to build the knowledge and understanding of the students. The duration of 6 months is too long.	The content is comprehensive, but the duration too long. The short course will be changed to run for over two months.
Accessibility	The accessibility of the course in terms of the requirements is clear. Two expensive prescribed books at the first year level, over and above other prescribed books, may make the course inaccessible. Recommended the use of OER's (open education resources) and that the "notes" of presenter referred to are compiled in a more formal OER. This could add value to other healthcare professionals' accessibility to content or as a reference source.	OER's and facilitator's notes will be made available to students. The recommended books for optional reading are available from the library.
Appropriate content (Fit for purpose) & integrated	The content is appropriate and addresses the objectives, and should lead to reaching the outcomes.	

assessment system	The assessments are not appropriate for the purpose of a short course.	The assessments changed to self - assessments online.
Clarity	Objectives should be specific and measurable, eg. “The students will better appreciate (measurable, possible, specific) the need for understanding basic science concepts” is unclear. Under teaching activities, what is meant by “self-directed learning”.	The objective was changed to: “The students will understand the application of basic science concepts as demonstrated in nursing care plans and case studies”. Changed to “independent self-activities”.
Relevance was found to be theory-practice integration for nursing students (after the analysis of the students’ needs)	Theory-practice integration is indicated in each session. The application of knowledge is the culmination of specific objectives and is well thought through. Recommended that examples of case studies or care plans are provided to students to assess or critique. It would also be of value for problem-solving skills.	Case studies and nursing care plans will be incorporated during the group sessions.

5.6 Discussion

During the design and development phase of this study, a science based short course was developed considering the findings from the previous phases (scoping review, chapter 3 and needs analysis, chapter 4).

The outline for the short course reflects the changes made by the researcher from the findings of the expert reviewers (Appendix H).

5.6.1 Accessibility

The expert reviewers suggested that the two (2) prescribed books should be optional but available in the library. Two expensive prescribed books at the first year level, over and above other prescribed books, may make the course inaccessible. The use of OER's (open education resources) was recommended. The reviewers further suggested that the "notes" of the presenter are compiled in a more formal OER. This could add value to other healthcare professionals' accessibility to content or as a reference source.

5.6.2 Relevance

The needs analysis of student participants and the opinions of nurse educators revealed that the content in a science-based short course should be relevant to clinical nursing practice. Theory-practice integration of necessary content only should be presented hands-on, safe environment e.g. the development of nursing care plans and case studies in a simulation room.

5.6.3 Appropriateness

The reviewers concluded that the initial duration of six (6) months was too long. The foundational basic science concepts should be taught before other nursing subjects are introduced. The duration was changed to two (2) months at the beginning of the first year of training.

5.6.4 Innovative teaching methods

The analysis of the literature and educational needs revealed that blended learning with student-centred teaching strategies lead to the best outcomes. Modern technology, games and small group tutorials are some of the elements included in the short course as suggested during the analysis phase of this study.

5.7 Conclusion

This chapter explained the development and evaluation of the short course to teach basic science concepts to first-year nursing students. The following chapter will describe the conclusions, limitations and recommendations of this study.

CHAPTER SIX - CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter is the concluding chapter of the research report. In this chapter, a summary will be presented, emphasizing the main findings gathered from the results. Limitation of the research will be discussed, and lastly, include recommendations for nursing education, practice and research.

6.2 Summary

The purpose of this study was to design and develop a science-based short course that will assist first-year nursing students to cope academically with science subjects by providing an accessible and relevant course. The objectives were

- to review international attempts to introduce science-based courses to undergraduate students
- to identify the needs of first-year undergraduate nursing students concerning the structure, content, and delivery of a science-based course
- to develop a science-based short course for first-year nursing students considering nurse educators' opinion
- to evaluate and review the developed short course

The research methodology chosen for this study proved to be appropriate as the outcomes met the objectives. The first objective was met during the scoping review, and the second objective was met during a needs analysis of the nursing students. The short course was developed to address the student needs, and the short course was evaluated with an expert review before implementation.

6.3 Main Findings

The research question that was asked in this study was: How can a science-based short course for first-year nursing students best provide access to the learning material and relevance to the student's needs? It was determined that a blended learning short course would be the preferred format in order to meet the learner's needs. A two-month programme was developed and included two modules on the basics of chemistry and physics and nurses mathematics. It was determined from the scoping review that Gen Z students prefer to learn and be taught in groups and need help in developing creativity (Moore, 2017). Gen Z students like independent, self-paced learning, not limited to a classroom but always connected to the internet (Seemiller & Grace, 2016). Seemiller & Grace (2016) concluded that Gen Z students see lecturers as learning facilitators helping them to develop relevant and practical skills. Gen Z students need help with how to evaluate multiple online sources critically. Moore (2017) suggested that good pedagogy is the foundation for modern educational techniques. Suggestions for teaching Gen Z students are integrating active and problem-based learning, engaging creativity, helping make connections, and helping students extract answers from overwhelming amounts of information and often assess (Moore, 2017). A student-centred approach with continuous personal feedback will lead to successful learning in modern students. Facilitators should be adaptable, especially to less-abled learners. Critical thinking skills can be taught using engaging materials, blended learning with phone-based instruction, interpretation of research and self-assessments (Beatty, 2018).

From the needs analysis, the generation most represented in nursing courses is currently the Gen Z group. These students have individual learning needs and prefer small group tutorials. Integration between theory and practice is important. The students participating in this study reflected positively on the fact that science subjects are essential in a science-based course like nursing. However, one in three students does not understand the relevance of basic sciences (i.e. specifically physics) in nursing. They believe that science subjects form the basis for scientific studies about the world and the human body and provide critical - and creative thinking skills.

Nurse educators' opinion reflected that fundamentals would form the basis of the content with applied exercises to implement in nursing and should be taught according to the key teaching principles. The educators see the value of interactive subject materials, but the students must understand why they are important for nursing practice. Basic science concepts should be taught as separate entities in the nursing curriculum. Make math fun but understandable and applicable to nursing practice. All the subject matter experts believe small group tutorials are the best way to teach chemistry, physics, and nurses math. Students can be taught critical thinking and problem-solving skills by creating, reading, and interpreting case studies, nursing care plans, and research articles.

The course addresses the misconception that Gen Z students want to learn mainly online, and therefore does not focus on online teaching. One of the aims of the short course is for the structure and the content to be specific to the student's needs, thereby making the learning accessible, relevant and appropriate. The nursing and educational expert who reviewed the science-based short course gave positive and constructive feedback. The course still needs to be further tested and piloted. It is hoped that nursing students who participate in the implementation of the short course will agree with the expert that the short course in basic sciences will lead to better academic and clinical success in nursing education with the outcome of safe patient care.

6.4 Limitations

This design and development research study created an accessible and relevant science-based short course for first-year nursing students to support them academically. The following limitations were identified:

- Literature on the best way to teach basic science concepts to undergraduate nurses proved difficult to find; research is done on basic sciences incorporated in medical and pharmacology courses, but no research on basic sciences in nursing curricula. Furthermore, a lot is written about nurses and their struggles with basic sciences suggesting few solutions.
- Since the university in the research setting did not have a student intake for the year of this study, no impact evaluation could be done by the users.

- The evaluation could not be done as part of this study because the Nursing Qualifications have changed from 2020, and the university in the research setting has integrated the science subjects into the nursing programme.
- Much difficulty was experienced in gaining cooperation from the subject matter experts teaching chemistry and physics in the research setting to assess what they feel needs to be included in a science-based short course for nursing students from their scientific perspective.

6.5 Recommendations for Nursing Education

Basic science education is widely recognised as paramount to fundamental nursing knowledge and the application into safe nursing practices. Despite a scholastic background in chemistry, physics and mathematics or the attendance to an introductory science course, the failure rate of science-related subjects remains high among first-year nursing students. This study shows that a science-based short course might be beneficial and can be applied to other therapeutic science courses.

The development of a science-based short course to support nursing students academically will ultimately result in the appropriate implementation of basic science concepts into practicing safe nursing, which will benefit clinical practice, the nurse, and the patient.

The findings indicate access to a relevant and appropriate science-based short course with engaging materials; blended learning with phone-based instruction and self-assessments is beneficial for critical thinking. Small group training with a student-centred approach, including continuous personal feedback, will lead to successful learning by modern students. Nurse educators fulfilling their role as adaptable learning facilitators will help nursing students, including less-abled learners, develop relevant, creative, and practical skills.

Learners cannot develop critical thinking and creative application of basic science concepts if they do not understand the meaning of basic concepts in chemistry, physics and mathematics. Learning should, therefore, be designed to meet the needs of the students. Teaching advanced concepts in basic sciences and applying those in clinical practice should be built from a foundational explanation of basic science

concepts supporting the students in developing critical thinking and clinical application skills once they understand the basics.

This study also showed that educators should apply key teaching principles to facilitate practice and theory integrated skills for safe patient care while facilitating the science-based short course.

6.6 Recommendations for Nursing Research

A follow-up study might be worthwhile to determine the impact of the developed short course on the academic success and clinical patient safety of nursing students.

Evaluation research is recommended in order to systematically assess the impact of the developed short course once implemented.

More specifically, the summative evaluation approach would be beneficial using a combination of outcome – and impact evaluation. Outcome evaluation explores whether the short cause in chemistry, physics, and nurse mathematics caused demonstrable effects on a specifically defined target outcome which could be medication errors. Impact evaluation is broader and assesses the intended or unintended overall effects of the short course as a whole, for example, better critical thinking skills in nursing students or safe clinical nursing practices.

6.7 Recommendations for Nursing Practice

Basic knowledge of chemistry, physics, and mathematics concepts will form the foundation for further clinical application and critical thinking. The nursing students completing the science-based course will not only be able to define, describe, and practice the basic science concepts, but they will also understand why these concepts are important for nursing practice and will be able to apply the relevant concepts to nursing practice. The course is structured with many possibilities of clinical practicing via case studies and simulation in a safe environment will support the nursing students to succeed academically and apply the basic concepts in

everyday patient care environments and will result in safe, high-quality nursing care for all patients.

6.8 Conclusion

This study was conducted to design and develop an accessible, relevant, and appropriate science-based short course to support nursing students academically. Nursing students need academic support in basic sciences to build a foundational knowledge base of chemistry, physics, and mathematical concepts to ensure that a deeper knowledge can be acquired from the foundation as needed for application into safe clinical nursing practice.

In conclusion, it is estimated that the relevant and appropriate basic science concepts taught in this course will lead to a better understanding of basic science concepts and the appropriate application in clinical nurse practice resulting in safe patient care.

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Appendix A: Ethical Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Ms FM Liujk

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M181047

NAME: (Principal Investigator)	Ms FM Luijk
DEPARTMENT:	School of Therapeutic Sciences Department of Nursing Education Medical School University
PROJECT TITLE:	*The development of an accessible and relevant science-based course to assist nursing students to cope academically with science subjects* ***New study title noted on 2021/03/29***
DATE CONSIDERED:	26/10/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Ms L Crous
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	15/02/2019

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **«Missing mail merge field»** and therefore reports and re-certification will be due in the month of **«Missing mail merge field»** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator — Date: 29.03.2021

Appendix B: Permission from the Nursing Education Department

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

02 March 2022
Person No: 1948204
PAG

Ms FM Luijk
309 33 Avenue
Villieria
Pretoria
0186
South Africa

Dear Ms Fija Luijk

Master of Science in Nursing: Approval of Title

We have pleasure in advising that your proposal entitled *Development of an accessible and relevant science-based course to assist nursing students to cope academically with science subjects* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

DEPARTMENT OF NURSING EDUCATION

Mrs Sandra Benn
Registrar
Postgraduate Office
Faculty of Health Sciences
27 March 2019

PERMISSION TO CONDUCT RESEARCH STUDY.

MARIA FUMA LOUK 1948204

The above named candidate has expressed her intention to conduct a focus group to determine the learning needs, regarding basic sciences subjects, amongst undergraduate nursing students in the Department of Nursing Education in the School of Therapeutic Sciences with the view to peruse a Master of Science in Nursing (dissertation).

Research Topic "The development of an accessible and relevant science-based course to assist nursing students to cope academically with science subjects"

Mrs Lizelle Crous has agreed to supervise the applicant and I therefore support the request.

Yours sincerely

pp. W Lolak Prof. S. Schmollgruber.

Professor JE Maree
Head: Department of Nursing

Department of Nursing Education | School of Therapeutic Sciences | Faculty of Health Sciences
7 York Road, Parktown, 2193, South Africa. Tel: +27 11 489-4272 | Fax: +27 11 489-4180
www.wits.ac.za/therapeuticsciences/nursing

THERAPEUTIC SCIENCES

Appendix C: Study Information Sheet – Students

Dear student,

I, Fijma Luijk, am doing research on the development of a science-based short course to support nursing students with basic sciences. Research is a process used in seeking new knowledge. In this study we want to learn how to assist nursing students to cope academically with science subjects.

Invitation to Participate: I invite you to take part in a research study.

What is involved in the study? This could include but would not necessarily be limited to such features as:

1. This will be a Design and Development Research study because the needs of millennial students are of uttermost importance to develop an appropriate course. The Participant's involvement in the study will entail participation in a Monkey Survey questionnaire to assess the needs nursing students have to cope academically with science subjects.

2. Study start and end dates: January 2018 - November 2020

Risks of being involved in the study: No risks applicable. This study involves an anonymous questionnaire. Anonymity can be guaranteed.

Benefits of being in the study: There is no direct benefit to the Participant. The longer-term objective is the possibility of enhancement of science-based knowledge for nursing students.

The Participant will be given pertinent information on the study while involved in the project and after the results are available.

Participation is voluntary; the refusal to participate will involve no penalty or loss of benefits to which the Participant is otherwise entitled. The Participant may discontinue participation at any time without penalty, or loss of benefits to which the Participant is otherwise entitled. There is no requirement to provide a reason for withdrawing and any data collected on such a person will in default be destroyed, unless the Participant specifically consents to its retention.

Reimbursements: There is no payment or cost associated with participation.

Confidentiality: Personal information will be treated in the strictest confidence and will only be available to the Principal Investigator (PI) and her Supervisor, in the case wherein the PI is a postgraduate student.

All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly.

Contact details of researcher/s: to enable prospective or actual participants to get further information, or report adverse events, please find e-mail and telephone contact details of the Principal Investigator and his/her Supervisor:

Principal Investigator: Fijma Luijk E-mail address: fijmaluijk66@gmail.com Contact: 0828141936

Supervisor: Lizelle Crous E-mail address: Lizelle.Crous@wits.ac.za Contact: 0114884061

Contact details of HREC administrator and chair – for reporting of complaints / problems.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg (“Committee”). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.

Appendix D: Student Survey Questionnaire

Name of Survey: “Science help for nursing students – a needs analysis”

1. Age
2. Year of matriculation
3. Subjects in matric. You can choose more than one
   Life sciences
   Physical science
   Mathematics

4. Describe what science subjects mean to you (Think about what you like, don’t like, love or fear).

5. Do you think science subjects are relevant or needed in a nursing course? Explain your answer.

6. How confident are you about science subjects on a scale of 1-4?
   1 = No confidence □
   2 = Slight confidence □
   3 = Moderate confidence □
   4 = High confidence □

7. Do you think a short course in basic sciences will assist you to improve your confidence/performance in the science subjects? Explain your answer.

8. If you could choose the content for sciences in a short course, what topics would you include and why?

9. If a short course is developed, how should it be presented? Choose one of the below.
   Lectures □
   Small group tutorials □
   Online tutoring □
   Online course with self-assessments □
   Other □

10. a. Please explain why you chose the option in question 9?
    b. Is there any other information you would like to share with us regards to basic sciences for nurses?

Appendix E: Formal Request Letter Participation NEA Members

October 8, 2019

Dr. Joan Esterhuizen

Obo NEA Pretoria Chair

NEA Pretoria EXCO

Subject: Request to send a questionnaire to NEA Pretoria members

Dear Dr. Joan:

Thank you for replying to my request a week ago.

You suggested the following:

That I send you a formal letter stating what the questionnaire is about, and what my research purpose is.

That I attach the approval letter from the university's ethics Committee as well as the letter I plan to give to the research participants.

That the NEA Pretoria EXCO then discusses the request and decides how the researcher can be put in touch with the members.

The purpose of my research is to develop an accessible and relevant science-based short course that will assist first year nursing students to cope academically with science subjects.

The questionnaire will be send to nurse educators to answer the following question: What is the best method to teach science-based subjects to junior nursing students? The subject matters experts will comment on the course content and the structure. The "Monkey Survey" platform will be utilized to have little time, effort and cost implication for the nurse educators.

I look forward to hear from you.

Sincerely,



Fijma Luijk, Primary researcher

Appendix F: Study Information Sheet - Nurse Educators

Study title: Development of a science-based short course to support nursing students with basic sciences

Dear nurse educator,

I, Fijma Luijk, am doing research on the development of a science-based short course to support nursing students with basic sciences. Research is a process used in seeking new knowledge. In this study we want to learn how to assist nursing students to cope academically with science subjects. Not only do I want to learn about the needs student nurses have but also the vision and advice from nurse educators on the content and structure of such a course.

I invite you to take part in a research study.

What is involved in the study?

1. This will be a multi-method study. The Participant's involvement in the study will entail participation in a "Monkey Survey" Questionnaire to assess what nurse educators feel should be the content and structure of such a course.

2. Study start and end dates: January 2018- November 2020.

Risks of being involved in the study: No risks applicable. This study involves an anonymous questionnaire.

Benefits of being in the study: There is no direct benefit to the Participant. The longer-term objective is the possibility of enhancement of science-based knowledge for nursing students.

Participation is voluntary, the refusal to participate will involve no penalty or loss of benefits to which the Participant is otherwise entitled. The Participant may discontinue participation at any time without penalty, or loss of benefits to which the Participant is otherwise entitled. There is no requirement to provide a reason for withdrawing and any data collected on such a person will in default be destroyed, unless the Participant specifically consents to its retention.

Reimbursements: There is no payment or cost associated with participation, *e.g.* travel expenses and refreshments.

Confidentiality: Personal information will be treated in the strictest confidence and will only be available to the PI and her Supervisor, in the case wherein the PI is a postgraduate student.

All data collected in the course of the study will be securely retained for two (2) years, if a scientific publication arises from the study and six (6) years, if there is no publication. Thereafter it will be destroyed accordingly.

Anonymity can be guaranteed in online questionnaires.

Contact details of researcher/s: to enable prospective or actual Participants to get further information, or report adverse events, please find e-mail and telephone contact details of the Principal Investigator and her Supervisor:

Principal Investigator: Fijma Luijk

E-mail address: fijmaluijk66@gmail.com

Contact: 0828141936

Supervisor: Lizelle Crous

E-mail address: Lizelle.Crous@wits.ac.za

Contact: 0114884061

Contact details of HREC administrator and chair – for reporting of complaints / problems.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Study Information Sheet.

Date: October 2019

Appendix G: Nurse Educators Questionnaire

Platform: Survey monkey

Name of Survey: “What nurse educators would like to teach first year nursing students?”

Please explain how you are involved in nursing education e.g. Clinical facilitator or lecturer at private nursing school. Please elaborate on what year group and what subjects you train.

The following 3 questions ask about different subjects. Please explain how you would teach chemistry to nursing students? What content would you include, what teaching method would you use? Anything else that you want to add.

Please explain how you would teach physics to nursing students? What content would you include, what teaching method would you use? Anything else that you want to add.

Please explain how you would teach mathematics to nursing students? What content would you include, what teaching method would you use? Anything else that you want to add.

If a short course in basic science is developed, how should it be presented? Choose one option

Lectures

Small group tutorials

Online course

Online course with self-assessment

Other

Many of the nursing students in their first year fail chemistry and physics. Would you as nurse educator suggest that these subjects are taken out of the curriculum and rather be incorporated in other nursing subjects to be more relevant? Please elaborate on any suggestions not mentioned in this questionnaire

Appendix H: Teaching Plan - Basic Science Course for Nursing Students

School: School of Therapeutic Sciences	**Department:** Department of Nursing Education
Programme: Undergraduate Nursing Degree	**Course:** Science-based short course (2 Modules)
NQF level: 4	**Course credit value:** 46
Concept: Chemistry, Physics, Nursing Mathematics concepts	**Concept credit value**: 4 credits (40 notional hours)
Duration: 2 months	**Contact time:** 24 hours **Assessment time:** 4 hours **Self-directed learning:** 12 hours

Title: Basic sciences made easy !

Conceptual lens: Basic scientific knowledge needed for nurses

The gap between matriculation level and the first-year university commonly leads to prolonged study completion. To bridge the gap between school and university, a science-based short course will support undergraduate nursing students in succeeding academically.

This course is based specifically on the students' needs and aims at the understanding and application of basic science concepts related to nursing practice.

This course focuses on basic concepts applicable to safe nursing practice in three subjects :

- Chemistry
- Physics
- Nurses mathematics

The structure and content of this course will ensure access, relevance and appropriateness.

Course objectives:

The aim of this course is to help the students understand the basic science concepts in order to support problem-solving and critical thinking skills as well as the application of basic science concepts to nursing practice. This will ensure safe nursing practice.

Students will learn the basic concepts of chemistry, physics and nursing mathematics to help students prepare for the rest of the nursing course and for standardized exams.

The students will be able to describe and apply basic science concepts and practice calculations and formulas.

Module 1: Basic Chemistry and Basic Physics

Learning outcomes and assessment criteria

- Outline a framework of knowledge in a topic area.

- Define and explain basic science concepts necessary for nursing practice.

- Relate the basic concepts of chemistry and physics to nursing practice.

- Demonstrate knowledge, understanding and practical application of basic science concepts.

- Provide orientation to and practicing of application of basic concepts in simulated and safe environment.

- Assessment of knowledge and practical application skills with online self-assessments and verbal feedback during group assignments.

Learning activities

Teaching sessions may include a short formal lecture and all the sessions will have small group tutorial for application of the knowledge in a simulated environment of written case studies. Students will be requested to read the written material prior to class as well as a written summary of the steps of the nursing care plan. Online sources like videos will be available to be viewed before class.

Learning assessment

The application of basic chemistry and physics concepts to nursing practice will be practiced during group assignments. The students will be required to draw up nursing care plans as part of applied nursing and the plans will be discussed during group sessions in a simulated environment.

Resources required

Prescribed textbook: *Science in Nursing* by Cree and Rischmiller, 5th Edition

Notes: Provided by facilitator. Links of appropriate websites will be communicated via e-mail.

o-o-o-o-o-o-o

Module 2: Nurses Mathematics

Learning outcomes and assessment criteria

- Outline a framework of knowledge in a topic area.

- Define and explain basic mathematical concepts necessary for nursing practice.

- Relate the basic concepts of mathematics to nursing practice.

- Demonstrate knowledge, understanding and practical application of basic mathematical

concepts.

- Provide orientation to and practicing of application of basic concepts in simulated and safe environment.

- Assessment of knowledge and practical application skills with online self-assessments and verbal feedback during group assignments.

Learning activities

Teaching sessions may include a short formal lecture and all the sessions will have small group tutorial for application of the knowledge in a simulated environment. Students will be requested to read the written material prior to class as well as viewing online sources before class. Dosage and volume calculations will make up the biggest part of this module.

Learning assessment

The teaching activities and home work will be conducted simultaneously to link the theory to practice. Emphasis is on applied mathematics e.g. drug dosages and volume calculations.

Mathematics homework will be marked during peer sessions. During the last session the students will perform a practical hands-on assignment with different stations all centred around medication administration and calculation.

Resources required

Prescribed textbook: *The Nurse, the Math, the Meds* by Mulholland and Turner, 3d Edition

Notes: Provided by facilitator

Links of appropriate websites will be communicated via e-mail. Other materials with the specifications will be discussed during the first contact session (e.g., calculators).

References:

1. Cree, L. and Rischmiller, S. (2008). *Science in nursing*. Fourth ed. Australia: Elsevier, pp.1–428.
2. Mulholland, J.M. and Turner, S.J. (2015). *The nurse, the math, the meds : drug calculations using dimensional analysis*. St. Louis, Missouri: Elsevier/Mosby.
3. University of the Witwatersrand and School of Chemistry (2016). *Chemistry 1028 &1029: Student manual.*

Appendix I: Request for the Expert Review

Evaluation of course outline

Dear subject matter expert and educational specialist,

Please evaluate the short course developed as part of a research study.

TITLE OF PROPOSED RESEARCH: The development of an accessible and relevant science-based course to assist nursing students to cope academically with science subjects.

Purpose: To develop a science-based short course that will assist first year nursing students to cope academically with science subjects as part of their university programme.

Problem statement: The failure rate of science-related subjects is high among first year nursing students. The gap between matriculation level and the first-year university commonly leads to attrition and prolonged study completion. The University of the Witwatersrand offers orientation programmes to help students adapt both socially and academically but the failure rate in science subjects among the nursing students remains high. A short course related to the sciences has been run in the department of nursing for some years, and although there has been an improvement in students who have attended this course, not all students attended and the failure rates remain high. Developing an accessible and relevant short course, based specifically on the students' needs, should reduce failure rate, and therefore improve the throughput rates and reduce the attrition rate.

The target audience for this course will be first year nursing students irrespective of the science background.

The ADDIE model was used to develop the basic science course. (Analysis, Design, Development, Implementation, and Evaluation)

1. Needs analysis of the students revealed that they struggle immensely with chemistry concepts and calculations, application of physics in nursing and basic mathematic concepts and calculations as needed for nursing. About half the students

expressed that they don’t see the need for including any of the chemistry, physics or mathematics content in a nursing course.

Most of the participants (88%) prefer small group tutorials to any other teaching method.

The needs of subject matter experts (nurse educators) where analysed. 75% of them expressed the need for still including the basic chemistry, physics and math in the introductory course but the rest feel strongly that this should be part of basic sciences as covered during secondary school. The educators believe more advanced content should follow basic concepts and introductory content. All the educators would present this course via small group tutorials to ensure participation of all students and personal support for students who are struggling.

2. The outline of the course is attached where the design and development and potential implementation can be seen.

3. A subject matter expert and educational specialist will evaluate the course outline with the emphasis on but not limited to:

- Requirements for the course - desired outcomes

- Appropriate content (Fit for purpose) and integrated assessment system

- Theory – practice integration for nursing students

I look forward to hear from you.

Sincerely,



Fijma Luijk

Primary researcher

Appendix J: Language Editing Certificate

REGCOR
ENTERPRISES PTY LTD

(2015/375453/07)

Date: 24/03/2021

Dear Sir/Madam

This letter is to certify that I, Sarah Louise Cornelius, of Regcor Enterprises Pty Ltd, have completed the initial editing of the thesis titled *Development of an accessible and relevant science-based short course to support nursing students with basic sciences* by Fijma Maria Luijk.

I have ten years of experience in the field, having worked on multiple doctorates. Currently, I am a member of the Professional Editor's Guild (PEG).

This has been an initial (first-time) edit and all recommendations and errors have been noted in the comments. Any changes or lack of corrections done to the document after editing is not a reflection of the editing services provided. The onus is on the student to make sure the document is fully corrected before final submission even if that requires multiple edits.

Kind Regards
Sarah Louise Cornelius

Professional Editor's Guild
Associate Member
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